In the Eye of the Beholder:

Visual Biases in Package and Portion Size Perceptions

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Abstract

As the sizes of food packages and portions have changed rapidly over the past decades, it has become crucial to understand how consumers perceive and respond to changes in size. Existing evidence suggests that consumers make errors when visually estimating package and portion sizes, and these errors significantly influence subsequent food choices and intake. We outline four visual biases (arising from the underestimation of increasing portion sizes, the dimensionality of the portion size change, labeling effects, and consumer affect) that shape consumers’ perceptions of package and portion sizes. We discuss the causes of these biases, review their impact on food consumption decisions, and suggest concrete strategies to reduce them and to promote healthier eating. We conclude with a discussion of important theoretical and practical issues that should be addressed in the future.

Keywords: Portion size; Size estimation; Visual perception; Visual bias
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Highlights

1. Supersized portions appear smaller than they really are because of the underestimation bias.
2. Supersized portions are underestimated more strongly when all three dimensions (L, W, H) change.
3. Small and healthy-sounding labels and brands reduce perceived calorie content and portion size.
4. Portion size perceptions are independent of body mass but are more accurate for conflicted eaters.
5. Biased size perceptions influence portion size preferences and choices but remedies exist.
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When making decisions about food, consumers tend to rely more on judgments of food quality than food quantity. For example, the vast majority of consumers think that to lose weight, it is more important to monitor what they eat than how much they eat (Collins, 1996; Rozin, Ashmore, & Markwith, 1996). This focus on quality over quantity is reflected in many dietary guidelines and weight-loss programs which prioritize eliminating certain types of foods or nutrients (e.g., sodas, carbohydrates) over regulating the total food intake (Thompson & Veneman, 2005). As such, consumers may expect to gain more weight from eating very small portions of a food perceived as “unhealthy” (e.g., one mini-Snickers® bar containing 47 kcal) than from eating a very large quantity of “healthy” food (e.g., one cup of low-fat cottage cheese, three carrots and three pears, with a combined calorie count of 569 kcal) (Oakes, 2005).

In the meantime, the sizes of food packages and portions have changed dramatically (Nestle, 2003; Rolls, Morris, & Roe, 2002). Portions grew by 60% for salty snacks and 52% for soft drinks in the course of just 20 years (Nielsen & Popkin, 2003). Due to public concerns about the negative implications of supersized portions for consumer health (Ledikwe, Ello-Martin, & Rolls, 2005; Young & Nestle, 2003), some marketers have attempted to downsize their products, but with mixed results (Deutsch, 2007). A few downsizing attempts have successfully attracted health and budget-conscious consumers (e.g., T. G. I. Friday’s “Right Portion Right Price” menu, Horovitz, 2007). However, other downsizing attempts have tried to pass all the cost to consumers (e.g., by charging the same price for a smaller size) or to conceal the size reduction through product packaging (e.g., by replacing some of the product in a package with air). These tactics
have drawn strong criticism for deceiving unsuspecting consumers who typically fail to check quantity information (Grynbaum, 2014).

In view of these trends, it has become crucial to understand how consumers perceive and respond to changes in package and portion size. In this article, we review four systematic visual biases that drive consumers’ perceptions of package and portion size, show how these biases influence food consumption decisions, and suggest how they can be reduced. We conclude with a discussion of potential directions for future research.

FOUR TYPES OF BIASES AND THEIR REMEDIES

Although information about food quantity is increasingly easy to find, including in restaurants, consumers rarely consult quantity labels (Wansink & Chandon, 2014). Instead, consumers tend to base their food purchase and consumption decisions on instant visual impressions of package and portion size. This is because they expect the package to be a reliable proxy for the amount of food inside (Lennard, Mitchell, et al., 2001), and because some people find quantity information difficult to process, especially when it is presented in non-metric units (Viswanathan, Rosa, & Harris, 2005).

