

Understanding consumer response to product supersizing and downsizing is important for policy makers, consumer researchers, and marketers. In three laboratory experiments and two field studies, the authors find that changes in size appear smaller when packages and portions change in all three spatial dimensions—height, width, and length—than when they change in only one dimension. Specifically, they show that size estimations follow an inelastic power function of the actual size of the product, especially when all three spatial dimensions change simultaneously. As a result, consumers are more likely to supersize their orders when products change in one dimension and are more likely to downsize their orders when products change in three dimensions. When changing dosage, consumers pour more product into and out of conical containers (e.g., martini cocktail glasses, in which volume changes in three dimensions) than cylindrical containers (e.g., highball glasses, in which volume changes in one dimension). Finally, consumers expect (and marketers offer) steeper quantity discounts when products are supersized in three dimensions than when they are supersized in one dimension, regardless of whether size information is present.

Keywords: packaging, purchase quantity, food, visual biases, estimation, psychophysics

Supersize in One Dimension, Downsize in Three Dimensions: Effects of Spatial Dimensionality on Size Perceptions and Preferences

Product package and portion sizes have grown significantly over the past decades. During the past 20 years, for example, portion sizes have increased by 60% for salty snacks and 52% for soft drinks (Nielsen and Popkin 2003). Because larger package and portion sizes increase consumption intake, the “supersizing” trend is believed to be a prime driver of the current obesity epidemic (Ledikwe, Ello-Martin, and Rolls 2005; Wansink 1996). To respond to pub-

lic concerns about overconsumption and to reduce the threat of adverse regulation and litigation, some companies have recently begun downsizing their portions and packages. For example, in 2003, Kraft Foods successfully introduced 100-calorie packs for its cookies; in 2007, the restaurant chain TGI Friday’s introduced “Right Portion, Right Price” menu items, which were 30% smaller and 33% cheaper than regular-size portions. Concurrent with the problem of overconsumption, concerns about the rising production and environmental costs of packaging have encouraged companies such as Nestlé Waters and Coca-Cola to switch to less elongated packages, which require less packaging material for a given volume (Deutsch 2007).

In these circumstances, the issue of how consumers respond to changes in both the size and the shape of portions and packages has become important for marketers who want to increase the purchase and consumption of their products, as well as for consumers and regulators who are

*Pierre Chandon is Associate Professor of Marketing (e-mail: pierre.chandon@insead.edu), and Nailya Ordabayeva is a doctoral candidate (e-mail: nailya.ordabayeva@insead.edu), INSEAD. This article has benefited from the comments of Meg Campbell, Klaus Wertenbroch, Ziv Carmon, Philippe Delquié, Marwan Sinaceur, and Xavier Drèze. The authors thank Amit Sood, Armando Baquero, Liselott Pettersson, Cécile Adam, Joseph Lajos, Tomasz Obloj, Wenjie Tang, Imran Chowdhury, Alfonso Pedraza-Martinez, Moqi Xu, and Sam Aflaki for their help with the data collection. Dominique Hanssens served as associate editor for this article.

concerned about improving size estimations and reducing overconsumption. In recent years, a growing body of research has examined the effects of visual biases on consumer behavior (Krishna 2007). Studies of size-based biases have shown that people underestimate the magnitude of changes in portion or package sizes (Chandon and Wansink 2007b; Krider, Raghubir, and Krishna 2001). Studies of shape-based biases have shown that elongated objects appear larger than less elongated objects of the same size (Krishna 2006; Raghubir and Krishna 1999; Wansink and Van Ittersum 2003).

However, none of the existing studies have examined the effects of the shape of the size change itself and, in particular, the key issue of the spatial dimensionality of this size change. By spatial dimensionality, we mean the number of axes in a Cartesian coordinate system along which a package or portion is supersized or downsized. For example, marketers can supersize a cylindrical soft drink by increasing its height—a one-dimensional (1-D) change—or by increasing both its height and diameter—a three-dimensional (3-D) change because the package increases along all three spatial dimensions (height, width, and length). Because a 3-D object can be increased in one, two, or all three spatial dimensions, the dimensionality of size change is not confounded with the dimensionality of the object itself.

