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Research report

The portion size effect on food intake. An anchoring and adjustment process? ☆

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ABSTRACT

People consistently over-eat when served a large compared with a small (appropriate) portion of food. However, the mechanism underlying this so-called portion size effect is not well understood. We argue that the process of anchoring and adjustment naturally describes this effect, such that the size of a presented portion works as an anchor that strongly influences consumption. The classical anchoring and adjustment paradigm was applied to six hypothetical eating situations. Participants were asked to imagine being served either a small or a large portion of food (i.e., low and high anchor) and to indicate whether they would consume more or less than this amount. Then, they indicated how much they would eat. These estimates were compared with a no-anchor condition where participants did not imagine a specific portion size but only indicated how much they would eat. In addition, half of participants in the anchoring conditions received a discounting instruction stating that the portion size they had been asked to imagine was randomly selected and thus not informative for their consumption estimate. As expected, participants who imagined to be served larger portions estimated to consume significantly more food than participants in the no-anchor condition, and participants who imagined to be served smaller portions estimated to consume significantly less food than participants in the no-anchor condition. The discounting manipulation did not reduce this effect of the anchors. We suggest that the process of anchoring and adjustment may provide a useful framework to understand the portion size effect and we discuss implications of this perspective.

Introduction

Imagine consumers ordering a hamburger at McDonald's in 1955 and today. In 1955 they would receive a burger weighing around 1.6 ounces (45 g), whereas today, they would receive a burger that is five times bigger, weighing around 8 ounces (227 g) (Young & Nestle, 2007). How much food would they consume in each situation? When deciding how much to eat, a consumer would probably take the size of the burger as a starting point and think about whether to eat more or less than this portion. Then, they would eat a certain proportion of the food served – as a result eating much more today than in 1955. This phenomenon can be understood as an anchoring and adjustment process, where the portion size serves as an influential anchor to determine how much to eat, and where the subsequent adjustment process does not override the effects of this anchor. We suggest that this perspective can serve as a description for the portion size effect, a powerful force contributing to overeating in Western societies.

Portion sizes have changed significantly over the past decades, and have strongly changed our food environment. Increases in the size of food portions have been observed in supermarkets (Young & Nestle, 2003), restaurants (Schwartz & Byrd-Bredbenner, 2006), home recipes (Wansink & Payne, 2009), and fast food outlets and take-out establishments (Young & Nestle, 2002). The effect of these changes on our eating behavior is notable: doubling the portion size of a food or dish can lead to increases in food intake up to 18–25% for snacks and even up to 30–45% for lunch meals (Wansink, 2004). When offered larger food portions, individuals consume more food independently of individual characteristics (e.g., gender, body mass index), eating location and situation (e.g., restaurant, lunch) and food type and quality, without compensating for this excess intake in subsequent meals (Ello-Martin, Ledikwe, & Rolls, 2005; Fisher & Kral, 2008; Rolls, 2003; Rolls, Roe, & Meengs, 2007; Wansink, 2004; Wansink & Kim, 2005).

While this so-called portion size effect is known to contribute greatly to energy intake and may be linked to the obesity

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epidemic (Jeffery et al., 2007; Ledikwe, Ello-Martin, & Rolls, 2005), no research has provided conclusive evidence regarding *why* people over-consume when more food is served (Fisher & Kral, 2008; Kral, 2006; Wansink, 2004). Larger portions have been shown to increase bite size, bias calorie content estimations, enhance visual distortions and give more value to money by lowering the cost per unit of food, which enhances their perceived attractiveness to consumers (Fisher & Kral, 2008; Kral, 2006; Wansink, 1996, 2004). Although these findings may explain why larger portions are favored over smaller ones, they do not entirely explain why people consistently eat more from larger portions, such that people clearly over-consume even when the portion has been selected by someone else (e.g., restaurant cook, experimenter), when refill possibilities are free (such as in a typical laboratory experiment), when the small portion is already considered to be large (Marchiori, Corneille, & Klein, 2012), or when the large portion is so large that it clearly cannot be consumed by one person (e.g., 1000 g of macaroni and cheese; Rolls, Morris, & Roe, 2002). We suggest that the process of anchoring and adjustment, which has been widely studied in research on decision-making (for a review see Furnham & Boo, 2011), may account for these findings and may thus, at least partially, describe the process leading to the portion size effect.

The portion size effect from an anchoring and adjustment perspective

The anchoring and adjustment heuristic is a cognitive shortcut that people use when making decisions under uncertainty (Tversky & Kahneman, 1974). This process suggests that, when making a judgment in an uncertain situation, a person begins with a (implicitly) suggested or activated reference point (i.e., the anchor) and then makes adjustments to reach an intuitively correct estimate based on additional information (i.e., the adjustment process). Typically, this adjustment process is biased or incomplete, leading to outcomes that are biased toward the anchor (Strack & Mussweiler, 1997). This process of decision-making is typically not conscious to individuals, and is used especially when resources and motivation to reach the best possible answer are limited.

We argue that this process can potentially help to understand the portion size effect. Specifically, we propose that in eating situations, the portion size constitutes the reference point or anchor, which serves as the starting point for the decision process on how much to eat. Other information is then used to make adjustments away from this anchor, such as feelings of hunger, liking of the food or food variety. While a person may eat more when hungry or when the food is good, and less when there is little variation, these influences may mainly serve to make adjustments away from the initial portion size anchor, so that the amount eaten is still biased by the size of the portion served (cf. Rolls, Roe, Kral, Meengs, & Wall, 2004; Wansink & Kim, 2005).

