Natalina Zlatevska, Chris Dubelaar, & Stephen S. Holden

Sizing Up the Effect of Portion Size on Consumption: A Meta-Analytic Review

Food marketing is facing increasing challenges in using portion size (e.g., “supersizing”) as a marketing tool. Marketers have used portion size to attract customers and encourage purchase, but social agencies are expressing concern that larger portion sizes encourage greater consumption, which can cause excessive consumption and obesity. This article addresses two questions that are central to this debate: (1) How much effect does portion size have on consumption? and (2) Are there limits to this effect? A meta-analytic review reveals that, for a doubling of portion size, consumption increases by 35% on average. However, the effect has limits. An extended analysis shows that the effect of portion size is curvilinear: as portions become increasingly larger, the effect diminishes. In addition, although the portion-size effect is widespread and robust across a range of individual and environmental factors, the analysis shows that it is weaker among children, women, and overweight individuals, as well as for nonsnack food items and in contexts in which more attention is given to the food being eaten.

Keywords: portion size, food marketing, consumption norm, unit bias, obesity, supersizing

The maxim “bigger is better” seems to characterize both customer preferences and marketing efforts in many domains, particularly those of food and drink (Dubois, Rucker, and Galinsky 2012). By offering disproportionately large increases in portion sizes for “a few extra cents,” marketers win customers and profits (Dobson and Gerstner 2010). The widespread adoption of this strategy is reflected in growing portion sizes. For example, Coca-Cola bottles have grown from the original 6.5 oz. (192 ml) bottle to modern single-serve bottles of 10 oz. (300 ml), 16 oz. (500 ml), and 20 oz. (600 ml). Moreover, artistic depictions of the biblical Last Supper show that the quantities portrayed in the main dish, the amount of bread, and the size of the plate have increased over the past 1,000 years (Wansink and Wansink 2010).

Whether marketers have been responding to customer preferences for larger-sized portions or whether they have been shaping those preferences is not clear. What is clear is that consumers eat and drink more from larger portion sizes (Chandon and Wansink 2011; Wansink 2004). This has become a cause for concern, and marketers are increasingly challenged to consider the effects of portion size on consumption (Dobson and Gerstner 2010; Haws and Winterich 2013; National Alliance for Nutrition and Activity 2002). Morgan Spurlock famously drew public attention to marketers’ use of portion size in his 2004 documentary, *Super Size Me*. With worldwide attention on the “obesity epidemic” (Moore 2007; World Health Organization 2003, 2013), marketing and nutrition literature streams and government agencies have all identified food portion sizes as a potential contributing factor to rising obesity rates (Centers for Disease Control and Prevention 2004; Chandon and Wansink 2011; Rolls 2003; Steenhuis and Vermeer 2009; Young and Nestle 2002). New York City’s effort to restrict the sale of soft drinks of 16 oz. or more is evidence that social marketers and public health authorities are responding to the threat (Saul 2012). Although this attempt was resisted and ultimately overturned in court (Hughes 2013), the signal remains the same: social marketers and public health agencies regard portion size as a problem.

However, no one seems to have adequately quantified the size of the portion-size issue. We expect that an increase in portion size is linked with an increase in consumption, and we aim to show this linkage using standard meta-analytic techniques. However, we considered that it would be more useful to express *how much* consumption has changed as a function of increasing portion size. With this idea in mind, we developed an elasticity measure expressing consumption change as a function of portion-size change based on a linear regression analysis. Finally, we anticipate that the portion-size effect is limited or constrained under certain circumstances. First, we anticipate that the portion-size effect on consumption will diminish for very large portion sizes so that, eventually, increasing portion size will cease to have any effect on consumption. Second, we expect that

Natalina Zlatevska is Assistant Professor (e-mail: nzlatevs@bond.edu.au), Chris Dubelaar is Professor (e-mail: cdubelaa@bond.edu.au), and Stephen S. Holden is Associate Professor (e-mail: sholden@bond.edu.au), Faculty of Business, Bond University. The authors thank Lauren Block, Pierre Chandon, Peter Danaher, Wagner Kamakura, Harmen Oppewal, Gulasekaran (Sekar) Rajaguru, Mike Reid, and three anonymous *JM* reviewers for their helpful comments on previous versions of this article. Alexander Chernev served as area editor for this article.

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the portion-size effect will be moderated or constrained under at least some individual and environmental conditions. Before we proceed to quantifying the portion-size effect and exploring its limits, we first aim to clarify the concept of portion size and, in particular, to distinguish it from similar but distinct size-related manipulations.

A Disambiguation of Portion Size

In collecting studies that ostensibly related to manipulations of portion size, we found a confusing array of manipulations for portion size, serving size, package size, and so forth. We begin by setting aside the term "serving size" because it is a normative concept referring to a recommendation of the amount of food to consume (e.g., Mohr, Lichtenstein, and Janiszewski 2012). Typically, recommended serving sizes appear within standardized food information labels. Portion size is a descriptive concept referring to the quantity of food contained in a portion. It is usually indicated as the weight or volume of the contents of the package.[1] Thus, one portion size may contain more (or less) than one recommended individual serving size.

Next, we distinguish portion size and package size. This distinction is sometimes acknowledged by marketers through a notice advising consumers that the contents in the package may settle during shipment. Thus, the size of the container in which food or drink is served (be it a package, plate, or cup) is a factor that can be manipulated independently of portion size (e.g., Wansink 1996). In some studies, portion size and container size are confounded: a small portion is served on or in a small container and a large portion is served on or in a large container (e.g., Rolls, Roe, Krall et al. 2004; Van Kleef, Shimizu, and Wansink 2011). Although crossing portion size with container size is conceptually possible, it can be problematic because the physical limitations of putting a large portion into a small container can lead to an unbalanced design (e.g., Marchiori, Corneille, and Klein 2012). Container size is itself a conceptually multifaceted variable that can be broken down into container diameter, typically described as "plate size" (e.g., Koh and Pliner 2009; Rolls et al. 2007), and container volume (e.g., Stroeble, Ogden, and Hill 2009; Van Kleef, Shimizu, and Wansink 2011; Wansink 1996). Another variable related to the container is the "perceived size," which is influenced by the container shape; for example, a tall, thin glass appears to hold a larger quantity of drink than a short, squat glass (Wansink and Van Ittersum 2003, 2005). Other studies have focused on the size of the utensils used to serve or consume the food while the portion size (as we have defined it) remains fixed (e.g., Mishra, Mishra, and Masters 2012).

Another size variable researchers have examined is a difficult-to-define quality that we label "granularity." This variable refers to whether a portion has a fine granularity comprising many small parts or a coarse granularity comprising a few large parts. One form of granularity is partitioning, which is the manipulation of the number and size of packages that make up the portion size. For example, Do Vale, Pieters, and Zeelenberg (2008, Study 2) presented each participant in their study with either two 200 g packages of chips in one condition or nine 45 g packages of chips in another. The portion size was roughly equivalent, but the granularity was coarse in the first instance and fine in the second. Although the researchers referred to "large" and "small" package formats, respectively, we note that this labeling overlooks that package size is necessarily confounded with number: a few large packages versus multiple small packages. Another form of granularity relates to the size of the food morsels in the portion, or many small food morsels (e.g., mini cookies) versus fewer, larger food morsels (e.g., regular cookies) (see, e.g., Scott et al. 2008). Morsels and partitions are distinct and can be crossed or confounded. For example, in a study by Scott et al. (2008), the "small food configuration" comprised multiple small packages of many mini M&M's and the "large" configuration comprised a few large packages of fewer, regular-size M&M's.