The goal of this research is to examine the effects of the spatial dimensionality of portion or package size changes on consumers' estimations of product volume, on their preferences for supersizing and downsizing in purchase and consumption decisions, and on the magnitude of the price discounts offered for buying larger sizes. Drawing on research on visual biases, our main hypothesis is that people are less sensitive to size changes when packages and portions change in all three dimensions than when they change in only one dimension. We find strong support for this hypothesis across five experiments, three in the laboratory and two in the field.

This research contributes to the literature on visual biases by showing the importance of studying the interaction of shape and size effects rather than focusing on each effect separately. In particular, we show that when a reference size is available, the elongation of the size change matters more than the elongation of the final object itself. For example, we find that a short, wide 100-gram cylindrical candle appears larger than a taller, thinner 100-gram candle if the short, wide candle was created by increasing the height of a shorter 50-gram candle with the same diameter and the tall, thin candle was created by increasing both the height and the diameter of another 50-gram candle with the same height-to-width ratio as the taller, thinner candle.

Our finding that spatial dimensionality influences consumers' willingness to pay (WTP) for larger packages and their purchase and consumption quantity decisions also shows that its effects are not simple response biases due to the unfamiliarity of the task and scale; this finding has important implications for consumers and marketers. In particular, our results show that consumers demand lower unit prices for larger packages not just because of diminishing marginal utility or storage costs but also because they underestimate the actual increase in product quantity provided by larger packages. Finally, we show that providing objective volume information improves the accuracy of size

estimations but does not reduce the effects of dimensionality on WTP for size increases. From a public policy perspective, we find that changing product sizes in one dimension encourages downsizing and reduces the risk of people consuming too much alcohol or overdosing medicine to infants.

HOW PEOPLE ESTIMATE PACKAGE OR PORTION SIZE CHANGE

When assessing portion size (e.g., of meals served in restaurants), size information is not mandatory, and consumers have little choice but to estimate it visually. In this context, several studies show that people are unable to judge portion sizes accurately and are often unaware of changes in portion size and that their estimations are biased by visual cues linked to the size and shape of the portion (Chandon and Wansink 2007b; Wansink, Painter, and North 2005). For most packaged goods, it is possible to know the magnitude of a package size change by simply reading the size information on the label. Still, surprisingly few people actually do so, and research has shown that people rely instead on nutrition claims or primes (Chandon and Wansink 2007a; Wansink and Chandon 2006). Consumers with low levels of education find size information to be difficult to read and process, especially when it uses nonmetric units (Viswanathan, Rosa, and Harris 2005). Finally, many consumers use the size of the package or portion itself as a proxy for the volume or weight of the product it contains. Lennard and colleagues (2001) find that 47% of consumers believe that, in general, the physical size of the package is a reliable guide to how much it contains.

Size Effects

Research in psychophysics has shown that visual estimations of the volume of an object follow an inelastic power function of the object's actual size (Stevens 1986). This relationship, the power law of sensation, is expressed mathematically as follows:

$$(1) \quad \text{ESTSIZE} = a \times (\text{ACTSIZE})^b,$$

where ESTSIZE is the estimated size, ACTSIZE is the actual size, a is an intercept, and b —the power exponent—captures the elasticity of the estimation and is always less than 1. Equation 1 has several notable properties. Estimations are nonlinear and exhibit marginally decreasing sensitivity (i.e., they are inelastic), such that the subjective impact of increasing object size diminishes as the size of the package increases. As a result, people underestimate the magnitude of size changes. If the actual volume is multiplied by a factor of r , the perceived volume is multiplied by a factor of $(r)^b$, which is a smaller number because $b < 1$. For example, if $b = .6$, a typical number when estimating the size of 3-D objects, an object three times larger appears less than two times larger ($3^{.6} = 1.93$).