Unfortunately, visual perception is not a reliable indicator of food portion or package size because of four types of visual biases, which pertain to the underestimation of package or portion size, dimensionality effects, labeling and affective biases. Below we outline the consequences of these biases for consumption decisions and discuss the effectiveness of various debiasing strategies.
The first bias in perceptions of package and portion size is the underestimation of the magnitude of the increase in the actual size of a package or a portion, whereby the perceived size grows more slowly than the actual size. Essentially, when consumers encounter a new supersized product (e.g., a new extra-large can of soda), they underestimate how much larger it is compared to the existing smaller size that they remember from prior purchase or that is displayed next to the supersized product on store shelves or on restaurant counters.

A stream of literature in psychophysics has established that the underestimation bias arises because people’s visual perceptions of the size of physical objects follow an inelastic power function of actual size, as captured by the following mathematical expression (Stevens, 1986):

\[ \text{ESTSIZE} = a \times \text{ACTSIZE}^b, \]

where ESTSIZE is estimated object size, ACTSIZE is actual object size, a is a constant term and b is the power exponent denoting the sensitivity of size estimations to changes in actual size.

In the context of food packages and portions, marketing studies have demonstrated that the power exponent b of consumers’ size perceptions typically ranges between .5 and .8 (Krishna, 2007, 2012), with values close to 1 observed only for one-dimensional figures such as lines which are rarely encountered in the food domain. This means that the sensitivity of consumers’ size estimations to actual size diminishes as the packages and portions grow bigger, resulting in the underestimation of large sizes. In other words, consumers become increasingly desensitized to package and portion size as packages and portions grow bigger, with the result that they choose and consume larger portions without realizing just how large these portions really are.
To test these predictions, Chandon and Wansink (2007a) asked the customers of fast food restaurants in three US cities to estimate the number of calories contained in meals that they had purchased. The results showed that consumers underestimated the size of their meals (the average estimated size was 546 Kcal compared to the actual 744 Kcal, a 27% underestimation); more so for large meals (estimated size was 687 Kcal vs. actual 1144 Kcal, a 40% underestimation) than small meals (estimated size was 433 Kcal vs. actual 484 Kcal, an 11% underestimation). This underestimation bias was replicated for round and square shapes (e.g., pizzas, Krider, Raghubir, & Krishna, 2001), when quantity increased or decreased (Chandon & Ordabayeva, 2009), as well as for food kept in the pantry (Chandon & Wansink, 2006).

Importantly, the prevalence and the magnitude of the underestimation bias did not depend on body mass or people’s knowledge about nutrition and portion size. The same authors (Chandon & Wansink, 2007a; Wansink & Chandon, 2006a) reported a similar pattern of underestimation among normal-weight and overweight individuals, among people with a high or low interest in nutrition, and even among trained dieticians. These findings are consistent with the prevailing view that visual biases are hardwired (Raghubir, 2007), suggesting that information-, attention-, and motivation-based strategies directed at debiasing size perceptions have limited effects. Accordingly, providing information about the underestimation bias does not improve the accuracy of consumers’ size perceptions (Chandon & Wansink, 2007a; Ordabayeva & Chandon, 2013). Drawing attention to the product does not improve estimation accuracy (Folkes & Matta, 2004), neither does consumers’ motivation to produce accurate estimates, be it inherent or induced through financial incentives (Ordabayeva & Chandon, 2013; Raghubir, 2007).

Instead, studies have found that piecemeal estimation, consisting of breaking up a large meal into its individual components (e.g., the main dish, the side dish, and the beverage) is an
effective way to reduce the underestimation bias. This is because the individual components of a meal have a smaller size than the total meal and therefore the perception of their size is more accurate. Thus piecemeal estimation of food portions improves consumers’ perceptions of total meal size and, as a result, weakens preferences for large meals, even among dieticians (Chandon & Wansink, 2007a). To illustrate, in one study dieticians were asked to estimate the sizes of small, medium and large fast-food meals containing a sandwich, chips, and a drink. They then indicated which of the three meals they would choose to consume afterwards. Those dieticians who estimated the size of individual meal components had more accurate size estimates and were more likely to choose a small meal than those who estimated the size of the full meal directly. Figure 1 summarizes these findings.