We suggest that the influence of such anchors may be especially pronounced in the domain of eating behavior because evaluating food quantities involves considerable uncertainties, which increase the reliance on anchoring cues, like the quantity of food served. Clearly, individuals often feel when they should eat in order to maintain energy levels, and they may approximately know how much they should consume in general (de Castro, 1988). Indeed, people naturally eat more when they are hungry than when they are satiated (de Castro & Elmore, 1988), and use sensory-specific satiety cues to stop eating from the same food (Rolls, Rolls, Rowe, & Sweeney, 1981). Food intake (amount) is not primarily determined by sensory, biological or physiological cues, but also by past experience with food and eating, as shown in animals (Booth, 1972) and humans (Birch & Deysher, 1986). Familiarity with food has helped us to determine meal size in advance, especially when meal time is often shorter than the time needed for post-ingestive feedback to signal us when to stop eating (Le Magnen, 1956), also known as learned satiety (see Brunstrom, 2004).

At the same time, however, there is evidence that meal size is not very tightly controlled, and it has been described as 'elastic' (Hetherington, 2007). We may not know exactly how much food to consume, but rather have an approximate estimate of the appropriate amount when entering an eating situation (Herman & Polivy, 2005; Hermans, Herman, Larsen, & Engels, 2010). This amount is then greatly influenced and governed by 'non-regulatory' psychological, sociological and cultural factors (de Castro, 1996). Little help is however offered by diet recommendations, nutritional information and labels, and health policies and advertisements, which are often experienced as complex or even contradictory, and are difficult to use as clear guidelines for consumption in everyday settings (e.g., De Ridder, De Vet, Stok, Adriaanse, & De Wit, 2012). In these circumstances, anchors such as the portion size may become influential as they serve as relatively easy indicators of what might be an appropriate consumption amount (Herman & Polivy, 2005; Kral, 2006; Wansink, 2004).

In addition, eating is sometimes seen as a low-involvement (mundane) behavior and routine activity (Wansink, 2004), often accompanied by secondary activities, such as working, reading, listening to the radio or watching television (Bellisle & Dalix, 2001; Bellisle, Dalix, & Slama, 2004; Wansink, 2004). Research has even reported that individuals often stop eating simply when the TV show is over, when they have no time to continue eating or simply because no food remains (Tuomisto, Tuomisto, Hetherington, & Lappalainen, 1998; Wansink, Payne, & Chandon, 2007). Thus, in many cases, little conscious decision-making seems to be involved in determining what and how much to consume (Wansink & Sobal, 2007). Again, the portion size may then serve as a powerful anchor to influence consumption, because little effort is exerted to adjust one's judgment away from this highly visible anchor and make an accurate judgment of how much one should eat.

In sum, in a typical eating situation, we may not be very confident in determining exactly how much we should consume, and we may sometimes not spend much time and resources on this decision. As in other situations where we have to make decisions under uncertainty, available anchors, in this case the food portion size, then provide a helpful cue to guide how much we eat within a personal range of possible food intake amounts.

The current research

We tested the effects of portion size anchors on eating decisions and thus examined the applicability of the anchoring and adjustment interpretation to the portion size effect. Our experiment was closely modeled on the original research paradigm for testing the anchoring and adjustment heuristic. In the classic study using this paradigm, participants were asked to estimate the percentage of African nations in the UN (Tversky & Kahneman, 1974). In order to do so, they first had to evaluate whether this percentage was above or beneath an arbitrary number (i.e., the anchor), which was determined by spinning a rigged wheel that always produced 25% or 65%, the low and high anchor conditions. After this comparative judgment task, participants gave their best estimate of the actual percentage of African nations in the UN. Typically, results show that this absolute estimate is assimilated toward the anchor, such that the mean estimate of those receiving the low anchor was 25% compared with 45% for those receiving the high anchor. The spinning wheel was used to inform participants about the randomness of the (anchor) value and that it should not be taken as relevant information, in order to control for conversational inferences (Schwarz, 1994), social desirability and numerical effects (see Mussweiler, 2001).

In the current experiment, we transferred this set-up to the domain of eating behavior and examined whether participants estimated that they would eat more or less than a given portion size. This portion was either large or small and, according to our hypothesis, could serve as the anchors for their estimates. Then they estimated how much they would consume. These latter estimates were compared with a condition in which participants received no portion-size anchor. While this set-up admittedly constitutes a hypothetical, rather than an actual eating situation, it allowed us to test the effects of the portion size cues directly by comparing them with the no-anchor condition. In an actual eating situation, such a no-anchor condition is difficult or even impossible to create, since we suggest that the amount of food served automatically constitutes an anchor for eating behavior. In addition, this set-up allowed us to test the reliability of the anchoring effect by including six different foods and eating situations per participant. This set-up is similar to applications of the anchoring and adjustment perspective to other domains, such as research showing that anchors strongly influence sentencing decision of even experienced judges (Englich & Mussweiler, 2001; Englich, Mussweiler, & Strack, 2006), or that random numbers can affect consumers' judgments of willingness-to-pay for various products (Simonson & Drolet, 2004).

We asked participants to imagine being in a typical lunch or snacking situation, and to imagine being served either a small (low anchor condition) or a large quantity of food (high anchor condition). In the control condition, only the type of food was mentioned without a portion size. Then, participants in the anchor conditions indicated whether they would consume more or less than the amount specified by the portion. After this, all participants estimated how much food they would consume. We hypothesized that participants' estimates would be biased toward the anchor, such that participants in the large portion size condition would estimate a higher food intake than participants in the small portion condition. Participants in the no-anchor condition should not be biased and provide estimates roughly equivalent to typical average intakes.

In addition, half of the participants in the anchor conditions received an additional instruction that was designed to discount the informativeness of the portion size anchor. Although earlier research has repeatedly shown that such instructions do not prevent participants' reliance on anchoring values and do not influence the anchoring effect (Mussweiler, 2001; Mussweiler, Englich, & Strack, 2004; Tversky & Kahneman, 1974), we included this manipulation in order to explore whether this phenomenon also holds for the domain of eating behavior and the anchors of portion sizes. If such discounting information could reduce the portion size effect, this would have significant implications for educational interventions. If it does not reduce the portion size effect, it would suggest that interventions need to go further than providing information to discount the informativeness of the portion size.