There is considerable empirical evidence that people's estimations of the size of a variety of geometrical objects are inelastic. In her review of psychophysics research on size perception, Krishna (2007, p. 180) states that "the exponent range of .5–1.0 appears fairly robust and generalizable across shapes of the same dimensionality." These results were replicated in various consumer contexts, such as when estimating the sizes of round and square pizzas

(Krider, Raghubir, and Krishna 2001), the sizes of fast-food meals (Chandon and Wansink 2007b), or the quantity of product in home pantries (Chandon and Wansink 2006). Although familiarity, expertise, and self-construal traits (but not gender) influence the elasticity of size estimations, almost all people provide inelastic size estimations (Krishna, Zou, and Zhang 2008).

Interaction of Size and Shape Effects: Effects of the Dimensionality of Size Change

Several studies have examined the effects of the shape of an object on estimations of its size when size itself is held constant. The major finding of these studies is that people perceive objects with a higher height-to-width ratio as larger than less elongated objects of the same size, a phenomenon referred to as the “elongation bias” (Piaget 1969). For example, tall, thin glasses are perceived as containing a greater volume than short, wide glasses (Raghubir and Krishna 1999; Wansink and Van Ittersum 2003). This effect persists even with real packages that provide volume information. Yang and Raghubir (2005) find that, on average, people’s volume estimations are 16% higher for beer bottles than for beer cans that are the same size but less elongated.

Recent studies have expanded these results and reversed the elongation bias in some conditions. Krishna (2006) finds that the elongation bias does not hold when people touch a glass without looking at it. Folkes and Matta (2004) do not find the elongation bias for complex package shapes; rather, they find that people perceive unusual package shapes that attract more attention as larger. Although all these studies examine how object shape influences perceived size when size is held constant, they do not examine whether the shape of the size change itself (i.e., how the object “grows”) influences the perceived magnitude of the size changes.

Several studies have estimated psychophysical functions for objects of different dimensionality (Ekman 1958; Frayman and Dawson 1981; Teghtsoonian 1965). These studies find that people’s estimations of the length of a line are fairly accurate, with exponents close to 1.0. In contrast, people’s estimations of the area of two-dimensional (2-D) objects are inelastic, with exponents between .7 and .8 across a variety of object shapes. Estimations of 3-D objects, such as cylinders or spheres, are often even less elastic, with exponents around .6. These differences are probably determined by multiple factors (for a review, see Krishna 2007) and can be explained by biases in information selection (ignoring the second or third dimension), biases in information integration (incorrectly combining the information from the different dimensions, for example, by adding them instead of multiplying them), differences in the salience of dimensions, and differences in the attention-getting effects of objects of different dimensionality. In any case, these results suggest that the dimensionality of objects systematically influences the elasticity of size estimations, with higher dimensionality leading to lower size estimation elasticity.

Still, these studies alone do not provide conclusive evidence that resizing an object along one or multiple dimensions influences people’s perceptions of the magnitude of the size change. First, these findings are based on estimations of the sizes of objects that are one-dimensional, two-dimensional, or three-dimensional by construction (e.g.,

lines for 1-D objects, rectangles for 2-D objects, and cylinders for 3-D objects). Therefore, the elasticity results may be caused by the specific visual properties of the objects themselves (e.g., their shape or texture) and not just by their dimensionality. This may explain some inconsistent findings, such as those of Moyer and colleagues (1978), who find a lower exponent for the estimation of a 2-D object (the area of U.S. states on a map) than for the estimation of 3-D objects (tennis balls and volley balls). A second, and more important, limitation of these studies is that the differences in exponents may be driven by the dimensionality of the objects themselves and not by the dimensionality of the size changes. Indeed, it is possible to increase the size of a 3-D object along one dimension only (e.g., by changing only its height), along two dimensions (e.g., by changing its height and width), or along all three dimensions.