In summary, there are several related but conceptually distinct manipulations of size. All can be manipulated independently and can therefore be crossed or confounded with portion size and one another. Although these other size manipulations are worthy of research, this article focuses on portion size and its effect on consumption.

Method

To conduct a meta-analysis to answer the questions about the size and extent of the portion-size effect, we initially looked for relevant papers through a search of ABI/INFORM, ProQuest Digital Dissertations, Business Source Premier, Web of Science, and other databases using keywords related to the size or amount of food offered. Some specific search terms were "portion size," "serving size," and "unit bias," used as a synonym for and potential explanation of the portion-size effect (Geier, Rozin, and Doros 2006). We also manually searched through the following journals and conference proceedings: *Journal of Marketing*, *Journal of Marketing Research*, *Journal of Consumer Research*, *Journal of Consumer Psychology*, *Journal of Public Policy & Marketing*, *Annual Review of Nutrition*, *American Journal of Clinical Nutrition*, *Body and Society*, *British Journal of Sociology*, *Social Science and Medicine*, *Appetite*, *International Journal of Obesity*, *Advances in Consumer Research*, American Marketing Association proceedings, and Obesity Society abstract supplements. When we found an article, we examined the references to identify further studies. In addition, we used Web of Science, Scopus, and Google Scholar to search the citations of included articles. The approach we used is consistent with several authors' recommendations (Hunter and Schmidt 1990; Rosenthal 1979). In an effort to counteract the file-drawer problem often associated with a meta-analysis, we placed a call on ELMAR (Electronic List for Marketing Academics and Researchers) for working papers. Finally, we sent e-mails to researchers in the domain asking for published and unpublished works. We received two articles from different

[1]Some researchers, particularly food and nutrition scientists, may report portion sizes in kilojoules or calories. This can be confusing because recommended serving size is often reported as kilojoules or calories on nutrition information labels.

authors as a result of our calls for unpublished research, but neither of them manipulated portion size as we define it.

The criteria for inclusion in the meta-analysis for quantifying the portion-size effect required that (1) the independent variable manipulated portion size of food or drink and (2) the dependent variable included an interpretable measure of consumption. Studies varied widely in terms of how consumption was measured. Most reported actual consumption, but there was considerable variation in the measures used, including grams, ounces, kilojoules, calories, and even percentages of a basic meal size (e.g., Levitsky and Youn 2004). Furthermore, some studies reported intended consumption; for example, "The subject was asked how much of the product she would use in this situation" (Wansink 1996, p. 3). Others measured perceived consumption; for example, "Participants were asked to estimate how many crackers they believed they consumed" (Wansink, Payne, and Shimizu 2011, p. 1098). Accordingly, we report on the portion-size effect for actual, intended, and perceived consumption separately.

Our search for research published through December 2013 returned 52 articles, which we broke down into 211 identifiable studies. However, we could not calculate effect sizes for 17 of the studies collected because 13 did not indicate the level of significance in the original article, and 4 studies were field based and did not provide the sample size. We excluded an additional 6 studies that examined nonfood consumption. Of the remaining 188 separate studies, 84 captured size manipulations other than portion size and were thus excluded, leaving us with 104 studies that captured the portion-size effect as we have defined it (for a detailed list of these studies, see Table 1). Of these 104 studies, 23 seemed to confound portion size with container size in their manipulation (marked in Table 1 with a superscript "a" in the "Data Identifier" column). In terms of the dependent measure, actual consumption was reported in 88 studies, intended consumption in 13, and perceived consumption in 3.

The first effect-size metric we examined was the standardized difference in means expressed as Cohen's d (Cohen 1988). The mean difference reflects how much more was consumed from the larger portion size than from the smaller or "control" portion size. Thus, a positive value for Cohen's d reflects the expected portion-size effect, with a larger mean difference reflecting a larger effect. We adopted a random-effects perspective: we assumed the true effect size to vary from one study to the next and that the studies represented a random sample of effect sizes (Hunter and Schmidt 1990).

We calculated Rosenthal's fail-safe N (Rosenthal 1979) for our study to be 1,554, this being "the number 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, p. 464). This number comfortably exceeds Rosenthal's (1991) recommendation that, for a robust meta-analysis, the fail-safe N should exceed 5k + 10, which is 530 (k = 104) in the current study. We also produced a funnel plot showing portion-size effects mapped against standard errors (see Figure 1). Most studies appeared within the funnel, as is typically expected, but there seems to be a skew such that studies with larger standard errors have larger effects. This could be interpreted as a possible publication bias (strong effects from "small" studies), but it is more likely that the variation in standard errors reflects different strength manipulations of portion size (Sterne et al. 2011). For example, two points (to the lower right outside the triangle) represented different conditions in an 11-day study (Rolls, Roe, and Meengs 2007): the larger standard errors arise because of the much-larger quantities of food being served. We examine the strength of the portion-size manipulation at length subsequently.

We directly established the heterogeneity of effect sizes through the I^2 index (Higgins and Thompson 2002; Huedo-Medina et al. 2006). The I^2 index is calculated with the formula $100 \times (Q - df)/Q$, where Cochran's Q is as defined by Hunter and Schmidt (1990). The I^2 index quantifies heterogeneity as low (25%), medium (50%), or high (75%) (Higgins and Thompson 2002). We report the observed heterogeneity of each calculated effect size in the following section.

Results and Discussion

Quantifying the Size of the Portion-Size Effect

Increasing portion size reliably increased consumption (d = .45, k = 88, I^2 = 65%). The top bar in Figure 2 shows the average size of the portion-size effect on actual consumption and the 95% confidence limits around the estimate. Figure 2 also shows that there was a significant but smaller effect of portion size on intended consumption (d = .18, k = 13, I^2 = 41%) and on perceived consumption (d = .38, k = 3, I^2 = 0%).

We note that a great deal of heterogeneity was observed in the effect size for portion size on actual consumption (I^2 = 65%). This relatively high level of heterogeneity is likely due to the treatment of all portion-size manipulations as equal, which is simply not the case. The size of the portion-size effect is likely to depend on the degree of change in portion size, an observation we made previously, in line with Sterne et al. (2011), as a potential explanation for the observed asymmetry in the funnel plot. This then highlights the limitations of the meta-analytic effect size, which treats all portion-size manipulations as constant. As Chernev, Bockeholt, and Goodman (2010) note, meta-analytic mean effect sizes are not easily interpreted beyond simple comparisons of "control" versus "treatment." Thus, the standard meta-analysis makes no allowance for the size of the change in portion size: a 50%, 100%, and 200% change in portion size are all treated the same, whereas a measure of effect scaled on the degree to which portion size has changed will address the high heterogeneity. Importantly, it will also provide a more practical and useful measure of the portion-size effect.

