

Whether Smaller Plates Reduce Consumption Depends on Who's Serving and Who's Looking: A Meta-Analysis

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ABSTRACT The literature on whether varying plate size has an effect on consumption is mixed and contradictory. This meta-analysis of 56 studies from 20 papers shows that varying the size of the container holding food (e.g., plate or bowl) has a substantial effect on amount self-served and/or consumed (Cohen's $d = .43$). More generally, we found a doubling of plate size increased the amount self-served or amount consumed by 41%. Our analysis resolves the various contradictions of past reviews: we found that the plate-size effect had a substantial effect on amount self-served ($d = .51$) and on amount consumed when the portion was self-served ($d = .70$) or manipulated along with (confounded with) plate size ($d = .48$). However, plate size had no effect on amount consumed when the portion size was held constant ($d = .03$). Overall, plate size had a stronger effect when participants were unaware that they were participating in a food study ($d = .76$).

Does plate size affect how much we eat? The Small Plate Movement (www.smallplatemovement.org) is founded on the premise that smaller plates lead us to eat less, but the evidence on the effect of plate size¹ is greatly disputed. Some researchers report that smaller plates reduce consumption (Wansink and Kim 2005; Wansink, Payne, and Werle 2008; Van Kleef et al. 2012; Wansink and Van Ittersum 2013). But many others report finding no effect (Rolls et al. 2004, 2007; Shah et al. 2011; Yip et al. 2013; Libotte et al. 2014). Some even report negative effects (e.g., Robinson et al. 2015c).

Four recent reviews do little to clarify the effects of plate (or bowl or other food-container) size on consumption. In a qualitative review, Casazza et al. (2015) concluded that plate size was a “robust driver of self-served portion sizes.” Robinson and Matheson (2015) in another qualitative review concluded that “smaller diameter plates [and] bowls” reduce consumption while acknowledging that there were some studies that showed no effect. In the only meta-analysis (quantitative review), Robinson et al. (2014b) concluded that “evidence to date does not show that dishware size has a consistent effect on food intake.” Finally, Libotte et al. (2014) in another qualitative review noted that de-

spite widespread recommendations to use plate size to control portions, “the evidence to support this is contradictory.”

In short, the effects of plate size are unclear. We therefore sought to answer the question of whether smaller plates reduce consumption and, given the equivocal results, to determine the conditions under which plate size affects consumption.

We first distinguished between two distinct dependent variables: the amount of food self-served vs the amount consumed. Robinson et al.'s (2014b) meta-analysis focused on “formally measured or recorded food intake,” while Casazza et al. (2015) focused on self-served portions. In general, the amount self-served is presumed to mediate the amount consumed (see fig. 1), an assumption confirmed in a number of studies that examine both dependent variables (e.g., Koh and Pliner 2009; Van Kleef et al. 2012). Wansink and Johnson (2015) and Robinson et al. (2015b) report that studies measuring both show that the amount consumed is 85%–90% of the amount self-served. However, the effect of plate size on amount consumed might be different if portions are not self-served. We therefore examined both dependent variables.

In terms of independent variables, we first distinguished between manipulations of area (i.e., plate size in its strict

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1. We are using the term “plate size” generically here. It therefore includes plates, bowls, and other food containers such as packages.

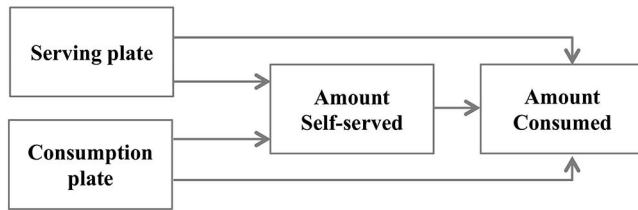


Figure 1. Plate size effects.

sense) and volume (as in bowls and packages). Some studies manipulate the plate size in two dimensions (i.e., expanding the diameter of a round plate increases its area); others manipulate three dimensions (i.e., increasing the volume). Importantly, both Robinson et al. (2014b) and Libotte et al. (2014) have observed that manipulations of area appeared to have no effect, while manipulations of volume did. This result seems surprising as a doubling of area would be more noticeable than a doubling of volume. Research by Chandon and Ordabayeva (2009) and Ordabayeva and Chandon (2013) supports this notion by showing that consumers appear to be more sensitive to a manipulation in one dimension and less sensitive to manipulations in three dimensions. We therefore sought to reexamine this unexpected result.

We also distinguish between whether it was the consumption plate or the serving plate that was manipulated, a variable Libotte et al. (2014) referred to as “food-serving mode.” Conceptually, consumption and serving plates could independently and even interactively affect both amount of food self-served and amount consumed (see fig. 1). While consumption and serving-plate manipulations could be crossed, no one has done so to our knowledge. We anticipated that manipulations of the serving-plate size and the consumption-plate size would show a positive effect.

We also examined two further variables that have been little examined in the past. The first is to break down those studies examining amount consumed by how the portion size was manipulated: was the portion size fixed (the same for both plate sizes), self-served, or varied (and therefore confounded) with plate size. Research has shown that portion size has a strong effect on consumption (doubling of a portion leads to 35% greater consumption on average; Zlatevska et al. 2014). We therefore sought to examine whether plate size had an effect independent of portion size.

The second is whether the plate-size effect is mitigated in studies where people are aware that they are participating in a food study. A number of recent studies suggest that awareness may mitigate various food consumption effects in general (Robinson et al. 2014a) and, more specifically, plate-

size effects (Libotte et al. 2014), portion-size effects (Zlatevska et al. 2014), and partitioning effects (Holden and Zlatevska 2015).