Only two extant studies have manipulated the dimensionality of a size increase while holding the shape of an object constant. The first (Pearson 1964) shows that decreasing the height of a cylinder while holding its diameter constant reduces its apparent volume faster than when decreasing its diameter while holding its height constant. The second (Frayman and Dawson 1981) also finds that people’s estimations of the volume of a cylinder are more elastic when the height of the cylinder is decreased than when the height-to-diameter proportion of the cylinder is maintained (and thus the size is decreased along both dimensions). However, Frayman and Dawson’s (1981) results are statistically significant only for the smallest sizes of their set (8 centimeters³, or .27 fluid ounces), which is much smaller than most portions and packages on the market. In addition, these studies use abstract geometric objects (wooden cylinders) and arbitrary units (a comparison with a standard sphere assigned a value of 100 points). It remains to be determined whether their results will hold among consumers estimating familiar product packages or food portions and with the smaller magnitudes of size changes typically observed in commercial products.

In summary, psychophysics studies lead us to expect that estimations of the size of product packages or food portions follow an inelastic power function of their actual size. Furthermore, we hypothesize that size estimations are even less elastic when a package or portion is increased or decreased along all three dimensions than when it is changed along one dimension only. We test these two hypotheses in Study 1.

STUDY 1: EFFECTS OF RESIZING DIMENSIONALITY ON SIZE ESTIMATIONS

Method

Study 1 uses a mixed design with six within-subjects size conditions (50, 100, 200, 400, 800, and 1600 grams) and two between-subjects resizing dimensionality conditions (1-D or 3-D resizing). An experimenter recruited people near a large urban university to participate in a study about packaging in exchange for a voucher for a sandwich and a soda. The experimenter implemented the between-subjects dimensionality manipulation by assigning each participant to one of two rooms. In both rooms, participants viewed color pictures of six ordinary cylindrical candles, which were identical except for their size. The six pictures were arranged in increasing order on a table and were labeled A–

F. We told the participants that the smallest candle weighed 50 grams and asked them to write the size (in grams) of the remaining five candles in whatever order they wanted. We chose grams as the size unit because candles are typically sold by weight and people are more familiar with grams than with other size measures, such as centimeters³. Candles are sometimes described in terms of burn time, but we did not choose this unit because the shape of a candle can influence how fast it burns. We assumed a one-to-one correspondence between participants' estimations of volume and weight change because the stimuli were identical across the resizing conditions in every respect except for size.

We chose ordinary cylindrical candles as stimuli because they are familiar objects commonly available in a variety of sizes (e.g., from 50 grams, a typical size for a glow candle, to 1.6 kilograms, the approximate size of a medium decorative pillar candle). Table 1 shows the dimensions of the 12 candles used in Study 1 (pictures appear in the Web Appendix at <http://www.marketingpower.com/jmrdec09>). The largest candles (Size F) were identical in the two dimensionality conditions. In the 1-D size change condition, the smaller candles were created by halving their height from one size to the next. In the 3-D size change condition, the height and diameter of the candles were both reduced by 20.6% from one size to the next, which is enough to halve the volume of the cylinders. Thus, the candles were shorter and wider (less elongated) in the 1-D condition than the same-size candles in the 3-D condition.

Results

To test whether the elasticity of size estimations is lower in the 3-D condition than in the 1-D condition, we first fit a power model for each of the 60 participants (using the five estimates they provided) by linearizing the power model shown in Equation 1 as follows:

$$(2) \quad \ln(\text{ESTSIZE}) = \alpha + \beta \times \ln(\text{ACTSIZE}) + \epsilon,$$