Method

Participants

One hundred and thirty-three students of the Free University of Brussels participated and received financial compensation (€8) for an experimental session including three unrelated experiments. The present research was placed second. Exclusion criteria were defined as in other studies examining the portion size effect: participants were excluded if they were obese ($BMI > 30\ kg/m^2$), were dieting, were controlling food intake in order to gain or lose weight, or were not hungry at all (i.e., reporting 1 on a 1–7 point scale). The Ethical Committee of the Free University of Brussels approved the study.

Study design

Participants were randomly assigned to one of six experimental conditions in a 3 (Anchor: low vs. high vs. none) × 2 (Discounting instruction: present vs. absent) between-subjects design.

Experimental manipulations

The size of the imagined portions was manipulated by providing low and high anchors for the foods. Foods and their anchor values are reported in Table 1. Low and high anchor values were determined by dividing by two or by multiplying by two the average amount of food consumed per person per eating occasion, respectively (based on a pilot study, n = 20, and national American and French data: U.S. Environmental Protection Agency (EPA), 2003 and Dubuisson et al., 2010, respectively). Soup, beefsteak and pasta were chosen as lunch foods, and potato chips, fruit juice and bite-size cheese cubes as afternoon snacks. In addition, the perceived informativeness of the anchors was manipulated with a discounting instruction, which was based on the instruction typically used in anchoring and adjustment studies (Mussweiler, 2001). Half of the participants (except those in the no-anchor condition) were told that in order to reduce the influence of the values included in the questions on their responses, these had been randomly selected. Thus, the anchors had no informative power with respect to actual quantities of the foods.

Procedure

Upon arrival, participants were greeted by the experimenter and seated in individual cubicles, after providing written informed consent. Consistent with the paradigm used in anchoring studies, the current study was introduced as a pre-test for the construction of a general-knowledge questionnaire aiming to find the best wording for the questions (Mussweiler, 2001). Participants were instructed to strictly follow the order of the questions in the paper–pencil questionnaire and to answer them as accurately as possible.

Participants were asked to imagine that they were taking a midday meal or a snack (depending on the food): "Imagine that you are having lunch in a restaurant. At your table, a waiter just brought you soup/beefsteak/pasta"; or "Imagine that you are having an afternoon snack. At home, you just served yourself potato chips/cheese cubes/fruit juice." Participants in the low and the high anchor condition then received the comparative question: "Will your consumption be lower or higher than [Anchor Value, see Table 1]?" Then, all the participants received the question probing their consumption estimate, which served as our dependent variable: "How much soup/beefsteak/pasta/potato chips/cheese cubes/fruit juice will you consume?" For the pasta and the beefsteak, participants were asked to imagine eating that food with their favorite sauce. In order to prevent food intake limitations and to render the eating situation as natural as possible, the following instruction was given to all

Table 1
Portion sizes (i.e., anchors) of six foods presented to participants. For each food, a participant was presented with either the low or the high anchor (i.e., a small or a large portion).

	Low portion anchor	High portion anchor
Little cheese cubes (in number)	3	12
Soup (in ml)	125	500
Beefsteak (in grams)	100	400
Pasta (in grams)	75	300
Fruit juice (in ml)	150	600
Potato chips (in grams)	50	200

participants: “Your consumption should not be limited to the content of your plate or by any additional financial cost.” Questions about absolute food intake were answered in grams (for pasta, beef steak and chips), numbers (for cheese cubes) and milliliters (for soup and fruit juice).

Before receiving these food-related questions, participants answered food-unrelated questions (e.g., about Belgium and its citizens) in the same procedure to familiarize them with the procedure. Then, they answered the questions concerning the six foods, as described above. The foods were presented in random order, and the presentation of the high and low anchors alternated across foods. To support the cover story, participants then completed a bogus questionnaire about the difficulty and the understanding of the questions, as well as their suitability for persons of different age groups.

Additional measures

Next, participants responded to several control measures on 7-point scales anchored (1) not at all and (7) a lot: Food liking (“Do you like consuming [specific food]?”), hunger (“How hungry are you right now?”), consumption monitoring (“Do you monitor the nutritional content of the food you consume?” and “Do you control your food intake in order to gain or lose weight?”), plate cleaning tendency (“How often to you eat until your plate, bowl or container is empty?”) and snacking frequency (“Do you usually snack between meals?”). Dieting behavior (“Are you currently on a diet to lose or gain weight?”) was assessed with a Yes/No question. Sociodemographic data included age, gender, weight, height, nationality and mother tongue. Finally, participants indicated whether they had already participated in a similar study and their conjecture about the purpose of the study, before being debriefed. None of the participants identified the real aim of the research, and they generally believed to be completing a household habits survey.

Data analysis

Analyses of variance were run to examine the effects of anchor and value informativeness on standardized scores of intake estimates for all six foods pooled together. All tests were performed with IBM SPSS for Windows (release 18.0.0, 2010).

Results

Estimates of six participants deviated from the question mean by more than five standard deviations and were excluded from the analysis (in line with McClelland, 2000). The final sample consisted of 128 students (73 male; M_{age} of 20.5 ± 2, range 16–28; M_{BMI} of 21.7 ± 2.5, range 17.26–29.41, 84% Belgian). Overall, participants reported liking the foods ($M = 5.5 \pm 1.4$). Analysis of variance, with anchor as a predictor, showed no significant differences between conditions regarding BMI, age, hunger, food liking, food intake monitoring, plate cleaning tendency and snacking behavior ($ps > .1$).