---Insert Figure 1 about here---

Helping people realize just how large today’s supersized portions really are may also enhance the sensory pleasure that people derive from the meal. Indeed, studies have shown that supersized portions often yield lower sensory pleasure because of sensory-specific satiation (Garbinsky, Morewedge, & Shiv, 2014; Cornil & Chandon, 2015a, 2015b).

**Dimensionality biases and their remedies**

The second bias in consumers’ size perceptions arises from the shape of the change in package or portion size, notably the dimensionality (whether the package or portion changes in one, two or three dimensions, and whether the dimensions change in the same or in opposite directions). In short, the underestimation bias is lower when a package or a portion changes in one dimension (e.g., when a tube of Lay’s Stax® potato chips increases only in height) than in
multiple dimensions (e.g., when a bag of Lay’s potato chips increases in height, width and length). Size perception is even less accurate when some dimensions change in opposite directions, such as when the base of a package decreases while the height increases (elongation).

Reviewing the literature in psychophysics, Krishna (2007) reported that the elasticity of size estimations (i.e. the sensitivity of consumers’ size estimations to changes in actual size, as denoted by exponent b in the power function in the previous section) depends on the dimensionality of an object. Specifically, the elasticity of size estimates is higher for one-dimensional objects such as lines (b = 1.0) than for two-dimensional objects such as squares (b is between .7 and .8) or three-dimensional objects such as cubes (b = .6). A later study showed that this was not driven by the nature of the object itself, but by the dimensionality of the size change (Chandon & Ordabayeva, 2009). It is easier for individuals to track volume changes in packages or portions when the change happens in a single dimension (e.g., when a box of candy doubles in size by doubling its length) than when the change is compounded across multiple dimensions (e.g., when the box doubles in size by increasing each dimension by 26%, since 26%×26%×26%=100%). For example, in one study Chandon and Ordabayeva (2009) asked people to estimate the sizes of six packages of detergent and wool that doubled in size either through a change in one dimension (the display of detergent increased in width, the display of wool increased in length) or a change in three dimensions (the detergent box increased in length, width and height, the wool increased in diameter). As shown in Figure 2, the sensitivity (and accuracy) of size estimations was significantly lower for three-dimensional size increases (b = .68) than for one-dimensional size increases (b = .93).

---Insert Figure 2 about here---
The dimensionality bias also shapes consumers’ price expectations, product choices and usage behavior. Consumers expect greater quantity discounts (by up to 57%) for packages supersized along three dimensions, exhibit a weaker preference for supersized meals and products (by up to 32%) when the supersizing occurs along three dimensions, and are more likely to over-pour liquids (by up to 19%) into a conical container (which increases in height and diameter) than a cylindrical one (which only increases in height).

The dimensionality bias does not occur because people have more difficulty tracking changes in multiple dimensions than in one; it arises because people have difficulty compounding the changes along all three dimensions. In fact, other studies have found that size perceptions behave as if people use an additive rather than a multiplicative rule to combine the changes along individual dimensions into a single estimate of volume change (Ordabayeva & Chandon, 2013). According to the additive change heuristic, a package which doubles in size through a proportionate (26%) increase in all dimensions is perceived to have grown by just 78% (because 26%+26%+26%=78%).

One of the implications of this linear (additive) heuristic is that the dimensionality bias can be reduced by linearizing the change in volume from multiple spatial dimensions to one. Accordingly, if the goal is to boost consumers’ preference and willingness-to-pay for supersized packages and meals, while simultaneously reducing overconsumption, then packages and meals that increase in only one dimension should be preferred and endorsed. If, however, the goal is to boost consumers’ acceptance of downsized packages and portions, then a three-dimensional change in volume should be preferred because it is less likely to be detected than a one-dimensional change. For example, in one study, the acceptance of a downsized soda pack
increased by up to 21% when the pack shrank in height and diameter as opposed to just height (Chandon & Ordabayeva, 2009).