To estimate how much actual consumption changes as a function of the change in portion size, we developed scalar measures for both portion size and consumption. We recorded the proportional change in portion size as the change in portion size relative to the smaller portion (see Equation 1) and expressed the proportional change in con-

TABLE 1
Summary of Studies Used in the Portion-Size Meta-Analysis

Article	ID	Data Identifier[c]	Portion Served		Amount Consumed		Cohen's d	Moderators (Independent Variables)				
			"Small"	"Large"	"Small"	"Large"		Age[d]	Gender[e]	BMI[f]	Snack Food[g]	Food Focus[g]
Burger et al. (2011)	1	(Intended)	1 serve	2 serves	—	—	.04	1		0	0	1
Burger, Fisher, and Johnson (2011)	2	Blindfolded[b]	410 g	820 g	266.13 g	322.58 g	.21	1		0	0	0
	3	Not blindfolded[b]	410 g	820 g	283.87 g	383.87 g	.21	1		0	0	1
Diliberti et al. (2004)	4	[b]	248 g	377 g	234.4 8g	335.6 g	.59	1			0	1
Fisher (2007)	5	2–3 years, other serve[b]	200 g	400 g	93.66 g	102.11 g	.14	0		1	0	1
	6	2–3 years, self serve[b]	200 g	400 g	93.66 g	89.44 g	.14	0		1	0	1
	7	5–6 years, other serve[b]	250 g	500 g	157.04 g	204.23 g	.13	0		1	0	1
	8	5–6 years, self serve[b]	250 g	500 g	157.04 g	169.72 g	.13	0		1	0	1
	9	8–9 years, other serve[b]	450 g	900 g	254.23 g	286.62 g	.12	0		1	0	1
	10	8–9 years, self serve[b]	450 g	900 g	254.23 g	267.61 g	.12	0		1	0	1
Fisher, Arreola, et al. (2007)	11	Children, chicken[b]	152.07 g	304.14 g	110.33 g	147.52 g	.45	0		0	0	1
	12	Children, crackers[b]	40.06 g	80.12 g	20.35 g	24.89 g	.11	0		0	1	1
	13	Children, cereal[b]	40 g	80 g	27 g	40.75 g	.45	0		0	0	1
	14	Children, juice	240.23 mL	480.46 mL	172.34 g	172.34 g	.11	0		0	0	1
	15	Children, macaroni and cheese[b]	300 g	600 g	149.67 g	158.28 g	.11	0		0	0	1
	16	Mothers, cereal[b]	80 g	160 g	50.75 g	54.5 g	.11	1	0	1	0	1
	17	Mothers, chicken[b]	200 g	400 g	161.27 g	212.14 g	.26	1	0	1	0	1
	18	Mothers, crackers[b]	60 g	120 g	45.67 g	53.46 g	.11	1	0	1	1	1
	19	Mothers, juice	336 mL	672 mL	255.32 g	357.45 g	.45	1	0	1	0	1
	20	Mothers, macaroni and cheese[b]	400 g	800 g	240.4 g	280.79 g	.26	1	0	1	0	1
	21	Mothers, rice[b]	200 g	400 g	136.25 g	160 g	.11	1	0	1	0	1
Fisher, Liu, et al. (2007)	22	High energy density[b]	250 g	500 g	156 g	211 g	.69	0		0	0	1
	23	Reference energy density[b]	250 g	500 g	160 g	209 g	.61	0		0	0	1
Fisher, Rolls, and Birch (2003)	24	Children < 4 years of age	125 g	250 g	99 g	104 g	.30	0			0	1
	25	Children > 4 years of age	175 g	350 g	110 g	140 g	.47	0			0	1
Flood, Roe, and Rolls (2006)	26	Women[b]	360 g	540 g	300 g	331 g	.49	1	0	0	1	1
	27	Men[b]	360 g	540 g	320 g	403 g	1.13	1	1	0	1	1
Hermans et al. (2011)	28		—	—	388.1 9g	524.98 g	1.72	1	0	0	0	1
Jeffery et al. (2007)	29		767 kcal	1,528 kcal	687 kcal	1,019 kcal	1.14	1	0	1	0	1
Kral et al. (2009)	30	Applesauce[b]	122 g	244 g	90 g	129.1 g	.54	0		0	1	1
	31	Broccoli[b]	75 g	150 g	24 g	25 g	.05	0		0	0	1
	32	Carrots[b]	75 g	150 g	19 g	20 g	.08	0		0	0	1

TABLE 1
Continued

Article	ID	Data Identifier[c]	Portion Served		Amount Consumed		Cohen's d	Moderators (Independent Variables)				
			"Small"	"Large"	"Small"	"Large"		Age[d]	Gender[e]	BMI[f]	Snack Food[g]	Food Focus[g]
Kral, Roe, and Rolls (2004)	33	High energy density, S–M[b]	500 g	700 g	339.8 g	359.4 g	.29	1	0	0	0	1
	34	Low energy density, S–M[b]	500 g	700 g	357.9 g	416.8 g	.52	1	0	0	0	1
	35	High energy density, M–L[b]	700 g	900 g	359 g	392.9 g	.17	1	0	0	0	1
	36	Low energy density, M–L[b]	700 g	900 g	416.8 g	424.2 g	.06	1	0	0	0	1
Levitsky and Youn (2004)	37	Pasta, S–M	100%	125%	350 g	430 g	.60	1		0	0	1
	38	Bread sticks, S–M	100%	125%	11 g	14 g	.60	1		0	0	1
	39	Ice cream, S–M	100%	125%	59 g	85 g	.60	1		0	1	1
	40	Vegetable soup, S–M	100%	125%	130 g	160 g	.60	1		0	0	1
	41	Pasta, M–L	125%	150%	430 g	460 g	.60	1		0	0	1
	42	Bread sticks, M–L	125%	150%	14 g	16 g	.60	1		0	0	1
	43	Vegetable soup, M–L	125%	150%	160 g	190 g	.60	1		0	0	1
	44	Ice cream, M–L	125%	150%	85 g	97 g	.60	1		0	1	1
Looney and Raynor (2011)	45	Study 1	150 g	300 g	84.2 kcal	99 kcal	.07	0			1	1
Marchiori, Corneille, and Klein (2012)	46	(Medium portion size)/ (small container size) vs. (large portion size)/ (large container size)[ab]	200 g	600 g	30.4 g	59.8 g	.62	1		0	1	0
Raynor and Wing (2007)	47	Study 1[b]	813.3 g	1629.4 g	521.01 g	932.86 g	1.05	1		0	1	1
Rolls, Engell, and Birch (2000)	48	3.6 years, S–M[b]	150 g	263 g	44.8 g	54.6 g	.18	0	0	0	0	1
	49	3.6 years, M–L[b]	263 g	376 g	54.6 g	39.6 g	–.30	0	0	0	0	1
	50	5.0 years, S–M[b]	225 g	338 g	100.7 g	122.7 g	.36	0	0	0	0	1
	51	5.0 years, M–L[b]	338 g	450 g	76.7 g	100.7 g	.27	0	0	0	0	1
Rolls, Morris, and Roe (2002)	52	Plate, S–M[b]	500 g	625 g	340 g	374 g	.40	1		0	0	1
	53	Serving dish, S–M[b]	500 g	625 g	330 g	374 g	.42	1		0	0	1
	54	Plate, M–L[b]	625 g	750 g	374 g	410 g	.33	1		0	0	1
	55	Serving dish, M–L[b]	625 g	750 g	374 g	390 g	.35	1		0	0	1
	56	Plate, L–XL[b]	750 g	1,000 g	410 g	446 g	.40	1		0	0	1
	57	Serving dish, L–XL[b]	750 g	1,000 g	390 g	410 g	.42	1		0	0	1
Rolls, Roe, Kral, et al. (2004)	58	Women, S–M[ab]	28 g	42 g	25.48 g	34.21 g	.62	1	0	0	1	0
	59	Men, S–M [ab]	28 g	42 g	26.19 g	39.13 g	.73	1	1	0	1	0
	60	Women, M–L[ab]	42 g	85 g	34.21 g	50.2 g	.62	1	0	0	1	0
	61	Men, M–L[ab]	42 g	85 g	39.13 g	61.05 g	.73	1	1	0	1	0
	62	Women, L–XL[ab]	85 g	128 g	50.2 g	54.61 g	.15	1	0	0	1	0
	63	Men, L–XL[ab]	85 g	128 g	61.05 g	81.84 g	.73	1	1	0	1	0
	64	Women, XL–XXL[ab]	128 g	170 g	54.61 g	59.04 g	.15	1	0	0	1	0
	65	Men, XL–XXL[ab]	128 g	170 g	81.84 g	83.64 g	.33	1	1	0	1	0