Effects of the discounting information

The discounting manipulation only had a marginally significant main effect, $F(1,82) = 2.89$, $p = .093$, $n^2_p = .03$, showing that participants who had received the discounting manipulation gave somewhat higher consumption estimates overall than participants who had not received this information. Importantly, however, there was no interaction effect with portion size, $F(1,82) = 1.25$, $p = .29$, $n^2_p = .02$, suggesting that the discounting manipulation did not modulate the effects of the portion size anchors. Thus, this variable was not further considered, and all subsequent analyses were collapsed over this factor.

Effects of portion size anchor on food intake estimates

An analysis of variance revealed a significant main effect of anchor on participants' food intake estimates, $F(2,125) = 43.99$, $p < .001$, $n^2_p = .41$. As hypothesized, participants given a high anchor reported that they would consume significantly more food than participants given no anchor, $F(1,83) = 24.46$, $p < .001$, $n^2_p = .23$. Conversely, participants who had been given a low anchor reported that they would consume significantly less food than participants given no anchor, $F(1,83) = 15.35$, $p < .001$, $n^2_p = .16$. These results are displayed in Fig. 1 for all six foods.

This ANOVA was then repeated for only low and high anchor conditions, leaving out the no-anchor control condition, given that portion size studies typically have no equivalent to our no-anchor condition. Again, as expected, this showed that the portion size anchor significantly influenced food intake estimates, with

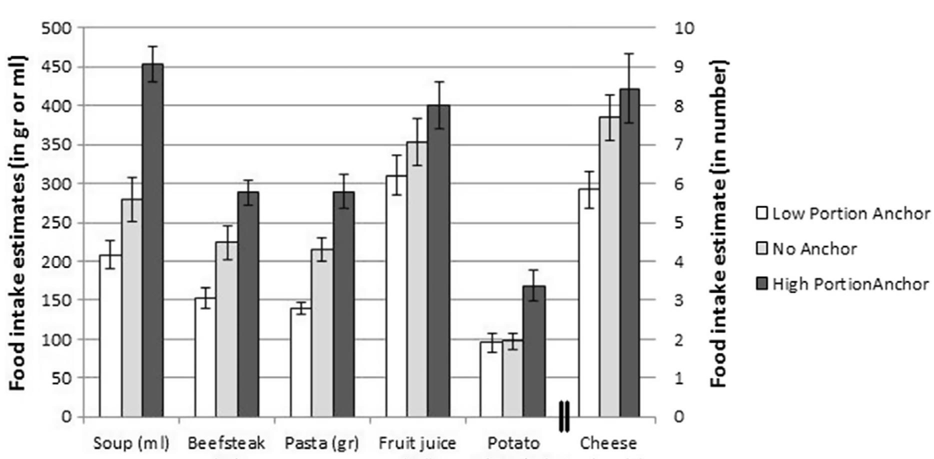

Fig. 1. Effects of portion size anchors on participants' food intake estimates for the six experimental foods. Error bars refer to the standard error of the means. Parentheses next to foods indicate the metric of the food intake estimate.

participants estimating to consume more when a larger compared with a smaller portion was imagined, $F(1,84) = 102.21$, $p < .001$, $\eta^2_p = .55$. Food intake estimates increased by 77% across foods when the high anchor was provided compared with the low anchor.

Effect of portion size anchor for different foods

We then examined whether the effect of the portion size anchors was dependent on the specific food that was presented to participants. A repeated measures analysis, with anchor as between-subjects factor and food type as within-subjects factor, revealed a significant interaction effect, $F(10,625) = 2.51$, $p < .01$, $\eta^2_p = .04$. When comparing the low-anchor with the high-anchor condition, simple effects with Bonferroni corrections showed that differences between low and high anchors were significant for all foods ($ps < .03$) except juice ($p = .14$), as shown in Fig. 1. Increases for each food from small to large portion ranged from 44% for cheese, 118% for soup, 89% for beefsteak, 107% for pasta, 29% for fruit juice and 76% for potato chips. When comparing low and high anchors with the no-anchor condition, results showed that when given high anchors, participants estimated that they would consume significantly more soup, beefsteak, pasta and chips than participants given no anchor ($ps < .05$); when given low anchors, participants estimated that they would consume significantly less beefsteak and pasta than participants given no anchor ($ps < .03$).

Effects of food and participant characteristics

The results did not change when controlling for food and participant characteristics (age, hunger, food liking, BMI and frequency of consumption monitoring, plate cleaning and snacking behavior). None of the participant and food characteristics had a significant impact ($ps > .1$).

Manipulation check

We examined the responses that the participants in the anchoring conditions gave to the initial comparative questions (“Would you eat more or less than. . .?”) to check the effect of the anchoring manipulation. If the manipulation was effective, participants shown a low anchor should have mainly reported consuming a higher amount than the presented portion, while when shown a high anchor, they should have mainly reported consuming a lower amount than the presented portion. Results confirmed this. On average across all foods, 81% of participants reported food intake estimates in the predicted direction (range: 67–94%).

Consumption estimates in the no-anchor condition

As can be seen in Table 2, the consumption estimates provided by participants in the no-anchor condition were similar to the amounts typically consumed for each of the selected foods. Thus, participants who did not receive a portion size anchor gave reasonable consumption estimates.

Table 2
Food intake estimates in the no-anchor condition and average estimates form three national surveys (USA, France and the Netherlands; U.S. Environmental Protection Agency (EPA), 2003; Dubuisson et al., 2010; Dutch National Food Consumption Survey 2007–2010, respectively) on average food consumption per capita.

	No-anchor condition	National surveys
Little cheese cubes (grams)	33.3 ± 17	40
Soup (ml)	275 ± 185	335
Beefsteak (grams)	220 ± 137	120
Pasta (grams)	216 ± 96	165
Fruit juice (ml)	353 ± 190	288
Potato chips (grams)	95 ± 68	70

Discussion

The present study applied an anchoring and adjustment framework to examine food intake estimates in different portion size conditions. In line with our hypotheses, participants who imagined being served larger portions of food indicated that they would consume significantly more than participants who imagined no specific amount. Vice versa, participants who imagined smaller portions estimated that they would consume significantly less than participants who imagined no specific amount. These portion size anchors impacted intake estimates even when participants were told that the information (i.e., the portion size anchors) presented to them was randomly chosen and not informative.