Moreover, the use of the additive change heuristic implies that product downsizing can go completely unnoticed if the product is downsized through elongation. Prior research found that elongated packages appear to be larger than short, wide packages of the same volume (Raghubir & Krishna, 1999; Wansink & van Ittersum, 2003). A more recent study found that the additive change heuristic can explain the elongation effect by suggesting that people fail to compound the reduction in the two dimensions of the base of the product (Ordabayeva & Chandon, 2013). Furthermore, the additive change model can actually recommend specific changes in the individual package or portion dimensions that can potentially completely hide product downsizing. Ordabayeva and Chandon (2013) verified these model predictions in one study, in which they asked participants to estimate the sizes of objects that decreased by 8%, 16% and 24% in size from the reference through a reduction in height only (1D downsizing) or through elongated downsizing (achieved by elongating the object’s height and shrinking its base, or by elongating its length and shrinking its height and width) which the additive change model predicted would not be perceived. When people relied only on visual estimation of product size, they underestimated the magnitude of the downsizing that occurred in 1D (a 24% reduction in actual size was perceived as a 20% reduction), and hardly noticed the downsizing that occurred through elongation (a 24% actual size reduction was perceived as only a 2% reduction). Allowing people to feel the weight of the product (visual and haptic estimation) helped to eliminate the errors in estimating elongated downsizing, but only partly (a 24% actual size reduction was perceived as a 9% reduction). Elongated downsizing is so potent that, in a different study, buyers of a known food brand were significantly more likely to accept product
downsizing when the package was downsized through elongation (using less dramatic changes in shape so as to respect design and shelving constraints) (Ordabayeva & Chandon, 2013).

Other studies found that transparent packaging improved volume estimation by facilitating the individual’s ability to monitor product quantity inside the package as the product was being consumed (Deng & Srinivasan, 2013). However, this positive effect of transparent packages on consumers’ ability to monitor product (and consumption) volume may be trumped by the detrimental effect of transparent packages on self-control due to the greater salience of tempting foods inside the packaging. Consumers’ desire to regulate food intake and a product’s inherent ability to facilitate (or jeopardize) this goal may thus interfere with perceptions of package and portion size. We consider these interactions in a later section on affective biases in package and portion size perceptions.

**Labeling biases and their remedies**

The third bias that drives consumers’ package and portion size perceptions arises from food size labels and front-of-pack labels. While various food labels have been linked to perceptions of taste (e.g., Levin & Gaeth, 1988; Raghunathan, Naylor, & Hoyer, 2006; Wansink & Park, 2002), the focus here is on size labels that have been shown to drive perceptions of package and portion size beyond simple considerations of taste.

First, labeling the sizes of food packages or portions as “small,” “medium,” or “large” significantly affects size perceptions. In a series of studies, Aydinoğlu and Krishna (2011) found that consumers perceived the portions of snack foods (pretzels, nuts, small sandwiches and cookies) to be smaller when they were labeled “small” rather than “medium,” or “medium”
rather than “large.” This, again, encourages consumers to eat more while thinking that they are eating less, an important issue because the use of size labels is not standardized and varies significantly across stores and restaurants (Young & Nestle, 1998). For example, the “medium” size of popcorn sold at AMC theatres contains fewer calories (680 Kcal) than the “small” portion of popcorn available at Regal Cinemas (800 Kcal). Similarly, a medium serving of French fries available at McDonald’s contains virtually the same amount of fries (117 g) as a small serving available at Burger King (116 g).

Health and nutrition-related labels also significantly bias calorie perceptions, which are typically construed as a measure of meal size. For example, labeling a food “low-fat” creates an inference that the food contains fewer calories (Wansink & Chandon, 2006b), hence consumers eat more of it because they think a larger serving size is appropriate and feel less guilty during consumption. The effect of “low-fat” labeling is particularly pronounced for hedonic foods that induce guilt during consumption, and among overweight individuals who are more susceptible to guilt-reduction cues. Providing information about the actual number of servings contained in a portion can curb the effect of “low-fat” labeling on food intake, but only among normal-weight individuals for whom the serving-size effect of “low-fat” labels is dominant, and not among overweight individuals for whom the guilt-reduction effect of “low-fat” labels is dominant.