Finally, we also extended previous analyses by addressing the multidimensionality and scalability of plate size by developing an elasticity measure of the effect of plate size on consumption.

METHOD

We have followed PRISMA principles (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) as the basis for reporting our method and our results (Beller et al. 2013). The interventions we examined were manipulations of plate size (defined broadly as plate, bowl, and other food container); the outcomes we examined were amount self-served and amount consumed. Further details on the interventions, outcomes, and studies that were included in our analysis are provided in the following.

Interventions

Our primary interest was in examining the effect of plate-size manipulations, so studies needed to have at least two levels of plate size to be included in the analysis.² Some studies included three or more levels, for example, “small,” “medium,” and “large” (Rolls et al. 2004, 2007). In these cases, the comparison of “small” versus “medium” was entered into the meta-analysis as one study and “medium” vs. “large” as another. We note that Robinson et al. (2014b) did this but also included an additional study comparing “small” versus “large.” We did not because it creates a problem of “double-counting” the effects. It also creates one effect that is a function of a manipulation that is equal to the sum of two other manipulations. This highlights that the plate size effect is scalable, and we might expect a larger change from a larger change in plate size. This is an issue that we address later.

In order to try and separate some of the conflicting findings regarding plate size, we distinguish between various types of interventions. First, and in line with Robinson et al. (2014b), we distinguish between manipulation of area whether reported as diameter (e.g., Rolls et al. 2007) or area (e.g., Koh

2. We excluded studies that manipulated the size and number of containers simultaneously. Specifically, Wansink and Cheney (2005), which manipulated both the size and the number of serving bowls (2×4 L vs. 4×2 L), was excluded even though it was included in other reviews (Libotte et al. 2014; Robinson and Matheson 2015). The problem is that the size manipulation is confounded with the number manipulation, a feature of “partitioning” studies that can have paradoxical and contradictory effects (Zlatevska et al. 2014; Holden and Zlatevska 2015).

and Pliner 2009), and also volume whether reported as bowl size (Ahn et al. 2010) or package size (Wansink and Kim 2005). Second and in line with an observation by Libotte et al. (2014), we distinguished between whether the plate being manipulated was the serving plate (e.g., Wansink 1996) or the consumption plate (e.g., Rolls et al. 2007).

Outcomes

Amount of food consumed was recorded in a wide variety of ways: grams (Marchiori et al. 2012), ounces (Wansink et al. 2006), kilojoules (Shah et al. 2011), calories (Di Santis et al. 2013), and “percentage of plate surface” (Wansink and Van Ittersum 2013). To avoid any confusion with energy intake (kilojoules), we only included amount consumed for foods that were homogenous in terms of energy density. In such cases, whether a study measured weight consumed or energy consumed was of no consequence.³

We also included studies that reported amount self-served even though they were excluded in some previous reviews.⁴ We note that five studies measured both amount self-served and amount consumed and are therefore reported for each outcome (Koh and Pliner 2009; Van Kleef et al. 2012; Di Santis et al. 2013; Van Ittersum and Wansink 2013; Wansink et al. 2014).

We excluded all studies that measured perceptions and judgments such as serving a portion to match a target (Bryant and Dundes 2005; Van Ittersum and Wansink 2012; McClain et al. 2014; Penaforte et al. 2014). Despite their promise, we also excluded studies that measured body weight change (Pedersen et al. 2007; Ahn et al. 2010; Hanks et al. 2013)⁵ and food waste (Kallbekken and Sælen 2013) as the outcomes.

Participants and Study Designs

We included both within-subject (e.g., Rolls et al. 2007) and between-subject experimental designs (e.g., Wansink and Van Ittersum 2013), field and laboratory based experiments, with both random (e.g., Van Kleef et al. 2012), and non-

random assignment of subjects to conditions (e.g., Koh and Pliner 2009).

Search Strategy

Studies relevant for the meta-analysis were initially identified through a search of ABI/Inform, ProQuest Digital Dissertations, Business Source Premier, Web of Science, Psych-Info, SCOPUS, Google Scholar, and other databases using the following keywords: portion size, plate size, package size, bowl size, dishware, and container size. We also manually searched through the following relevant journals and conference proceedings where papers on portion size, plate size, or container size have been previously published: *Journal of Marketing*, *Journal of Marketing Research*, *Journal of Consumer Research*, *Journal of Consumer Psychology*, *Journal of Public Policy and Marketing*, *Obesity Reviews*, *Annual Review of Nutrition*, *American Journal of Clinical Nutrition*, *Body and Society*, *British Journal of Sociology*, *Social Science and Medicine*, *Appetite*, *Journal of Obesity Research*, *Advances in Consumer Research*, American Marketing Association proceedings, and the Obesity Society abstract supplements. The references in articles found in our search were also examined to identify further studies. We also acknowledge and thank the reviewers and editors for identifying some articles that were in press or otherwise missed through the above process.

Data Extraction

We recorded data from each study that would allow for the calculation of a standardized mean difference (Cohen’s *d*; see figs. 2a, 2b). To enable the later calculation of an elasticity coefficient, we also recorded the amount self-served and/or consumed from the “small” and “large” plate size condition and the size of the plate if, and as, reported by the researchers themselves.

Finally, we coded for two further variables of interest. First, we coded for whether or not portion size was self-served, manipulated along with (i.e., confounded with) plate size, or held constant across plate-size conditions. Second, we coded for whether people were aware that they were participating in a “food study.” For participants to be unaware, the research would generally feature a nonfood cover story, and consumption was measured covertly. While it is difficult for a within-subjects design to disguise the fact that food is the focus of the study as noted by Van Kleef et al. (2012), within-subject designs with children were, in some instances, included (e.g., Van Ittersum and Wansink 2013; Wansink et al. 2014, study 2). These studies featured a

3. Studies measuring the consumption of nonfood items such as bleach and detergent were excluded (Wansink 1996, study 5). A six-week pilot study showing a decline in consumption by Robinson and Matheson (2015) also had to be excluded due to insufficient data.