In line with the anchoring and adjustment perspective, we interpret these findings such that in order to determine their estimated food intake, participants took the amount of food served as a reference point on which to base their estimate. Possibly, when considering whether to eat more or less than the served portion, information confirming the appropriateness of the portion size was elicited, leading people to believe the amount of food to be appropriate to consume in a single eating occasion (see Strack & Mussweiler, 1997). Thus, even though they often reported not to eat the full portion, participants made only incomplete adjustments such that their final estimate was still close to the anchor. Consistent with this interpretation, research has shown that individuals fall prey to the portion size effect because they tend to interpret hefty portions as ‘normative’ or ‘appropriate’ intake (Herman & Polivy, 2005; Wansink, 2004, 2010; Wansink, Van Ittersum, & Painter, 2006).

In contrast, in the no-anchor condition, individuals were not able to anchor their estimate on a suggested reference point and no biased information was rendered available to affect food intake estimates. Without this external visual cue, individuals had to rely on other cues to determine food intake. As a result, when no reference portion was suggested and thus accessible to bias their estimates, participants estimated that they would consume intermediate amounts of food (i.e., significantly less than when given a high anchor and significantly more than when given a low anchor). This finding is consistent with a study in which participants were blindfolded while eating and could thus not rely on visual portion size cues, and which showed that the portion size effect was less strong for blindfolded participants than for participants not eating blindfolded (Barkeling, Linné, Melin, & Rooth, 2003; Linné, Barkeling, Rössner, & Rooth, 2002). Together, our findings are also consistent with the perspective that in addition to physiological signals, food intake may be heavily influenced by external factors and cognitive processes (e.g., Lowe & Butryn, 2007; Marchiori & Papies, 2014; Papies & Hamstra, 2010; Stroebe, van Koningsbruggen, Papies, & Aarts, 2013).

Limitations and future research

One potential limitation of the current study is that we measured participants’ reported food intake estimates rather than their actual food intake. Although the current study used a very similar design to other portion size studies, (i.e., an “available” amount of food is being manipulated while a food intake decision is assessed), a validation in an actual consumption setting will be an important next step. For this, however, it will be crucial to develop and include a design that allows for the inclusion of a no-anchor control condition even in a set-up that tests actual food consumption.

However, the current study also provided some evidence for participants’ expertise in imagining the amounts of food and in providing realistic food intake estimates. We used national consumption data and a pilot study to determine the low and the high anchors, respectively below and above typical average food intakes. Consistent with this, when shown an anchor below recommended intake, participants in the current study indeed estimated a higher food intake amount, while when they were shown an anchor above recommended intake, they estimated that they would eat a lower amount of food. This suggests that they had some sense of what would be a reasonable portion to consume. Moreover, participants deviated less from the low anchor than from the high anchor in their estimated food intakes, which is consistent with the fact that the higher anchors were further away from typical consumption amounts than the lower anchors. Importantly, in the control condition, the amounts of food reported by participants as their estimated food intake were strikingly similar to the amounts of food that can be observed in national data reports about average food intakes. Together, these findings suggest that the expected intake reported by participants is at least somewhat comparable with actual consumption situations.

In addition, research has shown that actual food consumption amount tends to be close to participants' predicted consumption. Research on food intake reports in hypothetical situations, for example when using food pictures (Wilkinson et al., 2012), shows that how much people say they would eat in response to food pictures corresponds closely to what they actually eat of the same foods in the same experiment. Similar results have been found with fake foods (Bucher, van der Horst, & Siegrist, 2012), or when reporting food intake from memory (Godwin, Chambers, & Cleveland, 2004). A recent study found that when participants are asked to report visually on mounds the amount of M&M's they would consume during a forthcoming snacking occasion (i.e., a 22 min TV show), their expected food intake amount correlated highly with their actual snack intake (Marchiori, Klein, Bernard, & Bratanova, 2014). Similarly, ad libitum energy intake has been found to be significantly predicted by prospective consumption estimates in people with diabetes (Dubé, Tremblay, Lavoie, & Weisnagel, 2013). These findings suggest that even though it is hypothetical, asking participants how much they would eat in a specific situation most likely bears some relation with what they would actually eat.

Another potential limitation of the current study is that the food amounts presented as low anchors were below dietary recommendations, while most studies on the portion size effect tend to serve small portions that are still above dietary recommendations (although for exceptions see Hermans, Larsen, Herman, & Engels, 2012; Spill, Birch, Roe, & Rolls, 2011). Future research should investigate whether our interpretation of the portion size effect also holds when both anchors are above dietary recommendations.

Further studies should also address the question whether the presentation of a larger anchor changes people's norms of how much would be appropriate to eat in a given situation, and also whether this changes any potential initial and possibly more appropriate consumption beliefs. Thus, within an anchoring and adjustment framework, norms that reflect an appropriate consumption amount might still be the mediating mechanism that contributes to larger portions eliciting more consumption than smaller portions (Wansink, 2004).

In the current study, the manipulation of the informativeness of the portion sizes (i.e., instructing participants to disregard the values and to consider them as random) did not prevent reliance on the portion size anchors. This is consistent with findings in other domains where clearly irrelevant anchors were still very effective and where information that clearly reduced the informativeness of the anchors did not affect their effectiveness (e.g., Critcher & Gilovich, 2008; Mussweiler et al., 2004; Tversky & Kahneman, 1974). Our finding is also consistent with the pervasiveness and robustness of anchoring effects more generally. For example, research on the anchoring and adjustment effect has shown that even experts fall prey to the influence of anchors in a variety of domains (e.g., Englich et al., 2006). Similarly, nutrition experts (e.g., dieticians, nurses, nutrition science professors) are unable to prevent the influence of portion size anchors (Wansink, 2006; Wansink et al., 2006).