Highlighting the presence of healthy ingredients in a meal also biases consumers’ perceptions of the calories it contains. When Chernev and Gal (2010) asked participants to estimate the calorie content of a hamburger with or without a side of broccoli, they found that consumers mentally averaged (instead of adding) the calorie content of a hamburger and broccoli to compute the size of the combined meal. This resulted in lower (rather than higher) calorie estimations for the hamburger with broccoli (665 Kcal) than for the one without (761 Kcal). The
averaging bias is particularly pronounced when attention is drawn to the healthiness of meal ingredients, for example, by asking consumers to compare the healthiness of the individual components of a combined meal prior to eliciting their estimations of meal size. The averaging bias is mitigated when attention is diverted away from the healthiness of individual ingredients to the size of the ingredients, for example, by asking participants to compare the size of individual meal components prior to eliciting their estimations of meal size.

Similar to highlighting the healthiness of meal ingredients, communicating the healthy positioning of the food or restaurant brand significantly biases calorie perceptions. A series of studies on perceptions of meals served at McDonald’s (which is perceived as relatively unhealthy) and Subway (which advertises its healthy positioning) found that consumers, on average, thought that meals contained fewer calories when served at Subway than at McDonald’s (Chandon & Wansink, 2007b). Consumers were also less sensitive to changes in actual portion sizes served at Subway than at McDonald’s, as shown in Figure 3. For example, a 1000 Kcal meal would, on average, be perceived to contain 744 Kcal at McDonald’s and only 585 Kcal at Subway. A follow-up study showed that this “health halo” created by healthy positioning led diners to eat more at Subway than at McDonald’s (1011 Kcal vs. 648 Kcal, respectively), while thinking that they ate less (487 Kcal vs. 600 Kcal, respectively). As shown in Figure 4, an effective strategy to reduce this labeling bias is to encourage consumers to consider a counterfactual (“consider-the-opposite” condition); specifically, how the healthy positioning of a restaurant may not generalize to the healthiness of all the food items consumed at the restaurant (Chandon & Wansink, 2007b). Figures 3 and 4 summarize these results.

---Insert Figures 3 and 4 about here---
Finally, the design of the food label itself can influence consumers’ perceptions of package size. Deng and Khan (2009) reported that a cookie package was perceived to be heavier when the image of cookies was located on the right (vs. left), on the bottom (vs. top), or on the bottom-right (vs. top-left) of the package facing. This image location bias could be reduced if the package was placed next to packs with a similar product location displayed on the store shelf (such that a package with a product displayed in the “heavy” or “light” location would be assimilated to the surrounding packs that displayed products in the same “heavy” or “light” location, respectively). These findings suggest that pictorial information provided on food labels should be considered in addition to the verbal information when predicting the effects of labels on package and portion size perceptions. Specifically, consumers may eat more out of packages that display the product in “light” (vs. “heavy”) locations because they underestimate how much product the package actually contains. This means that strategically managing the location of the product display on the package facing and the location of the product in the supermarket aisle in ways that reduce the underestimation of package content may curb overconsumption.

Affective biases and their remedies

A final form of bias in package and portion size perceptions arises from consumers’ affective reactions to food. Early studies in social psychology found that a desire for an object could distort perceptions of object size. For example, cigarettes appeared to be larger to smokers than to non-smokers (Brendl, Markman, & Messner, 2003); water appeared to be closer to thirsty than to non-thirsty individuals (Balcetis & Dunning, 2010); a muffin appeared to be larger to dieters than to non-dieters (van Koningsbruggen, Stroebe, & Aarts, 2011).
Recent studies have shown that this misperception of food size arises not just from the greater desire that individuals experience towards hedonic foods, but from the broader conflict that they experience between their desire for hedonic foods and the perceived health risk of these foods (Cornil, Ordabayeva, Kaiser, Weber, & Chandon, 2014). Emotional conflict or ambivalence towards food actually improves (rather than reduces) consumers’ sensitivity to increases in package and portion size and thus improves estimation accuracy. This is probably because conflict draws greater attention to portions of hedonic foods and increases motivation to accurately estimate these portions.