4. We note that while some previous reviewers focused on amount consumed (Libotte et al. 2014; Robinson et al. 2014b), they did appear to include some studies measuring amount self-served (e.g., Wansink et al. 2006; Van Ittersum and Wansink 2013).

5. Ahn et al.’s (2010) data on actual consumption were included.

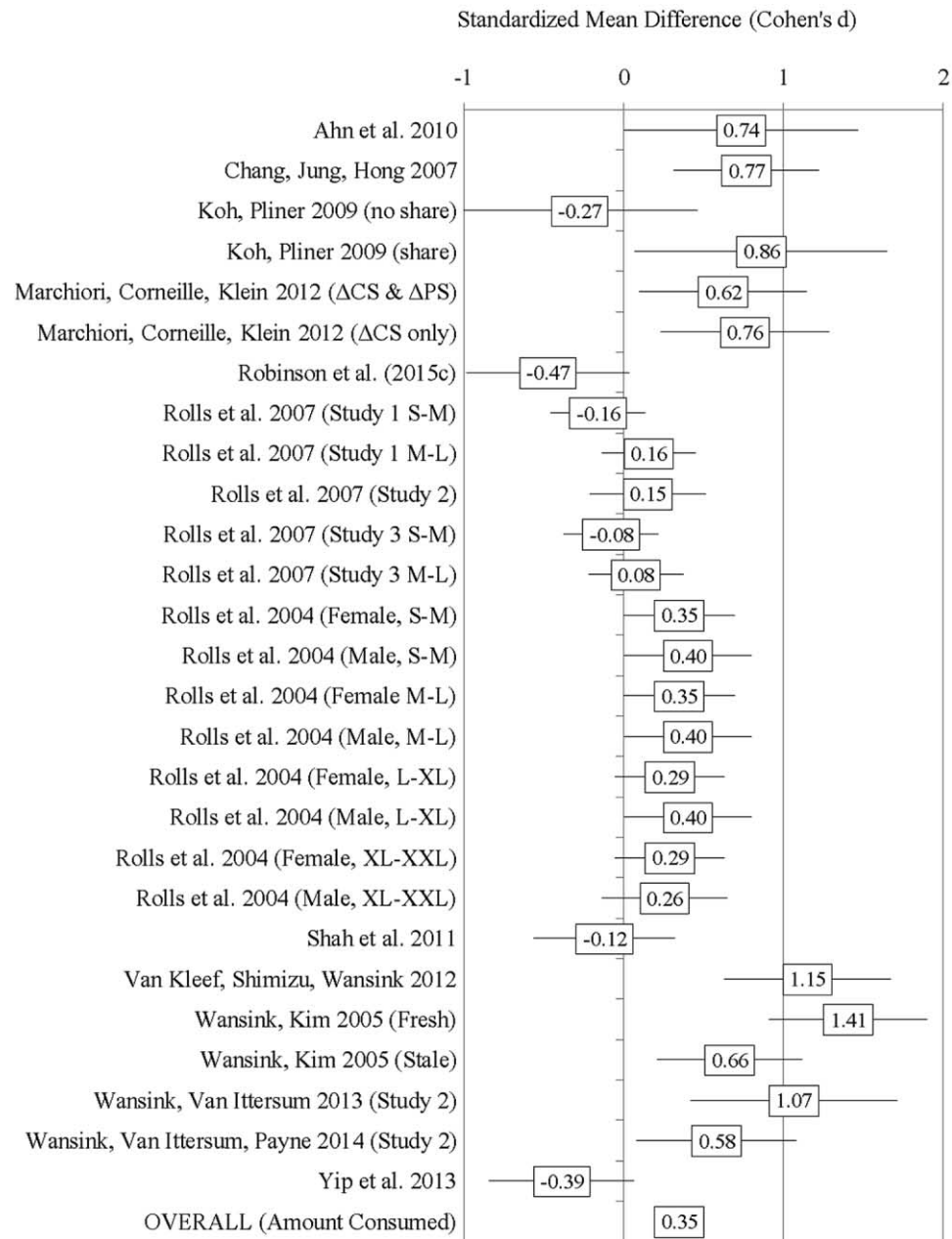


Figure 2a. Effect of plate size on amount consumed.

field-setting such as a school or summer-camp, and the food manipulations were incorporated into regular meals without notice to the children, so we judged the participants were unaware.

RESULTS

Fifty-six studies reported in 20 papers representing over 3,507 subjects were included in our meta-analysis (see figs. 2a, 2b; for details of the included studies and their respec-

tive effect-sizes; see appendix, available online, for full details of all studies). Using Cohen's *d*, a measure of standardized mean differences, calculated under a random effects model, we found the overall effect of plate size across the 56 studies was $d = .43$ (95% confidence intervals $\pm .11$), which would be described conventionally as a medium effect-size (Cohen 1988).