TABLE 1
Continued

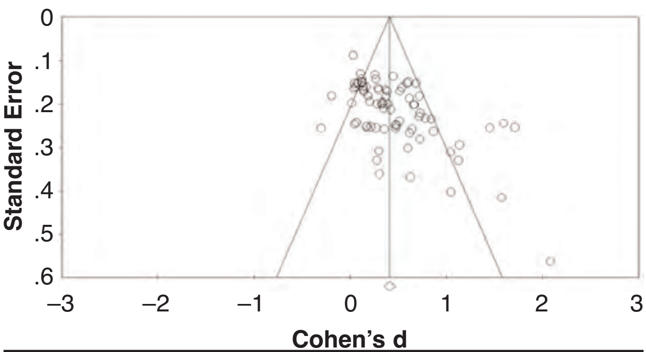
Article	ID	Data Identifier[c]	Portion Served		Amount Consumed		Cohen's d	Moderators (Independent Variables)				
			"Small"	"Large"	"Small"	"Large"		Age[d]	Gender[e]	BMI[f]	Snack Food[g]	Food Focus[g]
Rolls, Roe, Meengs, et al. (2004)	66	Women, S–M[b]	275 g	367 g	214 g	245 g	.39	1	0	0	0	1
	67	Men, S–M[b]	275 g	367 g	265 g	334 g	1.60	1	1	0	0	1
	68	Women, M–L[b]	367 g	458 g	245 g	249 g	.04	1	0	0	0	1
	69	Men, M–L[b]	367 g	458 g	334 g	383 g	.72	1	1	0	0	1
	70	Women, L–XL[b]	458 g	550 g	249 g	278 g	.30	1	0	0	0	1
	71	Men, L–XL[b]	458 g	550 g	383 g	415 g	.37	1	1	0	0	1
Rolls, Roe, and Meengs (2006a)	72	Women, S–M	100%	150%	4,400 kcal	5,000 kcal	.22	1	0	0	0	1
	73	Men, S–M	100%	150%	6,000 kcal	7,000 kcal	1.05	1	1	0	0	1
	74	Women, M–L	150%	200%	5,000 kcal	5,400 kcal	1.05	1	0	0	0	1
	75	Men, M–L	150%	200%	7,000 kcal	7,500 kcal	1.05	1	1	0	0	1
Rolls, Roe, and Meengs (2006b)	76	100% energy density	3,060 g	4,080 g	2,017 g	2,279 g	.79	1	0	0	0	1
	77	75% energy density	3,060 g	4,080 g	1,981 g	2,251 g	.73	1	0	0	0	1
Rolls, Roe, and Meengs (2007)	78	Men	2,135 g	3,154 g	1,918 g	2,215 g	1.58	1	1	0	0	1
	79	Women	1708.54 g	2500 g	1,439 g	1713 g	2.09	1	0	0	0	1
Scheibehenne, Todd, and Wansink (2010)	80	Eating in dark[b]	481 g	706 g	462 g	627 g	.87	1		0	0	1
	81	Eating in dark (perceived)	481 g	706 g	496 g	576 g	.48	1		0	0	1
	82	Eating in light[b]	451 g	636 g	432 g	525 g	.63	1		0	0	1
	83	Eating in light (perceived)	451 g	636 g	416 g	504 g	.31	1		0	0	1
Spill et al. (2010)	84	Carrots, S–M[b]	30 g	60 g	24.7 g	36.2 g	.59	0			0	1
	85	Carrots, M–L[b]	60 g	90 g	36.2 g	38.1 g	.27	0			0	1
Van Kleef, Shimuzu, and Wansink (2013)	86	Apple pie[b]	40 g	200 g	29.7 g	60.2 g	.67	1		0	1	1
	87	Chocolate[b]	10 g	100 g	6.5 g	8.3 g	.35	1		0	1	1
	88	Potato chips[b]	10 g	80 g	6.1 g	10.4 g	.67	1		0	1	1
Wansink (1994)	89	Diet Pepsi (intended)[a]	—	—	231 mL	334 mL	.52	1			1	
	90	Water (intended)[a]	—	—	352 mL	317 mL	.05	1			0	

TABLE 1
Continued

Article	ID	Data Identifier[c]	Portion Served		Amount Consumed		Cohen's d	Moderators (Independent Variables)				
			"Small"	"Large"	"Small"	"Large"		Age[d]	Gender[e]	BMI[f]	Snack Food[g]	Food Focus[g]
Wansink (1996)	91	Study 2, bottled water (intended)[a]	1,000 mL	2,000 mL	355 mL	410 mL	.65	1	0		0	1
	92	Study 2, tap water (intended)[a]	1,000 mL	2,000 mL	376 mL	387 mL	.17	1	0		0	1
	93	Study 3, regular price oil (intended)[a]	472 mL	944 mL	105 mL	137 mL	.28	1			0	1
	94	Study 3, sale price oil (intended)[a]	472 mL	944 mL	139 mL	141 mL	.02	1			0	1
	95	Study 4, Creamette spaghetti, S–M (intended)[a]	675 g	1,350 g	234 g	331 g	.38	1	0		0	1
	96	Study 4, Creamette spaghetti, M–L (intended)[a]	1,350 g	2,025 g	331 g	321 g	–.19	1	0		0	1
	97	Study 4, Crisco oil, S–M (intended)[a]	472 mL	944 mL	99 mL	134 mL	.38	1	0		0	1
	98	Study 4, Crisco oil, M–L (intended)[a]	944 mL	1,416 mL	134 mL	124 mL	–.19	1	0		0	1
	99	Study 4, M&M's, S–M (intended)[a]	114 g	228 g	63 g	103 g	.38	1	0		1	1
	100	Study 4, M&M's, M–L (intended)[a]	228 g	342 g	103 g	122 g	.19	1	0		1	1
Wansink and Kim (2005)	101	Fresh popcorn[ab]	120 g	240 g	58.9 g	85.6 g	1.45	1			1	0
	102	Stale popcorn[ab]	120 g	240 g	38 g	50.8 g	.85	1			1	0
Wansink, Painter, and North (2005)	103	[b]	510.3 g	—	240.97 g	416.73 g	.73	1		0	0	1
	104	(Perceived)	510.3 g	—	190.71 g	198.18 g	.28	1		0	0	1