Cornil and colleagues (2014) found that individuals who inherently felt conflicted towards hedonic foods – for example, people who regulated their food intake or those who struggled with self-control (Papies, Stroebe, & Aarts, 2008; Scott, Nowlis, Mandel, & Morales, 2008) – had more accurate perceptions of portion sizes of hedonic foods. When the researchers asked a group of restrained eaters (who typically experience a strong desire for hedonic foods) and unrestrained eaters at an urban gym to estimate six portions of potato chips, they found that restrained eaters’ estimations of “regular” chips were more accurate than their estimations of “low-fat” chips and than estimations of “regular” and “low-fat” chips made by unrestrained eaters (see Figure 5).

---Insert Figure 5 about here---

More importantly, Cornil and colleagues (2014) found that the accuracy of consumers’ portion size perceptions could be improved with manipulations that induced emotional conflict towards food, i.e. interventions that simultaneously boosted the desire for food and perceptions of the food’s unhealthiness. In one study this was achieved by asking participants to sample a small amount of potato chips (which induced a desire for chips, Wadhwa, Shiv, & Nowlis, 2008) and by labeling the chips as “regular” (which induced perceptions of the chips’ unhealthiness).
While these findings have made significant strides toward uncovering the potential role of affect in portion size perceptions, work in this area is still underway. Clearly, it is important for future studies to further investigate the role of specific emotions and motivations in size perception biases. We elaborate on this point in the General Discussion.

GENERAL DISCUSSION

This article has reviewed four prominent factors that bias consumers’ perceptions of package and portion size. We have also outlined the strategies that can effectively mitigate these biases and improve the accuracy of consumers’ package and portion size perceptions. Table 1 summarizes the key results.

---Insert Table 1 about here---

While the studies reviewed in the article cover significant ground in describing and explaining biases in package and portion size perceptions, a number of important issues remain unexplored. First, much of the research covered here has studied the effects of cognitive and affective factors on size perceptions separately, while it is possible that these factors interact. In the same way that affect influences individuals’ cognitive strategies and information processing in domains such as health risk perception and product evaluation (Keller, Lipkus, & Rimer, 2002; Pham, 2007), affective responses to food may influence the cognitive strategies (e.g., the size computation heuristics) employed to estimate package and portion size. Future research should explore these possibilities in order to devise better strategies to improve size perceptions.

Future research should also examine the effectiveness of novel strategies to reduce size estimation biases. Whereas prior work has shown that small portions are associated with both
higher estimation accuracy and greater consumption pleasure and flavor perceptions (Cornil & Chandon, 2015a, 2015b; Morewedge, Huh, & Vosgerau, 2010), it would be interesting to test whether focusing on the hedonic pleasure or the rich flavor of a meal improves consumers’ perceptual sensitivity to changes in food size. It could also be useful to identify tactics that enhance the predicted and actual pleasure derived from food consumption. One possibility may be to encourage the use of consumption rituals (e.g., simple gestures such deep breathing or closing eyes, Vohs, Wang, Gino, & Norton, 2013), which have been shown to enhance the enjoyment of hedonic foods such as chocolate as well as utilitarian foods such as carrots.

Similarly, it would be valuable to test the effectiveness of additional debiasing strategies that can be easily implemented in the marketplace. One such tactic may be drawing attention to foods’ unit price in the retail environment. While the display of unit price is not uniformly mandated, many retailers provide unit price information in their stores voluntarily. Prior studies have suggested that perceptions of package size and unit price are linked (Nason & Della Bitta, 1983; Wansink, 1996), suggesting that available unit price information may be used to infer package size. However, some consumers pay little attention to unit price information (Vanhuele & Drèze, 2002), and even when they do, they often misunderstand price and quantity information. For example, Mohan, Chandon, and Riis (2015) reported that most people, even highly educated ones, believed that 50% more product for free is as valuable as a 50% price reduction, whereas, in fact, 50% extra product volume reduces the unit price by only 33%. Although providing unit price information could reduce such errors, a significant proportion of consumers fail to recognize that a given percentage cost discount is more valuable than a quantity bonus of the same nominal magnitude. Therefore, finding ways to make unit price
information more prominent and influential in the size estimation process would help consumers make healthier in-store decisions.