To address the file-drawer problem (Rosenthal 1979), we calculated the fail-safe N to be 2,828. This is "the num-

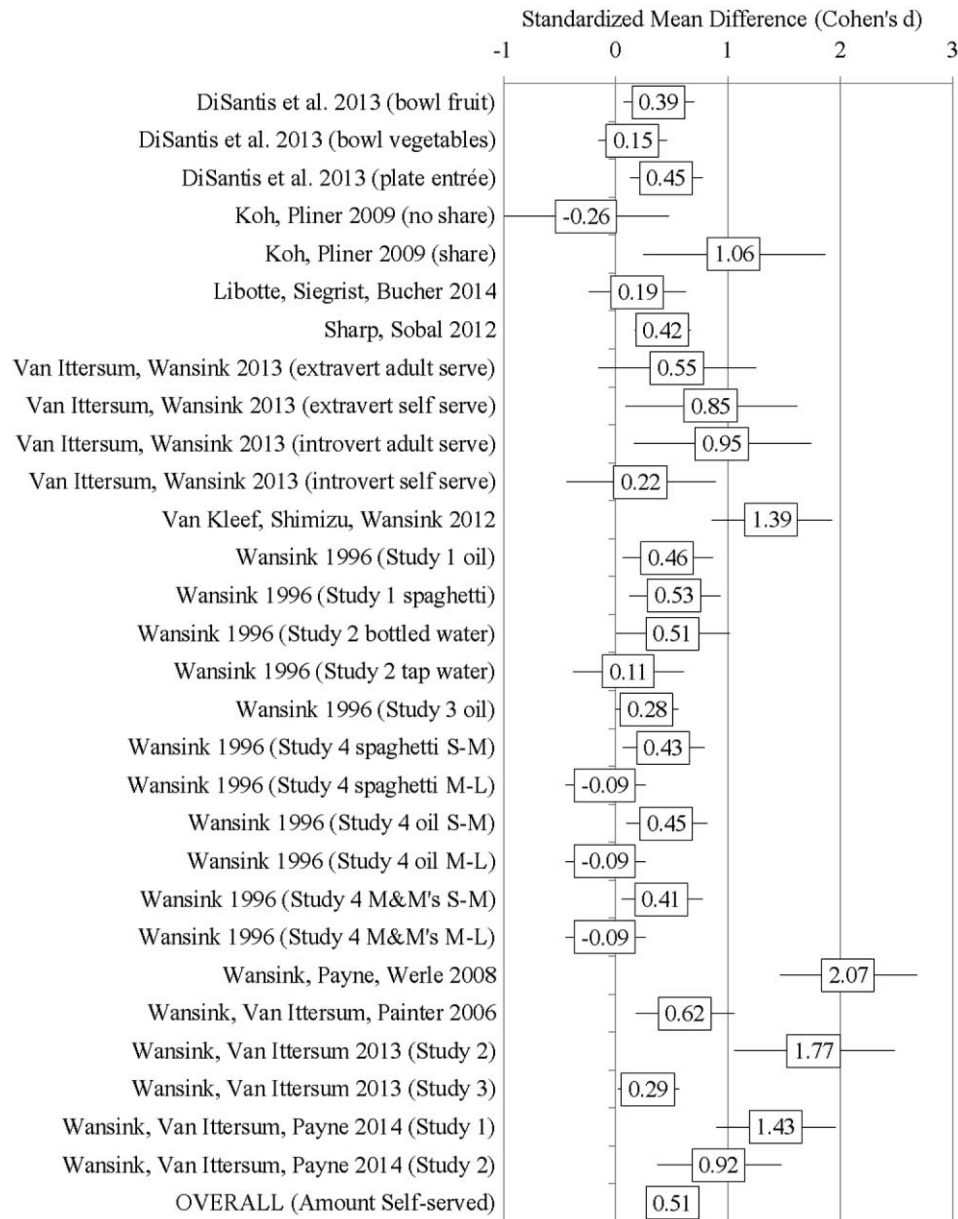


Figure 2b. Effect of plate size on amount self-served.

ber of [null effect] studies that would need to be added to a meta-analysis to reduce an overall statistically significant observed result to non-significance” (Rosenberg 2005, 464). A visual observation of the funnel plot for the $k = 56$ studies shows some asymmetry with some studies with larger standard errors being overrepresented. The first possible interpretation is that this shows publication bias. However, another possibility is that given the scalability of plate size, the variation in standard errors may represent different strength manipulations of plate size (Sterne et al. 2011).

That a large change in plate size might result in a larger effect is something we will capture later by calculating the plate size elasticity of consumption. In any case, standard meta-analytic reporting gives less weight to studies with higher standard errors and smaller n 's.

The heterogeneity of studies was considerable and the effect-size varied from study to study as indicated by $Q = 212.3$, which was much greater than the degrees of freedom ($df = 55$). The I^2 index, indicating the percentage of variation in the meta-analysis that was attributable to study

heterogeneity, was a substantial 74% (Higgins and Thompson 2002; Huedo-Medina et al. 2006).

The overall $d = .43$ shows that plate size had a positive effect on amount consumed and/or self-served. Due to the high degree of study heterogeneity, the fact that five studies provided measures of both amount self-served and amount consumed (and are therefore double-counted), and the existence of reviews reporting no plate size effect at least in terms of those studies which manipulate only area as opposed to volume (Libotte et al. 2014; Robinson et al. 2014b), we proceeded by breaking down the effect.

We first examined plate size effects broken down by the outcome measured (amount consumed vs. amount self-served), dimensions manipulated (area vs. volume), and type of plate (consumption vs. serving plate; see fig. 3). This analysis enabled us to understand more clearly the conflicting views of whether plate size has an effect, but we caution against interpreting this analysis as if the variables are fully crossed in an experimental sense. As may be seen, some cells in this analysis had no or few observations: we found no studies manipulating the area of a serving plate,

and only one study that examined the effect of a volume manipulation on amount consumed (Van Kleef et al. 2012). Even for those cells with more observations, the studies contained in each cell differed from studies in other cells in many ways beyond those variables used to create the subgroups.