where ESTSIZE is estimated size, ACTSIZE is actual size, α and β are the two model parameters (and are related to the parameters in Equation 1 as follows: $\alpha = \ln(a)$ and $\beta = b$), and ϵ is the error term. The mean value of the power exponent was .87 (SE = .02) across participants in the 1-D condition and .63 (SE = .03) across participants in the 3-D condition. As we expected, both exponents were significantly smaller than 1 (in the 1-D condition, $t = -5.6$, $p < .001$; in the 3-D condition, $t = -13.5$, $p < .001$), which indicates that size estimations were inelastic in both conditions. More important, the elasticity of size estimations was significantly lower in the 3-D condition than in the 1-D condition ($t = -4.7$, $p < .001$), as we expected. We obtained identical results when pooling estimations across dimensionality conditions and using a repeated measures moderated regression with actual size, dimensionality, and their interaction as independent variables (for these results, see the Web Appendix at <http://www.marketingpower.com/jmrdec09>).

To illustrate these results, Figure 1 shows the observed geometric means and confidence intervals of the size estimations across participants in the 1-D and 3-D conditions. The mean estimates were all below the 45-degree line, indicating that the participants significantly underestimated the actual increase in size in both conditions. In addition, the mean estimates were significantly higher in the 1-D condition than in the 3-D condition, as we predicted. The size estimates predicted by the fitted power models also appear in Figure 1. Both power curves are well inside the 95% confidence intervals for all sizes, indicating that power models fit the data well. Indeed, we found that the power model fits the data better ($R^2 = .79$, $F(1, 346) = 1276$, $p < .001$; Akaike information criterion [AIC] = -1.51) than a linear model ($\text{ESTSIZE} = a' + b' \times \text{ACTSIZE} + \epsilon'$; $R^2 = .56$, $F(1, 346) = 441$, $p < .001$; AIC = 11.16) and has a lower mean percentage error (MAPE = .40 for the power model versus MAPE = .52 for the linear model; $t = -9.3$, $p < .001$).

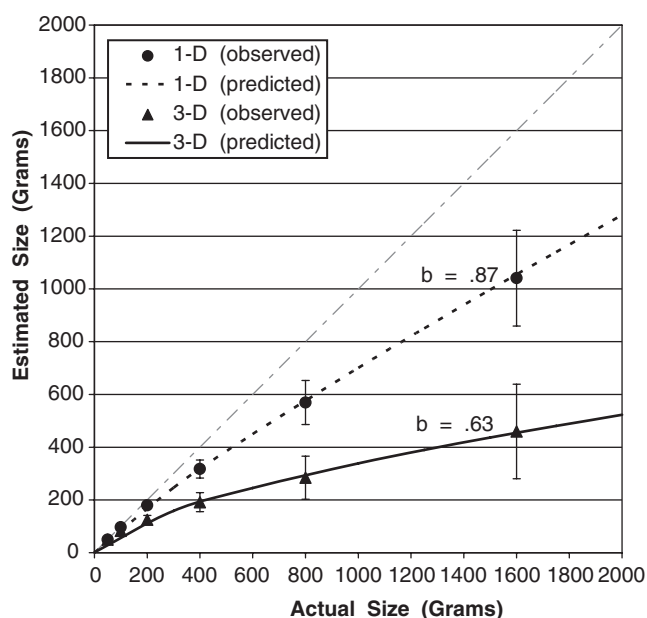
Table 1
STUDIES 1 AND 2: STIMULI DIMENSIONS