More generally, price and cost-related issues have received limited attention in the size perception literature. While biased size estimates influence consumers’ price expectations (Chandon & Ordabayeva, 2009), less is known about how price informs the size estimation process. In the meantime, changes in package and portion size are typically accompanied by changes in price (Mohan, Chandon, & Riis, 2015). It is important to understand how consumers combine and trade off package size information with price information to make food decisions.

Much of the research to date has focused on the effects of product-related factors on package and portion size perceptions, leaving the effects of non-food-related, environmental factors largely untapped. Yet environmental cues play a significant role in how consumers perceive and consume foods (Chandon & Wansink, 2012), and meal size perception is no exception. One study revealed that perceptions of meal size served on a plate were subject to the Delboeuf illusion: the same portion looks smaller on a large plate than on a smaller plate (Van Ittersum & Wansink, 2012). Other studies have shown that various sensory modalities (for example, sound pitch, food color) influence a host of food perceptions (Spence & Piqueras-Fiszman, 2014), and may therefore influence size perception as well.

Similarly, a more refined understanding of the influence of the sensory characteristics of the food itself on package and portion size perceptions is needed. For example, a recent study reported that a food’s texture influenced perceptions of its calorie content: foods with soft textures were perceived to be more caloric than foods with hard textures (Biswas, Szocs, Krishna, & Lehmann, 2014). It would be interesting to study how the experience of the food through other senses (e.g., smell, taste) influences visual estimations of food size. In this context,
examining the effect on size perceptions and consumption of novel food processing techniques such as the infusion of air into food (e.g., ice-cream) through a slow-churning process will be practically relevant.

Finally, the current understanding of how visual biases influence behaviors other than size estimation including food choice, portion size choice, ingestion, satiation and product usage remains relatively limited. Future research should more comprehensively delineate the behavioral outcomes of visual biases across lab and real-world settings.

In addressing these various questions, future studies will need to go beyond the traditional methods to test the practical relevance and implications of size perception biases and solutions in a natural consumption setting. This will entail expanding beyond the laboratory to environments in which food consumption actually takes place, from undergraduate student samples to more representative and larger populations, including vulnerable groups (e.g., children, individuals who are actively trying to lose weight or those who are trying to manage weight-related health issues), from estimations of food that is about to be consumed or has just been consumed to perceptions of food that is prepared (cooked) for oneself and others, food that is stored or stockpiled, and food that is wasted. Understanding how one-shot judgments of food quantity and quality (which have been the subject of most of the existing studies) translate to repeat behaviors and habits, and how interventions that improve food perceptions suggested in the literature endure over time are another avenue to be explored. Such approaches would enable a long-term perspective to emerge about the roots and remedies of size perception biases and thus allow us to address crucial questions about the effectiveness and sustainability of current food packaging and portion strategies for consumer health and wellbeing.


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<td>- Piecemeal estimation of individual meal components prior to estimation of total meal size reduces the underestimation bias.</td>
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<td>- Changing packages or portions along three dimensions, especially in opposite directions, increases acceptance of product downsizing.</td>
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<td>- Facilitating visual package or portion evaluation with non-visual information (e.g., weighing products by hand) reduces the dimensionality bias.</td>
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<td>- Directing attention to the size, rather than the healthiness, of individual components of a combined (healthy and unhealthy) meal, improves the accuracy of size estimations for combined meals.</td>
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<td>- Encouraging consumers to consider counterfactuals (why a meal is not unique to a particular restaurant or retailer) improves the accuracy of size estimations for meals served at restaurants and retailers with healthy positioning.</td>
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- Positioning a package that depicts the product in the “heavy” location on the label (bottom, right, bottom-right) next to packs that depict products in the similar “heavy” locations (and vice versa) within the store shelf display attenuates the bias created by the product’s image location on the label.