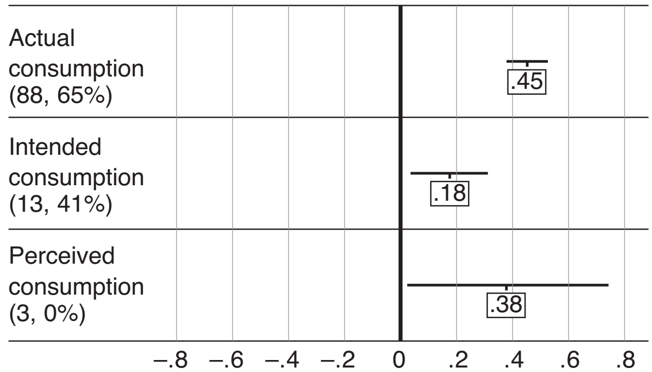
[a]These studies confounded container size with portion size.
[b]Studies in which portion served and amount consumed were codable in grams and were used in a test for curvilinearity.
[c]Independent variable (+ dependent variable if *not* actual consumption).
[d]0 = study with participants aged 15 years and younger, and 1 = study with participants older than 15 years.
[e]0 = female participants only, and 1 = male participants only.
[f]0 = participants' BMIs were ≤25, and 1 = participants' BMIs were >25.
[g]0 = no, and 1 = yes.
Notes: Article indicates the source; ID indicates the identification number assigned to each observation in the meta-analysis; Data Identifier provides a combination of key independent and dependent variables enabling the reader to identify the exact data used for each observation (line) in this table; Portion Served shows the "small" and "large" portion sizes (where available); Amount Consumed is shown for the "small" and "large" portions, respectively; Cohen's d is the measure of the effect size; and Moderators shows the value for each study on five moderators (with a missing value used to show if the study was not codable).

FIGURE 1
Funnel Plot of Cohen's d by Standard Error



Notes: The funnel plot displays each observation (k = 104) as a function of the effect size (Cohen's d) and the standard error. The angular lines mark the 95% confidence limits, with the expectation that most studies will fall within these lines. Asymmetry in the distribution of observations may suggest the operation of a bias.

FIGURE 2
Forest Plot of the Portion-Size Effect



Notes: The forest plot displays average effect sizes (shown as a number in the box below the bar on the right hand side) and their respective 95% CIs (indicated by the extremities of the bar) for three dependent variables: actual, intended, and perceived consumption. The numbers within the parentheses beneath each dependent variable label show the number of studies on which the effect-size estimate is based (k) and the heterogeneity of the estimate (I^2).

sumption as the change in consumption relative to the amount consumed from the smaller portion (see Equation 2).

(1) $\Delta S/S_S$, and

(2) $\Delta C/C_S$,

where
ΔS = change in portion size (larger portion size – smaller portion size),
S_S = smaller portion size,
ΔC = change in consumption (amount eaten from larger portion – amount eaten from smaller portion), and
C_S = consumption from smaller portion size

The effect of portion size was then estimated by the coefficient resulting from regressing the change in consumption (Equation 2) on the change in portion size (Equation 1) for k = 86 studies.[2] Because many of the articles used in the analysis provided multiple studies (see Table 1), and some of those articles used between-subjects designs and some used within-subject designs, we needed to implement a multilevel model to account for the fact that the observations were not all independent. Furthermore, because there is an infinite number of combinations of portion size possible for both large and small portions, we treated portion size as a random factor in the model, which enabled us to extrapolate to the population at large from our sample. This resulted in the following multilevel model:

$$\Delta C/C_{Sij} = B_{0j} + B_{1j} \times \Delta S/S_{Sij} + r_{ij},$$

$$B_{0j} = \gamma_{00} + \gamma_{01} \times \text{Design}_j + \gamma_{02} \times \text{Article(Design)}_j + u_{0j}, \text{ and}$$

$$B_{1j} = \gamma_{10} + \gamma_{11} \times \text{Design}_j + \gamma_{12} \times \text{Article(Design)}_j + u_{1j}.$$

Because all articles used either a within-subject or a between-subjects design, each article from which we obtained multiple studies is nested within design. The term Article is a series of 26 dummy variables to reflect that there are 27 articles from which we draw our data; thus, γ_{i2} is a coefficient reflecting the effect of each paper on the intercept and slope of the line. We first estimated the baseline model (intercept only) and then estimated the model with both intercept and slopes. The fit (given by –2 × log likelihood [–2LL]) for the intercept-only model is –23.02 and uses 1 degree of freedom. The intercept and slopes model we proposed uses 30 degrees of freedom and has a –2LL of –121.03, for a net change of 98.02 (distributed as χ^2) for 29 degrees of freedom ($p < .001$), indicating that our proposed model is a significant improvement on the baseline model. In this model, the intercept is nonsignificant, as we expected; the gammas for study design and 24 of the 26 dummy codes for articles are also nonsignificant. We obtained significant effects for the Fisher (2007) and Raynor and Wing (2007) articles only (–.21 and .39, respectively).

Across all food types and portion sizes (k = 86), our multilevel model shows that when portion size is doubled (i.e., when $\Delta S/S_S = 1$), the amount that respondents consume increases by 35% on average (B = .35, t = 3.33, $p < .01$, $R^2 = .89$). We note that it may be useful to interpret this coefficient as the portion-size elasticity of consumption. Although these results show that the portion-size effect is substantial, it is smaller than we would expect if consumption were guided by the portion size, as suggested by the notion of a consumption norm whereby people eat a fixed proportion of what they are served. If people were to follow such a rule or heuristic, we would expect a coefficient of 100%. The most common version of this explanation is that people tend to eat everything on their plate because of a norm or "unit bias" perhaps established by parental instructions received during childhood (e.g., Birch et al. 1987; Fay

[2]We could not include 2 of the 88 studies that examined actual consumption because they did not include portion sizes for both large and small portions (i.e., Hermans et al. 2011; Wansink, Painter, and North 2005). We consider neither "intended" nor "perceived" consumption in further analyses.

et al. 2011; Geier, Rozin, and Doros 2006; Wansink 2004; Wansink, Painter, and North 2005). However, a more general version is that people eat a *fixed percentage* of the portion served. Some are "plate cleaners" (Burger, Fisher, and Johnson 2011), some always leave 10% because it is considered polite to do so, and some eat only 50% of the portion because they are "on a diet." If consumers followed any of these rules, the expectation would be that "the percentage change in [portion] size would change consumption by the same percentage" (Geier, Rozin, and Doros 2006, p. 522). However, our analyses show that a 100% change in portion size leads to a 35% change in consumption, suggesting that if such consumption norms are operating, they are not driving the portion-size effect for everyone, or they represent an otherwise incomplete explanation.