As shown in figure 3, plate sizes had moderate to strong effects on amounts self-served and consumed across most cells ($d = .33$ up to $d = 1.15$). There was one notable exception: the manipulation of area of consumption plates had a small (and nonsignificant) effect on amount consumed ($d_A = .06 \pm .20$). This single cell where the area of a consumption plate was manipulated appears to account for the conflicting conclusions seen in the literature. The two reviews which focused on amounts consumed (top half of fig. 3) concluded that manipulations of area (“plates”) had no effect relative to manipulations of volume (“bowls”; Libotte et al. 2014; Robinson et al. 2014b). However, our analyses show that area and volume had an approximately equal effect on amount self-served ($d_{area} = .49 \pm .30$ vs. $d_{volume} = .52 \pm .19$) (bottom half of fig. 3). The two other reviews focused on amount self-

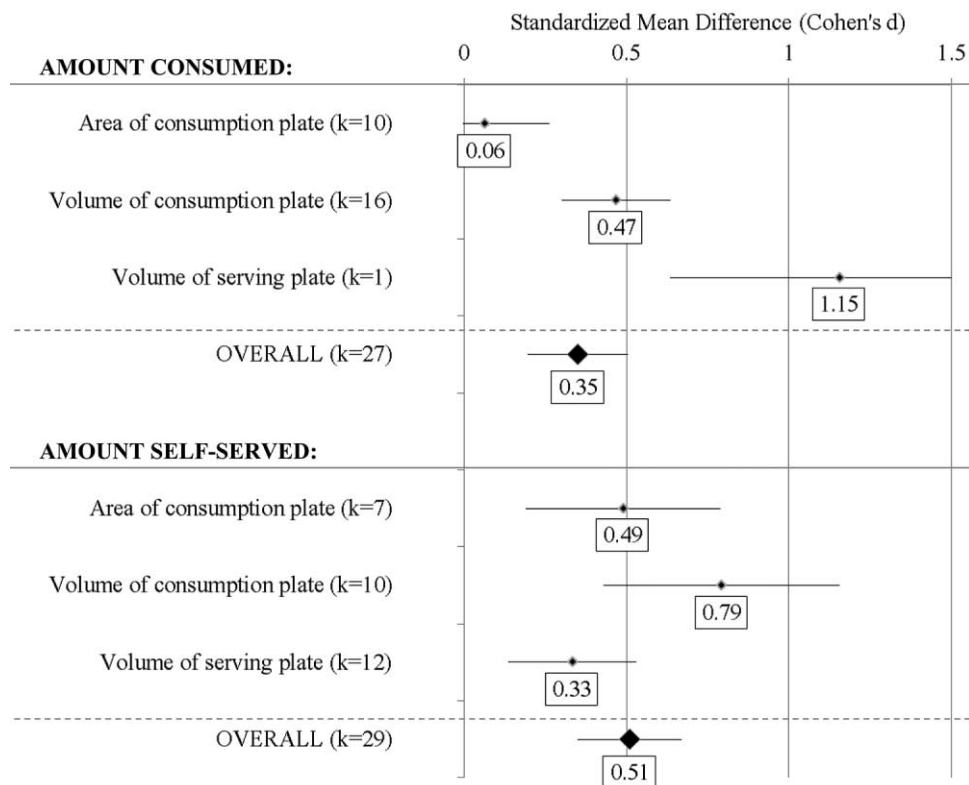


Figure 3. Effects of plate size: summary.

served and accordingly concluded that plate size had a clear positive effect (Casazza et al. 2015; Robinson and Matheson 2015).

While the presentation in figure 3 may encourage us to think that the anomalous effect is driven by something special about the interaction of area and consumption plate, we again highlight that it would be a mistake to think of the elements in this cell as having been randomly drawn from the population of all possible studies. This is perhaps highlighted by the fact that five of the 10 studies in this cell are from one article (Rolls et al 2007), and that there are no observations of the effect of manipulating the serving-plate area on amount consumed.

We then proceeded by examining the independent effects of five different variables on the plate size effect: (1) out-

come variable (amount consumed vs amount self-served), (2) dimensions manipulated (area or volume), (3) type of plate (consumption vs serving), (4) whether subjects were aware that they were participating in a food study or not, and (5) how portion size was manipulated within plate size for amount consumed. The results are presented in figure 4.

Of the five variables examined, the effect of plate size remains fairly consistent whether amount is self-served or amount consumed is measured, and whether area or volume, and serving plate or consumption plate is manipulated. However, the effect of plate size is considerably greater under specific conditions as shown in the bottom two panels of figure 4. Specifically, the plate-size effect was greater when consumers were unaware that they were participating in a food study ($d_{unaware} = .76$ vs $d_{aware} = .31$). We note that