| Affective   | Size estimations are more sensitive to changes in package and portion size when consumers experience an emotional conflict towards food (i.e. when the desire to eat delicious food conflicts with perceptions that the food is unhealthy). | - Individuals who inherently feel more conflicted towards food (restrained eaters evaluating hedonic food) report more accurate estimations of package and portion size increases than individuals who do not feel conflicted towards food (unrestrained eaters evaluating hedonic food, restrained or unrestrained eaters evaluating utilitarian food). - Inducing conflict towards food (by simultaneously encouraging consumers to sample the food and highlighting that the food is unhealthy) improves the sensitivity of size estimations. | Balcetis & Dunning (2010) Cornil, Ordabayeva, Kaiser, Weber, & Chandon (2014) van Koningsbruggen, Stroebe & Aarts (2011) |
FIGURE 1
THE UNDERESTIMATION BIAS IS REDUCED WITH PIECEMEAL ESTIMATION
(OBSERVED GEOMETRIC MEANS, 95% CONFIDENCE INTERVALS, AND MODEL
PREDICTIONS)

Note: Actual and estimated calories of small and large fast-food meals (determined via median split for regular-weight or overweight consumers). Increasing meal size, not body size (designated by BMI, body-mass index), leads to the underestimation of meal size, but separate estimation of the sandwich, side, and beverage contained in the meal eliminates the bias. Adapted from Figure 3 in Chandon, P., & Wansink B. (2007). Is obesity caused by calorie underestimation? A psychophysical model of meal size estimation. *Journal of Marketing Research*, 44 (1), 84-99.
Note: The underestimation of increasing sizes is stronger when objects increase in all three dimensions than when they increase in only one dimension. Adapted from Figure 2 in Chandon, P., & Ordabayeva, N. (2009). Supersize in one dimension, downsize in three dimensions: Effects of spatial dimensionality on size perceptions and preferences. *Journal of Marketing Research*, 46 (6), 725–738.
FIGURE 3

THE LABELING BIAS: HEALTH HALOS IN THE ESTIMATION OF THE SIZE OF FAST-FOOD MEALS (OBSERVED GEOMETRIC MEANS, 95% CONFIDENCE INTERVALS, AND MODEL PREDICTIONS)

Note: Actual and estimated calories of the four quartiles of meals from restaurants perceived to be healthy (Subway) and those perceived to be unhealthy (McDonald’s). Meals from Subway are perceived to contain fewer calories than same-size meals from McDonald’s. Adapted from Figure 3 in Chandon, P., & Wansink B. (2007). The biasing health halos of fast food restaurant health claims: Lower calorie estimates and higher side-dish consumption intentions. *Journal of Consumer Research*, 34 (October), 301–14.
FIGURE 4

THE LABELING BIAS IS ELIMINATED WITH COUNTERFACTUAL THINKING

Note: The perceived calorie content of the same meal is estimated to be lower when it is served in a healthy fictional restaurant, but the effect disappears after counterfactual prompting. Adapted from Figure 4 in Chandon, P., & Wansink B. (2007). The biasing health halos of fast food restaurant health claims: Lower calorie estimates and higher side-dish consumption intentions. *Journal of Consumer Research*, 34 (October), 301–14.
FIGURE 5

THE AFFECTIVE BIAS (GEOMETRIC MEANS AND MODEL PREDICTIONS)

Note: Ambivalence (the emotional conflict between the desire for food and the perceived unhealthiness of food) increases the sensitivity to increasing portion sizes. 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). Adapted from Figure 3 in Cornil, Y. Ordabayeva, N., Kaiser, U., Weber, B., & Chandon, P. (2014). The acuity of vice: Attitude ambivalence improves visual sensitivity to increasing Portion Sizes.” Journal of Consumer Psychology, 24 (2), 177-87.