The Limits on the Portion-Size Effect

The coefficient of 35% may reflect the average size of the portion-size effect across consumers: some people are following a consumption norm, but others are not. However, another possibility is that the coefficient represents an average across different degrees of portion-size change. That is, the consumption norm may operate for most people but only up to some point, at which it begins to break down. Ultimately, the portion-size effect must be reduced and even eliminated; otherwise, the outcome would be the same as for the character Mr. Creosote in the Monty Python film *The Meaning of Life*, who explodes as a result of eating too much. Accordingly, we would expect the doubling of a very small portion to have greater effect than the doubling of a very large portion.

Analytically, we expected the portion-size effect to be curvilinear. To test this idea, we first examined eight articles included in the meta-analysis that reported three or more levels of portion size and consumption (Kral, Roe, and Rolls 2004; Levitsky and Youn 2004; Rolls, Engell, and Birch 2000; Rolls, Morris, and Roe 2002; Rolls, Roe, Krall et al. 2004; Rolls, Roe, and Meengs 2006a; Rolls, Roe, Meengs et al. 2004; Spill et al. 2010) (for details, see Table 1). Each of these articles offered multiple portion-size changes from differing bases. For example, Rolls, Roe, Krall et al. (2004), using five portion sizes of chips (28 g [S], 42 g [M], 85 g [L], 128 g [XL], 170 g [XXL]), yielded four separate portion-size effects for men and women (i.e., eight studies): small to medium (S–M), medium to large (M–L), large to extra-large (L–XL), and extra-large to extra-extra-large (XL–XXL). Combining all these articles (k = 42) and coding the smallest portion size as "small," the next as "medium," and so forth, we found that the effect size became smaller for successively larger portion-size comparisons (as shown subsequently). This result is encouraging, considering that the size of the "small" portion varied across the eight articles:

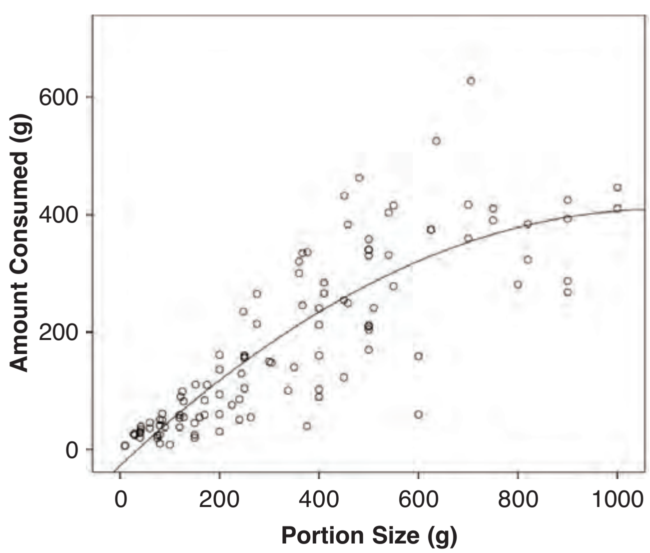
- Small to medium: $d_{S–M} = .56$, k = 17, $I^2 = 48\%$
- Medium to large: $d_{M–L} = .42$, k = 17, $I^2 = 57\%$
- Large to extra-large: $d_{L–XL} = .37$, k = 6, $I^2 = 0\%$
- Extra-large to extra-extra-large: $d_{XL–XXL} = .23$, k = 2, $I^2 = 0\%$

In a separate effort to search for curvilinearity in the portion-size effect in our data set, we examined all studies in which both portion size and consumption could be coded in grams (k = 71).[3] We also eliminated studies (k = 6) in which consumption reflected a sum across multiple eating occasions (Rolls, Roe, and Meengs 2006a, 2007) because they are not comparable with single-eating-occasion figures. This left us with 65 studies for this analysis (identified by a superscript "b" in the "Data Identifier" column of Table 1). We broke down each study into separate observations: one observation of grams served and grams consumed from the smaller portion, and another observation from the larger portion. The resulting data set comprised 109 observations[4] showing amount consumed as a function of amount served (as plotted in Figure 3) for a range of portion sizes (10 g to 1,629.40 g) and a range of foods and drinks. Fitting a curve to all 109 observations, we found that the portion-size effect was curvilinear (see Figure 3; consumption = .81 × portion size – 3.65×10^{-4} × [portion

[3]For this analysis, studies in which portion sizes were reported in volumes were converted to grams on the basis of a measure of density (grams/unit volume), if available, and studies in which portion size was reported in kilojoules (or calories) were converted on the basis of measures of energy density (kilojoules/gram), if available. We could not convert studies in which portions consisted of food representing mixed energy densities (e.g., a meal comprising different foods).

[4]The 65 studies yielded only 109 separate observations because some articles provided studies at multiple overlapping levels (e.g., S–M, M–L), as Table 1 shows. In such cases, we entered only one observation for each portion size. In addition, the grams served for the "larger" portion in Wansink, Painter, and North's (2005) bottomless soup bowl study were not fixed, which led us to exclude this observation; however, we retained the "smaller" portion observation.

FIGURE 3
Amount Consumed as a Function of Amount Served



Notes: The figure shows a plot of 109 observations of the average amount consumed by portion size. Modeling consumption as a quadratic function of portion size returned the following equation: Consumption = .81 × portion size – 3.65×10^{-4} × (portion size)^2, $R^2 = .74$.

size]^2; all coefficients significant at $p < .001$, $R^2 = .74$).[5] Together with our earlier subanalysis, the results confirm that the portion-size effect is likely limited for extremely large portions.

We reason that the portion-size effect operates because consumers rely on the external cue of portion size as a guide to consumption rather than internal cues such as satiation, at least for smaller portions. That is, they are sensitive to portion size but insensitive to internal cues. We note that this reasoning may seem difficult to reconcile with research showing that consumer judgments of quantity are insensitive to, and tend to underestimate, increases in portion size (Chandon 2009; Chandon and Ordabayeva 2009; Van Ittersum and Wansink 2012). The resolution is, we believe, that consumers may be using a heuristic—a consumption norm (i.e., eat a certain percentage of the portion)—while simultaneously failing to perceive how much larger a portion size may be. Therefore, the insensitivity of quantity judgment and the operation of a consumption norm jointly support the portion-size effect. Importantly, our data show that there is a limit to this effect as portion sizes increase, which we speculate may reflect internal cues such as satiation becoming more salient. Satiation is a complex construct (for a review, see De Graaf et al. 2004), but our purpose here is to advance a relatively straightforward explanation as to why a portion-size effect based on insensitivity to quantity and the use of consumption norms is unsustainable and ultimately diminishes or disappears.

Although our subanalyses show nonlinearity in the portion-size effect, we acknowledge that such results are based on a substantially reduced data set; however, we are encouraged that evidence of nonlinearity emerges despite the wide variety of food types represented. Although we have shown that there is a limit to the portion-size effect at larger portion sizes, we believe that much more work and many more data points are required to explore more completely the curvilinearity of the portion-size effect.