<i>Studies, Products, and Shapes</i>	<i>Dimensions</i>	<i>Size A</i>	<i>Size B</i>	<i>Size C</i>	<i>Size D</i>	<i>Size E</i>	<i>Size F</i>
<i>Study 1 (Candles)</i>	<i>Size (g)</i>	<i>50</i>	<i>100</i>	<i>200</i>	<i>400</i>	<i>800</i>	<i>1600</i>
1-D (cylinder)	Height (cm)	.53	1.05	2.1	4.2	8.4	16.8
	Diameter (cm)	10.0	10.0	10.0	10.0	10.0	10.0
3-D (cylinder)	Height (cm)	5.3	6.67	8.4	10.6	13.33	16.8
	Diameter (cm)	3.2	3.97	5	6.30	7.94	10.0
<i>Study 2 (Wool)</i>	<i>Size (g)</i>	<i>1.25</i>	<i>2.5</i>	<i>5.0</i>	<i>10.0</i>	<i>20.0</i>	<i>40.0</i>
1-D (strands)	Height (cm)	.60	.60	.60	.60	.60	.60
	Length (cm)	50	50	50	50	50	50
	Width (cm)	.60	1.20	2.40	4.80	9.60	19.20
3-D (spheres)	Diameter (cm)	2.54	3.20	4.03	5.08	6.40	8.06
<i>Study 2 (Detergent)</i>	<i>Size (g)</i>	<i>100</i>	<i>200</i>	<i>400</i>	<i>800</i>	<i>1600</i>	<i>3200</i>
1-D (tablets)	Height (cm)	1.35	1.35	1.35	1.35	1.35	1.35
	Length (cm)	14.40	14.40	14.40	14.40	14.40	14.40
	Width (cm)	2.60	5.20	10.40	20.80	41.60	83.20
3-D (powder in boxes)	Height (cm)	2.70	3.40	4.29	5.40	6.80	8.57
	Length (cm)	5.20	6.55	8.25	10.20	13.11	16.50
	Width (cm)	3.60	4.54	5.72	7.20	9.06	11.43

Notes: For Study 1, the dimensions are those of the picture. For Study 2, they are those of the actual products. g = grams, and cm = centimeters.

Figure 1

STUDY 1: EFFECTS OF SIZE AND DIMENSIONALITY ON SIZE ESTIMATIONS (OBSERVED GEOMETRIC MEANS, 95% CONFIDENCE INTERVALS, AND MODEL PREDICTIONS)



Discussion

The results of Study 1 strongly support our hypotheses that size estimations follow an inelastic power function of actual sizes and that they are even less elastic when products increase in three dimensions than when they increase in one dimension. The size of these effects was remarkable: For the 200-gram candles (Size C), estimates were 44% larger in the 1-D condition than in the 3-D condition (180 grams versus 125 grams, respectively). The difference reached 126% for the 1600-gram Size F candles (1041 grams versus 460 grams). In other words, a 32-fold increase in the size of the candle appeared as a 21-fold increase in the 1-D condition but as a 10-fold increase in the 3-D condition.

Study 1 also showed that candles appeared larger in the 1-D condition than in the 3-D condition, even though they were less elongated in the 1-D condition than in the 3-D condition, which is the opposite of the classic elongation bias result. Still, these results do not falsify the elongation bias, and the contradiction can be easily resolved by noting that our procedure (by providing the size of the smallest candle) encouraged participants to focus on the magnitude of size change. In the classic procedure of elongation bias studies, however, there is no reference size, and people simply see two objects with the same actual size, with one more elongated than the other. Therefore, we can summarize the elongation and dimensionality effects as follows: In the absence of a reference size, elongated objects appear larger (this is the elongation bias). In the presence of a reference size, the dimensionality (and, thus, the elongation) of the size change matters more than the elongation of the final object itself, and objects appear larger when they are super-

sized in one dimension than when they are supersized in three dimensions.

Study 1 has some limitations. First, prior studies have found that size estimations are more elastic when people see the actual objects rather than pictures of these objects (Ekman and Junge 1961; Frayman and Dawson 1981). Second, the 1-D package increases were implemented by increasing the height of the candles because increasing the width of a cylindrical candle would actually be a 2-D change. Therefore, it would be important to know whether the dimensionality effects found in Study 1 also hold when people are looking at real objects and when a dimension other than height (i.e., length or width) is manipulated in the 1-D condition. Third, the results may be response biases that only occurred because people were specifically asked to estimate sizes, something that few probably do spontaneously. Would dimensionality influence responses to more familiar tasks, such as estimating WTP, even when people are not explicitly asked to estimate size?