Anchoring effects have also been demonstrated with implausible anchors, like 900 °C as a temperature anchor for the Antarctic (Mussweiler & Strack, 2001). Similarly, although participants sometimes notice that the amount of food that is served to them is different and larger than their usual portion, they still do not adapt their food intake accordingly (Kral, Roe, & Rolls, 2004; Rolls et al., 2004). Indeed, portion size effects have been shown with implausible anchors, like 1000 g of macaroni and cheese (Rolls et al., 2002). Anchoring and other biases like the availability or representativeness heuristic have been observed even in children from 2nd grade onwards (Davidson, 1995; Davies & White, 2011; Smith, 1999), similar to portion size effects that have been shown in children as young as 2 years of age (Fisher & Kral, 2008).

Possible implications

Despite the limitations discussed above, we suggest that insight into anchoring and adjustment processes might still be useful for developing strategies to prevent the portion size effect, and future research might address this possibility. Changing the anchor that a given portion activates might be an effective strategy as some studies have already shown, even though this was typically not the goal of the study. For example, modifying the appearance of the portion, such as by cutting foods in half or by adding air to increase its volume, has been shown to decrease intake (e.g., Osterholt, Roe, & Rolls, 2007; Marchiori, Waroquier, & Klein, 2011, 2012). Similarly, providing new anchors, such as structured meals, plate models or portion size measurement aids, has also been demonstrated to lower energy intake (Anderson, Freeman, Stead, Wrieden, & Barton, 2008; Byrd-Bredbenner & Schwartz, 2004; Noakes, Foster, Keogh, & Clifton, 2004; Wing et al., 1996). Thus, while these studies did not explicitly manipulate anchors for consumption, their findings could be interpreted from an anchoring and adjustment perspective. Once the anchoring and adjustment perspective proves valid also in actual consumption studies, other intervention strategies (e.g., Mussweiler, Strack, & Pfeiffer, 2000) might be derived from this framework in similar ways.

Conclusion

Despite the important limitations outlined here, we suggest that the interpretation of the portion size effect as an anchoring and adjustment process may present a novel and potentially useful view on this phenomenon: the served portion size of food is used as a reference point to estimate food intake, which is subsequently adjusted incompletely based on individual, food-related and situation-related characteristics. As a next step, future research will have to validate the present findings in an actual consumption setting and determine the boundary conditions of this interpretation. The anchoring and adjustment perspective may open up new avenues for research, by interpreting known effects in this novel framework and by providing a theoretical framework to design new strategies to limit the portion size effect.

References

Anderson, A. S., Freeman, J., Stead, M., Wrieden, W. L., & Barton, K. L. (2008). Consumer views on portion size guidance to assist adult dietary choices. *Journal of Human Nutrition and Dietetics*, *21*, 373–406.

Barkeling, B., Linné, Y., Melin, E., & Rooth, P. (2003). Vision and eating behavior in obese subjects. *Obesity*, *11*, 130–134.