In addition to the limits imposed on the portion-size effect by physical limits and satiation, social agencies concerned about containing the portion-size effect are likely to be very interested in understanding the individual and environmental factors that attenuate or eliminate the effect. Despite the extensive number of studies in the literature examining the portion-size effect, there are few consistent theories describing any clear boundary conditions. Rather, most studies tend to show that the effect is robust across a wide range of contexts. For example, the portion-size effect operates across a range of individual characteristics: both men and women show the effect (Rolls, Roe, and Meengs 2007), it is unaffected by body mass index (BMI) (Fisher, Arreola, et al. 2007), and it is evident even among those with interest and/or expertise in nutrition (Chandon and Wansink 2007; Tangari et al. 2010; Wansink, Van Ittersum, and Painter 2006). Researchers have also shown that the effect operates across a surprisingly wide range of environmental conditions. For example, studies have shown that it operates even for less palatable foods (Wansink and Kim 2005) and in situations in which the subjects are literally blind to the portion size. Wansink, Painter, and North (2005) show that people ate significantly more from a "bottomless bowl" of soup that was continually and surreptitiously refilled (thereby disguising portion size) than those eating from the same size soup bowl that was not being refilled. Researchers have also documented the portion-size effect in a "dark restaurant" where customers were served by blind people and ate their meals in complete darkness (Scheibehenne, Todd, and Wansink 2010). The only factor that seems to have consistently reduced the portion-size effect is age: several studies have suggested that portion size does not strongly affect consumption by younger children (Birch et al. 1987; Fisher 2007; Fisher, Rolls, and Birch 2003; McConahy et al. 2002; Rolls, Engell, and Birch 2000). However, young adults show a portion-size effect similar to that of adults (Levitsky and Youn 2004; Looney and Raynor 2011).

Notwithstanding the bulk of research showing few moderators of the effect, we considered it worthwhile to examine a limited set of individual factors (age, gender, and BMI) and environmental factors (snack food and food focus) that might be identified as having some potential influence on the portion-size effect. We examined age because previous research has suggested that it is a moderator of the effect, so we coded studies as comprising respondents who were ≤15 or >15 years of age. Although there is no evidence that gender moderates the portion-size effect, many studies have reported the results for men and women separately, thereby enabling the testing of gender as a moderator. At least one study of BMI indicates that it has no influence on the portion-size effect (Fisher, Arreola, et al. 2007); nevertheless, the possibility that higher-BMI people are more susceptible to the portion-size effect warrants examination in view of research suggesting that they are less able to monitor internal cues of satiation and rely more on external consumption cues (Wansink, Payne, and Chandon 2007). Therefore, we coded and recorded as separate studies, when possible, the results for those samples with an average BMI > 25 versus those with a BMI ≤ 25.

In terms of environmental factors, we examined snack food and food focus. Although there is no evidence that snack foods are more subject to a portion-size effect than nonsnack foods, there has been a tendency in the criticism of supersizing to conflate the portion-size effect with unhealthy snack foods. In effect, if the portion-size effect works equally for unhealthy foods and healthy ones, this presents an opportunity for social marketers to supersize healthy foods. Accordingly, we coded studies as using snack food (e.g., M&M's) versus nonsnack foods (e.g., pasta, water) when possible. Finally, Wansink (2010a, b)

[5]We estimated this as a simple regression of consumption on portion size on the k = 109 data points. Because of the nonindependence of our data, we also ran a model with portion size as a random coefficient, which returned a similar result and fit ($R^2 = .65$). However, this function showed a decline for portion sizes beyond 800 g, which seems highly unlikely. In addition, we ran a log-log model, which also provided a good fit ($R^2 = .77$), but a plot of this function showed that it was virtually linear for the range of portion sizes across which it was estimated. Altogether, these results confirm our expectation that the portion-size effect is curvilinear.

suggests that mindlessness is a major factor contributing to overeating and the portion-size effect. If true, greater attention to the food during the consumption episode might limit the portion-size effect to some extent. Therefore, in an effort to capture some degree of the mindless–mindful dimension, we coded studies as having a food focus (participants knew their food consumption was being monitored) or no food focus (participants were not aware that their food consumption was being monitored). In the "no food focus" condition, the researcher's interest in food consumption was disguised by presenting the food incidentally and, in some instances, through a cover story. We reasoned that when there was no food focus, consumption would be more mindless.

To assess moderation effects, we returned to our elasticity model and again used a random coefficients model to examine for an interaction of each moderator (e.g., age) with portion-size change (i.e., $\Delta S/S_S$) (see Table 2). Note that we could not code all studies on all moderators (see missing values in Table 1), and only a limited crossing of moderators was available, meaning that moderators may be confounded with one another and with other unspecified variables. For example, all the studies identified as high BMI (>25) comprised adult female respondents only. Thus, we had no observations for high-BMI men or children. To maximize the number of available observations for each moderator, we used the simpler linear model showing change in consumption as a function of change in portion size; however, we note that the results should be treated with caution. We offer our analysis to encourage and assist further research endeavors in this important and underexamined area.

The results for the moderator analysis confirm that the portion size effect is robust and is observed across all conditions examined (see Table 2). Nonetheless, the results suggest that the size of the portion-size effect varies for different individual characteristics. Adult consumption increased by 39% for a doubling of portion size but increased by only 20% for children. We found that men responded to a doubling of portion size with a 52% increase in consumption and women responded with a 27% increase in consumption, a result we did not expect that calls for more investigation. Overweight people (BMI > 25) responded less (18%) to a doubling in portion size than did those with a BMI of 25 or less (34%). This result was also unexpected because it challenges research suggesting that overweight people are less sensitive to satiation and more sensitive to external cues (Wansink, Payne, and Chandon 2007). In terms of environmental factors, people responded more to a doubling of portion size of snack foods (37% increase in consumption) than to nonsnack foods (27%). When respondents were told that the study was about food, they responded less to a doubling of portion size (26%) than when there was no food focus (45%). This finding is consistent with the notion that mindfulness might help overcome overconsumption and the portion-size effect (Wansink 2010a, b).

General Discussion

Our research makes four significant contributions. The first is to clarify the conceptualization of portion size and related size manipulations and their effects on consumption. We have defined an array of distinct size-related constructs: portion size (quantity of food in the portion), container size (diameter and volume), container shape (perceived size), utensil size, and granularity (size of partitions and food morsels). Our research highlights the need for researchers to define size manipulations more clearly. For example, the tendency for marketing researchers to examine the effects of "small" and "large" granules (e.g., partitions, food morsels) on consumption consistently overlooks that granularity manipulates both number and size simultaneously. Any explanation attributed to granule size could equally be attributed to granule number because the two are necessarily confounded.