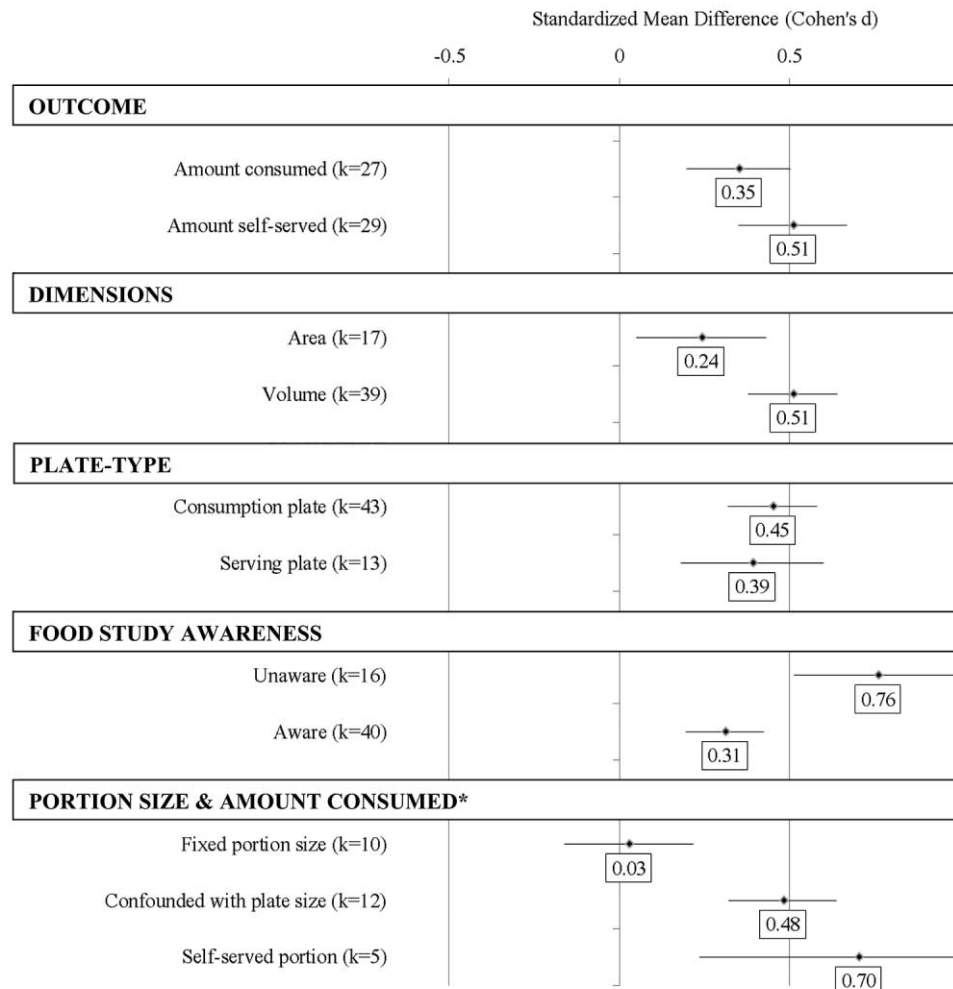


Figure 4. Effects of plate size: analysis by subgroups. * This analysis examines the effect of plate size on amount consumed only ($k = 27$).

not only was the effect larger, but it was statistically significant—the 95% confidence intervals for each estimate do not overlap. Furthermore, examining the effect of plate size on amount consumed, the effect was stronger if the consumers self-served their portions, or the portion sizes were confounded with the plate size. There is an important implication here—plate size does not appear to have an effect on amount consumed if the portion size remains fixed across plate sizes. So while the effect of plate size on amount consumed and amount self-served does not appear to be very different on average, the results suggest that the effect of plate size on amount consumed is, to a large degree, mediated by a portion-size effect. In the case of self-service, the larger plates apparently encourage larger portions, and so the consumer eats more.

We note that there are insufficient observations to say whether the effect of unawareness is crossed with these other variables. Of the 10 studies in which portion size was fixed, all comprised participants who were aware they were participating in a food study. Further research is required to establish whether or not plate size might have an effect where the portion is fixed if participants are unaware.

A limitation of this subgroup analysis is that it ignores possible interactions of the identified variables with one another, although, as noted, the lack of observations and lack of random sampling constrain any effort to conduct such an analysis. However, the problem does highlight that the anomalous cell seen in figure 3 where the plate size effect has no effect, may reflect the influence of variables other than those identified. For instance, in this anomalous cell, nine of the 10 studies were with subjects who were aware they were participating in a food, which tends to show a smaller effect as seen in figure 4. Moreover, there was one study out of 10 in this cell that showed a strong plate-size effect (Wansink and Van Ittersum 2013, study 2; see fig. 2a). The subjects in this study self-served their portions and were unaware they were participating in a food study.

Scaled Effect Size

To complete our analysis, we developed a scalable measure of the plate size effect to address the problem that Cohen's d is difficult to interpret. Cohen's d (and related standardized mean difference measures) report the effect of “control” versus “treatment” or, in our case, large versus small plate size, but nothing beyond this (Chernev et al. 2010). No allowance is made for the fact that some researchers increased the plate size from the small to large condition by 200% (Marchiori et al. 2012), while others increased it by

just 30% (Rolls et al. 2004). In other words, effect size as measured by Cohen's d cannot capture a plate-size effect that changes as a function of the change in plate size.

In an effort to address this problem, we calculated percentage change in plate size and the resulting percentage change in consumption to allow for the effect-size to be expressed as a plate size elasticity of consumption. The percentage change in consumption was calculated as follows:

$$\Delta C / C_S, \quad (1)$$

where ΔC = change in consumption (amount eaten from larger plate – amount eaten from smaller plate) and C_S = consumption from smaller plate size.

We then calculated the same change parameter for plate size, although we note that it was necessarily conditioned on the dimensions that were manipulated. For those studies reporting plate size as a diameter, we first converted this into an area ($(\text{diam}/2)^2 \cdot \pi$) and then expressed change in area for all observations as follows:

$$\Delta A / A_S, \quad (2)$$

where ΔA = change in area (larger area – smaller area) and A_S = smaller area.

Change in volume was measured in a similar way although we note that studies typically report change by capacity of the container (e.g., 100-g package or 2-L bowl) and almost never included information about the actual physical dimensions:

$$\Delta V / V_S, \quad (3)$$

where ΔV = change in volume (larger volume – smaller volume) and V_S = smaller volume.