Bellisle, F., & Dalix, A. M. (2001). Cognitive restraint can be offset by distraction, leading to increased meal intake in women. *The American Journal of Clinical Nutrition*, *74*, 197–200.
Bellisle, F., Dalix, A. M., & Slama, G. (2004). Non food-related environmental stimuli induce increased meal intake in healthy women. Comparison of television viewing versus listening to a recorded story in laboratory settings. *Appetite*, *43*, 175–180.
Birch, L. L., & Deysher, M. (1986). Caloric compensation and sensory specific satiety. Evidence for self-regulation of food intake by young children. *Learning and Motivation*, *16*, 341–355.
Booth, D. A. (1972). Conditioned satiety in the rat. *Journal of Comparative and Physiological Psychology*, *78*, 412–432.
Brunstrom, J. M. (2004). Does dietary learning occur outside awareness? *Consciousness and Cognition*, *13*, 453–470.
Bucher, T., van der Horst, K., & Siegrist, M. (2012). The fake food buffet. A new method in nutrition behavior research. *The British Journal of Nutrition*, *107*, 1553–1560.
Byrd-Bredbenner, C., & Schwartz, J. (2004). The effect of practical portion size measurement aids on the accuracy of portion size estimates made by young adults. *Journal of Human Nutrition and Dietetics*, *17*, 351–357.
Critcher, C. R., & Gilovich, T. (2008). Incidental environmental anchors. *Journal of Behavioral Decision Making*, *21*, 241–251.
de Castro, J. M. (1988). Physiological, environmental, and subjective determinants of food intake in humans. A meal pattern analysis. *Physiology & Behavior*, *44*, 651–659.
de Castro, J. M. (1996). How can eating behavior be regulated in the complex environments of free-living humans? *Neuroscience and Biobehavioral Reviews*, *20*, 119–131.
de Castro, J. M., & Elmore, D. K. (1988). Subjective hunger relationships with meal patterns in the spontaneous feeding behavior of humans. Evidence for a causal connection. *Physiology & Behavior*, *43*, 159–165.
Davidson, D. (1995). The representativeness heuristic and the conjunction fallacy effect in children's decision making. *Merrill-Palmer Quarterly*, *41*, 328–346.
Davies, M., & White, P. A. (2011). Use of availability heuristic by children. *British Journal of Developmental Psychology*, *12*, 503–505.
De Ridder, D., De Vet, E., Stok, M., Adriaanse, M., & De Wit, J. D. (2012). Obesity, overconsumption and self-regulation failure. The unsung role of eating appropriateness standards. *Health Psychology Review*, *7*, 1–20.
Dubé, M. C., Tremblay, A., Lavoie, C., & Weisnagel, S. J. (2013). Effect of exercise on food consumption and appetite sensations in subjects with diabetes. *Appetite*, *71*, 403–410.
Dubuisson, C., Lioret, S., Touvier, M., Dufour, A., Calamassi-Tran, G., Volatier, J.-L., et al. (2010). Trends in food and nutritional intakes of French adults from 1999 to 2007. Results from the INCA surveys. *The British Journal of Nutrition*, *103*, 1035–1048.
Ello-Martin, J. A., Ledikwe, J. H., & Rolls, B. J. (2005). The influence of food portion size and energy density on energy intake. Implications for weight management. *The American Journal of Clinical Nutrition*, *82*, 236–241.
Englich, B., & Mussweiler, T. (2001). Sentencing under uncertainty. Anchoring effects in the courtroom. *Journal of Applied Social Psychology*, *31*, 1535–1551.
Englich, B., Mussweiler, T., & Strack, F. (2006). Playing dice with criminal sentences. The influence of irrelevant anchors on experts' judicial decision making. *Personality and Social Psychology Bulletin*, *32*, 188–200.
Fisher, J. O., & Kral, T. V. E. (2008). Super-size me. Portion size effects on young children's eating. *Physiology & Behavior*, *94*, 39–47.
Furnham, A., & Boo, H. C. (2011). A literature review of the anchoring effect. *The Journal of Socio-Economics*, *40*, 35–42.
Godwin, S. L., Chambers, E., & Cleveland, L. (2004). Accuracy of reporting dietary intake using various portion-size aids in-person and via telephone. *Journal of the American Dietetic Association*, *104*, 585–594.
Herman, C. P., & Polivy, J. (2005). Normative influences on food intake. *Physiology & Behavior*, *86*, 762–772.
Hermans, R. C. J., Herman, C. P., Larsen, J. K., & Engels, R. C. M. E. (2010). Social modeling effects on young women's breakfast intake. *Journal of the American Dietetic Association*, *110*, 1901–1905.
Hermans, R. C. J., Larsen, J. K., Herman, C. P., & Engels, R. C. M. E. (2012). How much should I eat? Situational norms affect young women's food intake. *The British Journal of Nutrition*, *107*, 588–594.
Hetherington, M. M. (2007). Cues to overeat. Psychological factors influencing overconsumption. *The Proceedings of the Nutrition Society*, *66*, 113–123.
Jeffery, R. W., Rydell, S., Dunn, C. L., Harnack, L. J., Levine, S. S., Pentel, P. R., et al. (2007). Effects of portion size on chronic energy intake. *The International Journal of Behavioral Nutrition and Physical Activity*, *4*, 27.
Kral, T. V. E. (2006). Effects on hunger and satiety, perceived portion size and pleasantness of taste of varying the portion size of foods. *Appetite*, *46*, 103–105.
Kral, T. V. E., Roe, L. S., & Rolls, B. J. (2004). Combined effects of energy density and portion size on energy intake in women. *The American Journal of Clinical Nutrition*, *79*, 962–968.
Le Magnen, J. (1956). Effets sur la prise alimentaire du rat blanc des administrations postprandiales d'insuline et le mécanisme des appétits caloriques. *Journal de Physiologie*, *48*, 789–802.
Ledikwe, J. H., Ello-Martin, J. A., & Rolls, B. J. (2005). Portion sizes and the obesity epidemic. *The Journal of Nutrition*, *135*, 905–909.
Linné, Y., Barkeling, B., Rössner, S., & Rooth, P. (2002). Vision and eating behavior. *Obesity*, *10*, 92–95.
Lowe, M. R., & Butryn, M. L. (2007). Hedonic hunger. A new dimension of appetite? *Physiology & Behavior*, *91*(4), 432–439.
Marchiori, D., Corneille, O., & Klein, O. (2012). Container size influences snack food intake independently of portion size. *Appetite*, *58*, 814–817.
Marchiori, D., Klein, O., Bernard, P., & Bratanova, B. (2014) Personalized consumption goals prevent over-eating from large portions at a snacking situation. manuscript in revision.
Marchiori, D., & Papies, E. K. (2014). A brief mindfulness intervention reduces unhealthy eating when hungry, but not the portion size effect. *Appetite*, *75*, 40–45.
Marchiori, D., Waroquier, L., & Klein, O. (2011). Smaller food item sizes of snack foods influence reduced portions and caloric intake in young adults. *Journal of the American Dietetic Association*, *111*, 727–731.
Marchiori, D., Waroquier, L., & Klein, O. (2012). "Split them!" Smaller item sizes of cookies lead to a decrease in energy intake in children. *Journal of Nutrition Education and Behavior*, *44*, 251–255.
McClelland, G. H. (2000). Nasty data. Unruly, ill-mannered observations can ruin your analysis. In H. T. Reis & C. M. Judd (Eds.), *Handbook of research methods in social and personality psychology* (pp. 393–411). Cambridge, UK: Cambridge University Press.
Mussweiler, T. (2001). The durability of anchoring effects. *European Journal of Social Psychology*, *31*, 431–442.
Mussweiler, T., Englich, B., & Strack, F. (2004). Anchoring effect. In R. Pohl (Ed.), *Cognitive illusions. A handbook on fallacies and biases in thinking, judgment, and memory* (pp. 183–200). London: Psychology Press.
Mussweiler, T., & Strack, F. (2001). Considering the impossible. Explaining the effects of implausible anchors. *Social Cognition*, *19*, 145–160.
Mussweiler, T., Strack, F., & Pfeiffer, T. (2000). Overcoming the inevitable anchoring effect. Considering the opposite compensates for selective accessibility. *Personality and Social Psychology Bulletin*, *26*, 1142–1150.
Noakes, M., Foster, P. R., Keogh, J. B., & Clifton, P. M. (2004). Meal replacements are as effective as structured weight-loss diets for treating obesity in adults with features of metabolic syndrome. *The Journal of Nutrition*, *134*, 1894–1899.
Osterholt, K. M., Roe, L. S., & Rolls, B. J. (2007). Incorporation of air into a snack food reduces energy intake. *Appetite*, *48*, 351–358.
Papies, E. K., & Hamstra, P. (2010). Goal priming and eating behavior. Enhancing self-regulation by environmental cues. *Health Psychology*, *29*, 384–388.
Rolls, B. J. (2003). The supersizing of America. Portion size and the obesity epidemic. *Nutrition Today*, *38*, 42–53.
Rolls, B. J., Morris, E. L., & Roe, L. S. (2002). Portion size of food affects energy intake in normal-weight and overweight men and women. *The American Journal of Clinical Nutrition*, *76*, 1207–1213.
Rolls, B. J., Roe, L. S., Kral, T. V., Meengs, J. S., & Wall, D. E. (2004). Increasing the portion size of a packaged snack increases energy intake in men and women. *Appetite*, *42*, 63–69.
Rolls, B. J., Roe, L. S., & Meengs, J. S. (2007). The effect of large portion sizes on energy intake is sustained for 11 days. *Obesity*, *15*, 1535–1543.
Rolls, B. J., Rolls, E. T., Rowe, E. A., & Sweeney, K. (1981). Sensory specific satiety in man. *Physiology & Behavior*, *27*, 137–142.
Schwartz, J., & Byrd-Bredbenner, C. (2006). Portion distortion. Typical portion sizes selected by young adults. *Journal of the American Dietetic Association*, *106*, 1412–1418.
Schwarz, N. (1994). Judgment in social context. Biases, shortcomings, and the logic of conversation. *Advances in Experimental Social Psychology*, *26*, 123–162.
Simonson, I., & Drolet, A. (2004). Anchoring effects on consumers' willingness-to-pay and willingness-to-accept. *The Journal of Consumer Research*, *31*, 681–690.
Smith, H. D. (1999). Use of the anchoring and adjustment heuristic by children. *Current Psychology: Developmental, Learning, Personality, Social*, *18*, 294–300.
Spill, M. K., Birch, L. L., Roe, L. S., & Rolls, B. J. (2011). Hiding vegetables to reduce energy density. An effective strategy to increase children's vegetable intake and reduce energy intake. *The American Journal of Clinical Nutrition*, *94*, 735–741.
Strack, F., & Mussweiler, T. (1997). Explaining the enigmatic anchoring effect. Mechanisms of selective accessibility. *Journal of Personality and Social Psychology*, *73*, 437–446.
Stroebe, W., van Koningsbruggen, G. M., Papies, E. K., & Aarts, H. (2013). Why most dieters fail but some succeed. A goal conflict model of eating behavior. *Psychological Review*, *120*(1), 110–138.
Tuomisto, T., Tuomisto, M. T., Hetherington, M., & Lappalainen, R. (1998). Reasons for initiation and cessation of eating in obese men and women and the affective consequences of eating in everyday situations. *Appetite*, *30*, 211–222.
Tversky, A., & Kahneman, D. (1974). Judgment under uncertainty. Heuristics and biases. *Science*, *185*, 1124–1131.
U.S. Environmental Protection Agency (EPA) (2003). *CSFII analysis of food intake distributions*. Washington, DC: National Center for Environmental Assessment. EPA/600/R-03/029. Available from: National Technical Information Service, Springfield, VA; PB2003-103268, and <http://www.epa.gov/ncea>.
Wansink, B. (1996). Can package size accelerate usage volume? *Journal of Marketing*, *60*, 1–14.
Wansink, B. (2004). Environmental factors that increase the food intake and consumption volume of unknowing consumers. *Annual Review of Nutrition*, *24*, 455–479.
Wansink, B. (2006). *Mindless eating. Why we eat more than we think*. New York: Bantam-Dell.
Wansink, B. (2010). From mindless eating to mindlessly eating better. *Physiology & Behavior*, *100*, 454–463.
Wansink, B., & Kim, J. (2005). Bad popcorn in big buckets. Portion size can influence intake as much as taste. *Journal of Nutrition Education and Behavior*, *37*, 242–245.
Wansink, B., & Payne, C. R. (2009). The joy of cooking too much. 70 years of calorie increases in classic recipes. *Annals of Internal Medicine*, *150*, 291–292.