Our second key contribution is to quantify the portion-size effect. The meta-analysis revealed that the portion-size effect was a medium-sized effect (d = .45). This fits the standard method of establishing effect sizes, but it does not offer much useful insight for understanding how much portion size affects consumption. Through a more in-depth analysis, we establish that a doubling of portion size leads

TABLE 2
Results for Moderators of the Portion-Size Effect (Random Coefficients Model)

Moderator	Model	Estimate	t-Value	*p*-Value	Model Fit: R^2	Model Fit: –2LL
Age	$\Delta S/S_S$	.20	4.73	<.001	.89	–72.93
	Adults × $\Delta S/S_S$	.19	3.56	<.01		
Gender	$\Delta S/S_S$	.27	8.19	<.001	.64	–65.36
	Males × $\Delta S/S_S$	.25	2.60	.01		
BMI	$\Delta S/S_S$	.18	3.30	<.01	.88	–67.38
	BMI ≤ 25 × $\Delta S/S_S$	.16	2.51	.02		
Snack food	$\Delta S/S_S$	.37	8.01	<.001	.79	–64.59
	Not snacks × $\Delta S/S_S$	–.11	–1.89	.07		
Food focus	$\Delta S/S_S$	.26	9.20	<.001	.85	–67.56
	No food focus × $\Delta S/S_S$	.19	2.76	.01		

Notes: Moderator indicates the variable being examined, Model indicates both a term for the portion-size effect ($\Delta S/S_S$) and a term for the interaction of the moderator with the portion-size effect, Estimate is the regression coefficient, t-value and *p*-value provide the tests of significance for each coefficient, and Model Fit provides measures of the fit of the model to the data.

to a 35% increase in consumption on average across a range of food types and contexts.

Our third contribution is to show that the portion-size effect is curvilinear. In two separate subanalyses of our data, we show that the increase in consumption with increasing portion size dropped off as the portion sizes grew larger. For smaller portion sizes, we believe that consumption norms may be largely driving the portion-size effect; however, the portion-size effect is eliminated for larger portion sizes, perhaps because of an increasing salience of and reliance on internal cues.

Our fourth contribution is to explore conditions under which the portion-size effect is reduced. Our analyses suggest that the portion-size effect was attenuated for children, women, people with high BMIs, nonsnack foods, and eating with a food focus. These findings suggest that the moderators of the portion-size effect provide fruitful avenues for further research.

Overall, our results imply that increasing portion size leads to real and important increases in consumption. Without any corresponding increase in energy output, we would expect the increase in consumption to contribute to significant weight gain. Indeed, studies confirm that offering large portion sizes delivered over multiple sessions and meals does result in weight gain (Jeffery et al. 2007). Conversely, and as the portion-size effect predicts, longer-term studies have found that reduced portion sizes successfully reduced consumption (Freedman and Brochado 2010).

The implication for governments and social agencies concerned about obesity is that portion size may be an important contributing factor and that efforts to limit portion size may prove helpful (Goldman and Patton 2012). However, our finding that overweight people respond less to the portion-size effect than others raises the concern that downsizing may do little to help those who are already overweight.

Another of our results suggests that current parental interventions in childhood may be unhelpful. The finding that children's consumption is apparently less affected by portion size than that of adults suggests that learning, acculturation, and adaptation play a role (e.g., Birch et al. 1987). Simplistic rules such as "eat everything on your plate" create norms that may contribute to the problem (Wansink, Payne, and Werle 2008). Parents demanding that children eat their greens before a dessert may also be "training" children to override the internal cues that may naturally serve to limit the operation of the portion-size effect.

Future Directions for Research

Our research offers multiple rich pathways for exploring portion size and related size manipulations. More work is required to tease apart the operation of the process through which the portion-size effect occurs. On the one hand, we fear that the quantification of the portion-size effect in our research may be underestimated because many researchers, keen to avoid "floor" effects, tend to choose generous small portion sizes in their studies, so the observed portion-size effects may be relatively constrained. On the other hand, the fears raised about the portion-size effects may be overstated because our research shows there are limits to the effect. We have speculated that internal cues such as satiation will ultimately limit the effect, and we have empirically shown that there is a decline in the effect for larger portions. We believe that scholars need to pay more attention to exploring and delineating the nonlinear nature of the portion-size effect.

We have also explored various moderators of the effect, but we acknowledge that our work is tentative. However, what we offer should encourage more systematic investigation of the boundary conditions—in particular, when do people switch off their consumption norm, and when do they stop eating? We believe that there is much to be learned by investigating people's thoughts and beliefs around cessation of eating. Scholars might use protocol research to understand whether people are monitoring their hunger, their satiation, or both, and how and whether these factors interact with external factors such as portion size. We have speculated that the portion-size effect may be mediated by a consumption norm—a rule about what proportion of a portion one "ought" to eat. If true, this norm, like many heuristics, may operate beneath awareness and may be difficult to eliminate.

Finally, we note that our own research was hindered by the widely varying approaches adopted by researchers in examining and reporting portion-size effects. In particular, studies used many different metrics for reporting portion size and consumption, making comparisons extremely difficult or impossible. We addressed this limitation in part by offering a clear conceptualization of the various types of size manipulations. We hope that future researchers will consider reporting manipulations and measures in weight to allow for easier comparison of the absolute size of the portion-size effect in specific studies and future meta-analyses.

Marketing Implications

The clear implication of our research is that supersizing comes with a catch. Larger portions may facilitate sales, but they also increase consumption. A doubling of portion size leads to a 35% increase in consumption on average—potentially more when doubling smaller portions and potentially less when doubling larger portions. Encouragingly for the social researchers concerned about the contribution of portion size to obesity, our research shows that the portion-size effect has limits, although the tolerance of public agencies will surely be tested even before consumers "burn out" (Ma, Ailawadi, and Grewal 2013; Wansink 2012). To stave off the inevitable attack from governments and social agencies concerned about obesity, the obvious but unpalatable truth is that portion sizes should be restricted or reduced (e.g., Wansink and Van Ittersum 2007). Our results suggest that reducing portion sizes will reduce consumption and, given the curvilinear relationship we found, with potentially greater effect in the domain of smaller portions. Although marketers may be reluctant to give up the apparent profitability of larger and established sizes (Jain 2012), some encouraging research has suggested that consumers may be willing to choose a smaller portion option—even if not discounted or if charged a premium on the price per unit

(Schwartz et al. 2012; Wansink 2012). That is, at least some customers may pay a premium for a smaller portion. Moreover, public concern about obesity may make this segment increasingly important. Other possibilities include working with rather than against the portion-size effect. For example, the portion-size effect is robust and works for snack foods and healthier foods (albeit to a lesser extent). Therefore, a dual approach for addressing social concerns about overeating and obesity would be to encourage supersizing of healthy foods while limiting such practices among unhealthy foods.

Finally, the results from the food focus moderator are promising, suggesting that "mindfulness" may help mitigate the portion-size effect, as Wansink and Sobal (2007; see also Wansink 2010a, b) suggest. Although our results do not show the portion-size effect completely eliminated for food focus, nor indeed for any of the moderators, they do suggest that encouraging people to be more conscious while consuming food could be useful. Given the finding that children are less affected by the portion-size effect, we speculate that mindfulness essentially undoes people's training to "eat everything" they are served in a single portion and instead inclines them to tune in to internal cues.

It is clear that consumers do use portion size as a guide to consumption, leaving marketers with an obligation to be mindful of the size of the portions that they market. Our research shows that the effect is robust and observed across many conditions, but there is at least some promise that several factors may help reduce the effect. Overall, we offer marketers more understanding of the portion-size effect so that they may be better equipped to address how portion size might be used in marketing.

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