Examining WTP also enables us to reexamine why consumers demand quantity discounts (i.e., lower unit prices) for larger sizes. According to Nason and Della Bitta (1983), 81% of consumers expect to pay lower unit prices for larger sizes, and marketers commonly offer such quantity discounts. Common explanations for quantity discounts are diminishing marginal utility, budget constraints, fairness considerations (driven by expectations that larger sizes are more profitable for sellers because of lower packaging and other fixed costs), and the lower convenience of buying in larger quantities (Clements 2006). Study 1 suggests that another explanation could be that larger product sizes appear smaller than they really are because of the inelasticity of size estimations. In other words, WTP for larger sizes may be mediated by biased size estimations. This would imply that (1) WTP also follows an inelastic power function of actual sizes rather than the linear function that is often used, (2) quantity discounts are steeper when packages are supersized in three dimensions than when they are supersized in one dimension, and (3) interventions that reduce size biases, such as providing information about the actual size of the products, also reduce quantity discount expectations and the effects of the dimensionality of size changes. So far, these issues remain largely unanswered. Krider, Raghubir, and Krishna (2001) find a linear relationship between true area and reservation prices for three sizes of round and square pizzas. However, this result might be due to the limited range of sizes they use (pizzas varied between 50 and 150 square inches). They also find that providing information about the area of the pizzas (in square inches) reduced quantity discount expectations for square pizzas but not for round ones. We examine these issues in Study 2.

STUDY 2: EFFECTS OF RESIZING DIMENSIONALITY AND SIZE INFORMATION ON SIZE ESTIMATIONS AND QUANTITY DISCOUNT EXPECTATIONS

The main goals of Study 2 are to examine whether the dimensionality of product size change influences the prices people are willing to pay for increasing sizes (and, thus, quantity discount expectations) and whether these effects are mediated by size estimations. We also examine whether providing objective size information reduces quantity discount expectations and the effects of dimensionality. If con-

sumers expect quantity discounts at least partially because of inelastic size estimations (i.e., because they do not realize how large the larger sizes are), informing them about the actual size of each product should increase their WTP for larger sizes and thus reduce quantity discount expectations. It should also moderate the effects of dimensionality because people can simply read the label to know the product's size instead of relying on biased visual estimates. Finally, Study 2 examines whether the results of Study 1 regarding the effects of dimensionality on size estimations can be replicated when people are looking at actual products rather than at pictures of products, when 1-D size change is done by increasing the width rather than the height of products, and with two new products.

Method

One hundred sixty-two participants were recruited near a large urban university to participate in a study in exchange for a voucher for a sandwich and a soda. We used a mixed design with one within-subject factor (six geometrically increasing sizes labeled A–F), two between-subjects factors (the dimensionality of size increase: one versus three; size information: present versus absent), and one control condition (size information only and no visual inspection of the products). Two products, dishwashing detergent and wool, were used as within-subjects replications. Unlike in Study 1, in which the participants provided only size estimates, the dependent variable in Study 2 was WTP for each size. When size information was absent, participants also provided size estimates in grams (the typical unit for these two product categories). We systematically counterbalanced the order of the questions about WTP and size estimations when the participants provided both.

As in Study 1, the actual size of the products doubled from one size level to the next, and information about the smallest size (Size A = 100 grams for detergent, and Size A = 1.25 grams for wool) was provided. The price of Size A was also provided (\$.50 for detergent and \$.25 for wool). In the control condition, the actual weights of the six product sizes were available, and the participants were asked to provide their WTP for each size without actually seeing the products. In the other four conditions, the participants saw the actual products increase either in one dimension or in three dimensions, and information about their sizes was either available or not.