Wansink, B., Payne, C. R., & Chandon, P. (2007). Internal and external cues of meal cessation. The French paradox redux? *Obesity*, *15*, 2920–2924.
Wansink, B., & Sobal, J. (2007). Mindless eating. The 200 daily decisions we unknowingly make. *Environment and Behavior*, *39*, 106–123.
Wansink, B., Van Ittersum, K., & Painter, J. E. (2006). Ice cream illusions. Bowls, spoons and self-served portion sizes. *American Journal of Preventive Medicine*, *31*, 240–243.
Wilkinson, L. L., Hinton, E. C., Fay, S. H., Ferriday, D., Rogers, P. J., & Brunstrom, J. M. (2012). Computer-based assessments of expected satiety predict behavioural measures of portion-size selection and food intake. *Appetite*, *59*, 933–938.
Wing, R. R., Jeffery, R. W., Burton, L. R., Thorson, C., Nissinoff, K. S., & Baxter, J. E. (1996). Food provision vs structured meal plans in the behavioral treatment of obesity. *International Journal of Obesity and Related Metabolic Disorders*, *20*, 56–62.
Young, L. R., & Nestle, M. (2002). The contribution of expanding portion sizes to the US obesity epidemic. *American Journal of Public Health*, *92*, 246–249.
Young, L. R., & Nestle, M. (2003). Expanding portion sizes in the US marketplace. Implications for nutritional counselling. *Journal of the American Medical Association*, *103*, 231–234.
Young, L. R., & Nestle, M. (2007). Portion sizes and obesity. Responses of fast-food companies. *Journal of Public Health Policy*, *28*, 238–248.