We then regressed change in consumption (eq. [1]) on the change in plate size (be it area as in eq. [2] or volume as in eq. [3]) with no constant and with each study weighted by the meta-analytic weights generated under a random effects model.⁶ The coefficient generated represents an elasticity measure which can be interpreted as the percentage change in consumption for a doubling (100%) increase in plate size.

6. The regressions were modeled without a constant because a zero percent change in plate size has a zero percent change in consumption. In any case, and following Eisenhauer (2003), we note that when included, the constant was not significant, and the coefficient for change in plate size was little changed. While the presented regressions were weighted, unweighted regressions returned virtually identical results, consistent with the random-effects model weights being more “balanced” than under fixed-effects (Borenstein et al. 2009).

Looking across all 56 studies combined (including five studies that provided measures of both amounts self-served and consumed), doubling the plate size led to increases in amounts self-served/consumed of 41% on average ($p < .001$, $k = 56$). Alternatively stated, halving the plate size led to a 29% reduction in amount self-served/consumed on average. This scalable measure might offer some promise for exploring the conditions under which plate size effect varies but requires more observations (studies) in order to be stable.

DISCUSSION

The results from both the meta-analysis and the elasticity analysis show that plate size has a considerable effect overall on amount self-served and consumed. While two previous reviews concluded that plate size had no reliable effect on amount consumed (Libotte et al. 2014; Robinson et al. 2014b), our analysis found that there was a substantial plate size effect on amount consumed, but only if the consumer self-served their portions or portion size was varied in line with plate-size. Plate size had no effect on average in situations where portion sizes were held constant across plate sizes.

Our analyses have also suggested that a major driver of the effect is whether subjects are aware that they are participating in a food study or not. If participants were unaware that they were participating in a food study, the effect of manipulating plate-size was substantially (and significantly) larger ($d_{\text{unaware}} = .76$ vs. $d_{\text{aware}} = .31$), a finding in line with a suggestion by Libotte et al. (2014). This result is consistent with other recent reports suggesting that important demand effects operate in food studies. Zlatevska and colleagues (Zlatevska et al. 2014; Holden and Zlatevska 2015) have showed that the effects of portions and partitions respectively were reduced when research participants were participating in a study where food was the focus. Robinson and colleagues (Robinson 2014; Robinson et al. 2014a, 2015a) have conducted a meta-analysis and empirical studies showing that when subjects know they are being observed, their consumption is reduced.

Overall, our analysis supports the notion that plate size positively influences consumption when portions are self-served or varied in line with plate size and if consumers are unaware that their consumption is being monitored. But significant areas remain to be explored more fully. Our research highlights that more attention needs to be directed to the distinction between amount consumed and amount self-served and, in particular, the way in which self-served portions may effectively mediate the observed plate-size effect.

While some previous reviewers have suggested that bowls or manipulations of volume have a greater effect than manipulation of area (Libotte et al. 2014; Robinson et al. 2014), we consider this unlikely. Our results show that there is little distinction between manipulating a plate in two dimensions (area) or three dimensions (volume as in a bowl). Moreover, if there were to be a difference, we would expect two-dimensional changes to have a greater effect than three-dimensional changes in view of the compelling evidence that the perceived size and perceived change in size in containers is quite distinct from the actual change (Chandon and Ordabayeva 2009; Ordabayeva and Chandon 2013). Changes in one dimension are generally perceived as bigger than an equivalent change in three dimensions (Raghubir and Krishna 1999; Chandon and Ordabayeva 2009). In any case, very few of the studies included in our analysis gave any consideration to the perceived change. With regard to volume in particular, we found virtually no studies that reported the dimensions of the container. This made it impossible to code those studies manipulating volume for the number of dimensions changed. Given the promising opportunities offered through the manipulation of one versus all three dimensions as highlighted by Chandon and Ordabayeva (2009), we think that it would be helpful if, at the very least, future studies examining the effect of plate size, and especially volume, report the three dimensions of the container of both the smaller and larger plate.

In terms of future directions and implications, we think that further exploration of the awareness by participants of their participation in a food study deserves more attention. In their qualitative review, Libotte et al. (2014) noted that in all the studies they reviewed where they found a plate-size effect, “participants were distracted from food-consumption or serving,” and “no distraction factors were present in the studies that did not find a significant effect of plate size.” They confirmed this in their own study of plate size in a setting using a “fake-food buffet”: their study produced no effect. In our review, we report no effect of plate size on amount consumed if the portion size was held constant but there is an important caveat: all studies contributing to this result featured participants who were aware they were in a food study. Therefore, we need studies with unaware participants investigating whether or not plate size has an effect when portion sizes are held constant.

In view of the potential importance of subject awareness, we add our voice to Robinson’s (2014) call “to lie more to participants in eating behaviour experiments.” Importantly, we highlight that the blinding required is more than

simply blinding to the manipulation but also blinding to the measurement. That is, the individual needs to be “double-blinded”: unaware of the plate size manipulation and unaware even that they are participating in a food-consumption experiment.

However, we also hasten to add that blinding in the classic social experimentation sense overlooks another promising possibility related to the human adaptation to novel stimuli (Berlyne 1971). A novel stimulus attracts attention initially, becomes familiar, and ultimately is forgotten. This may explain how some longer-term trials with smaller dishware have reported success in reducing consumption (Ahn et al. 2010; Robinson and Matheson 2015) and weight (Pedersen et al. 2007; Hanks et al. 2013). Ensuring participants are blind to the manipulation or the measurement in such trials is likely to be virtually impossible. We speculate that awareness of the changed dishware attenuates over time. The result is therefore consistent with the notion that the effect works best when the participant is blind to the intervention. The difference is that through adaptation, the consumer becomes blind to long-term manipulations of plate size.

In summary, smaller plates will reduce the amount self-served to a plate. Smaller plates also reduce the amount consumed if the consumers are self-serving to those smaller plates or portion size is manipulated in line with the plate size. However, simply reducing plate size and holding portion size constant appears to have no effect—but this needs further investigation with unaware consumers. The plate-size effect is observed to be larger if the consumers do not believe they are being watched. So the widespread, long-term use of smaller plate sizes may help reduce consumption and perhaps obesity in precisely the same way that we have become blind to how large plate sizes have become. Continual use of smaller plate sizes may be both habit-forming and good for your health.

THE LARGER THEME: SMALL STEPS TOWARD OVERCOMING OBESITY

Obesity is growing (Flegal et al. 2002, 1998; Young and Nestle 2002), and concern about obesity is growing at a proportional rate. Despite enormous amounts of research and attention directed to the obesity problem, there appear to be no simple solutions. Perhaps this is an important finding: there is no large simple solution; rather obesity can only be successfully tackled by a series of small steps.

Our research suggests that substituting small for larger plates is one such small step that will help, especially if con-

sumers are self-serving to the plate, and if the change to smaller plates is not signaled to the consumer. This research fits within a larger field of small ways in which the amount we consume can be potentially limited by portions served such as smaller plates (shown in this article), smaller “food units” (Davis et al. 2016), smaller portions (Zlatevska et al. 2014), partitioned portions (Holden and Zlatevska 2015), or conversely, encouraging people to eat less by making portions appear larger (e.g., Wansink and Van Ittersum 2003, 2006; McClain et al. 2014).

At a broader level, the efforts toward downsizing consumed portion sizes all fit within a much larger field of small steps used to modify the consumption environment so as to nudge people toward healthier and less wasteful consumption behaviors (e.g., Szocs and Biswas 2016; Williamson, Block, and Keller 2016).

So there are solutions: they are small but also numerous. The greatest challenge perhaps is how to implement these ideas. In this regard, we see four different stakeholders we need to address: public health policy makers, food marketers, consumers, and food researchers.

The first stage in encouraging these small steps toward a solution is through the public health policy path. But it is difficult to imagine how these small steps might be implemented by the public health authorities, especially given evidence that consumers can react negatively to heavy-handed approaches (Pham et al. 2016). The best public health approach would appear to be to provide information and ideas for implementing small changes and leaving the changing to others.

A second step is for marketers to actively engage in encouraging healthier consumer habits. While some may view marketer involvement with some caution, they do in fact have the capacity—and in many instances, the interest—to help nudge consumers in the right direction. In this regard then, we might encourage marketers to implement ideas such as making healthy the default option (e.g., Peters et al. 2016).

Ultimately, change has to be implemented at the consumer level, and for this to work, a more consumer-empowered, bottom-up approach is probably needed. In this consumer-centric version, consumers are encouraged (by distributed information) to make informed decisions to help themselves. It is noted that in this regard, the very public outcry about the growth in obesity may be viewed as a positive. Due to this media attention, many consumers are searching for solutions, even if small and subtle. The Small Plate Movement (www.smallplatemovement.org) is an excellent exam-

ple of a consumer-focused intervention that encourages better habits for better living.

Finally, food researchers can help, and our research suggests directions for future efforts. While food researchers are typically united in seeking solutions for obesity, a search for strong, simple solutions can potentially hide smaller, subtle solutions. Our research was motivated by the considerable confusion about whether small plates work to reduce consumption. Many had studied the effect of small plate sizes in various settings, which generated a wide range of results, positive, neutral, and even negative. Even review articles have disagreed about whether there is an effect or not (Libotte et al. 2014; Robinson et al. 2014b; Casazza et al. 2015; Robinson and Matheson 2015). Our research resolved this confusion: we show that the effect of smaller plates on amount self-served is substantial, but the effect of smaller plates on amount consumed holds only under specific conditions, notably where consumers self-serve their portions or when portion size is reduced along with plate size. More research on the small steps that can be taken, and the conditions under which they do and do not operate, is to be encouraged.

Our research also revealed another sometimes entrenched practice in food science that we believe needs shifting: we found the overall effect of plate sizes was stronger if study participants were unaware that their consumption is being monitored. Our article adds to a growing body of research suggesting that the effects of portion sizes and partitioning are mitigated when subjects are aware they are in a food study (Zlatevska et al. 2014; Holden and Zlatevska 2015). This fits with broader reviews showing that aware participants tend to modify or constrain their consumption (Robinson et al. 2014a, 2015a). Importantly then, the small and subtle steps that can be used to modify consumption might be missed in studies where participants are aware they are in a food study.

The obesity problem can be resolved—through a series of small steps. Our research offers some clarification around one such small step. Use small plates, especially if you are self-serving your food to your plate. It will encourage you to self-serve and eat less. What about the problem that if someone installs smaller plates in their household, everyone will know, that is, be aware of the change? Our research does show that smaller plates work best if people are unaware that their consumption is being monitored. Fortunately, while humans tend to notice novel stimuli, the flip side is that they tend to adapt to and overlook familiar

stimuli. So even if the change to small plates in a household is a conscious decision, over time, the members of the household are likely to become unaware of the change, and we might expect to see behavior change accordingly. There is already some evidence to suggest that this is the case with individuals adopting smaller dishware showing a loss of weight over time (Pedersen et al. 2007; Hanks et al. 2013).

The problem of obesity is growing. Smaller plates are one of a range of small steps that can help reduce the amount self-served and thus the amount consumed.

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