Table 1 shows the actual dimensions of the stimuli in the two dimensionality conditions. Images of the stimuli appear in the Web Appendix (see <http://www.marketingpower.com/jmrdec09>). In the 3-D condition, the dishwashing detergent was in white cubic cardboard boxes that increased in height, length, and width, and the wool was in spherical balls that increased in diameter. In the 1-D condition, the dishwashing detergent was in tablets placed next to one another, forming rectangular blocks that were 4 tablets long, 1 tablet high, and between 1 and 32 tablets wide; the wool was in a rectangular pattern made of one single strand that zigzagged back and forth. This pattern was half a meter long, 1 strand high, and between 1 and 32 strands wide (see the picture in the Web Appendix). As Table 1 shows, the height of the stimuli was held constant in the 1-D condition and was always lower than in the 3-D condition. If people estimate sizes solely on the basis of the height of objects or the

change in height, estimates should be lower in the 1-D condition than in the 3-D condition. However, if—as we expect—size changes appear larger when they are 1-D changes than when they are multidimensional (regardless of which dimension is increased), size and WTP estimates should be higher in the 1-D than in the 3-D condition.

Size Estimation Results

We first estimated the power model shown in Equation 2 for each product and participant in the two conditions in which the participants did not know the actual size of the Products B–F. The average elasticity across participants was significantly larger in the 1-D condition than in the 3-D condition for both detergent ($\beta = .92$ versus $\beta = .75$; $t = 3.2$, $p < .01$) and wool ($\beta = .94$ versus $\beta = .61$; $t = 6.4$, $p < .01$). As in Study 1, we replicated these results in a repeated measures moderated regression model, in which we pooled data across conditions, participants, and category replications (for detailed results, see the Web Appendix at <http://www.marketingpower.com/jmrdec09>). To illustrate these results, Figure 2 shows the geometric means and confidence intervals of size estimations rescaled by the size of the smallest option (Size A) in the 1-D and 3-D conditions, pooled across the two products. As in Study 1, a nonlinear power model fit the size estimates well.

WTP Results

Figure 3 shows the mean WTP rescaled as a multiple of the price of the smallest size, pooled across the two products and the model predictions in each of the five conditions. We estimated the model shown in Equation 2 with (rescaled) WTP as the dependent variable for each partici-

Figure 2
STUDY 2: EFFECTS OF SIZE AND DIMENSIONALITY ON SIZE ESTIMATIONS (OBSERVED GEOMETRIC MEANS, 95% CONFIDENCE INTERVALS, AND MODEL PREDICTIONS)

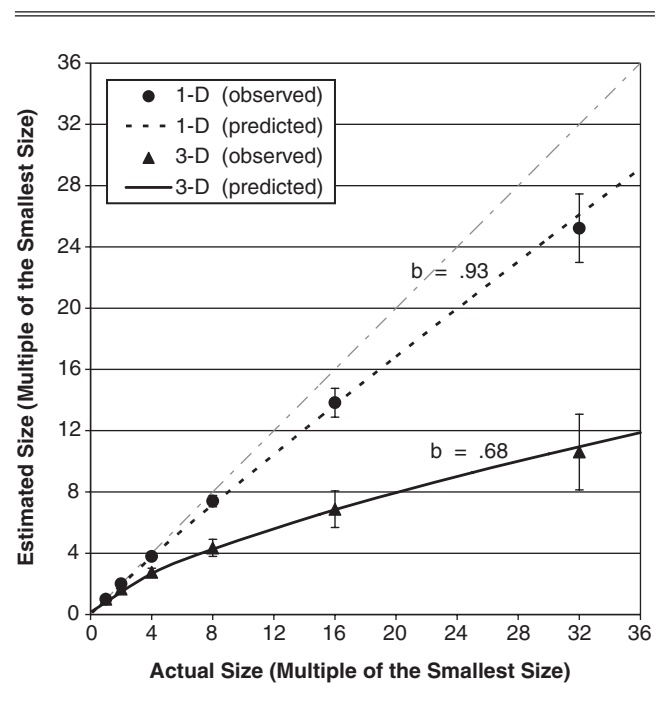
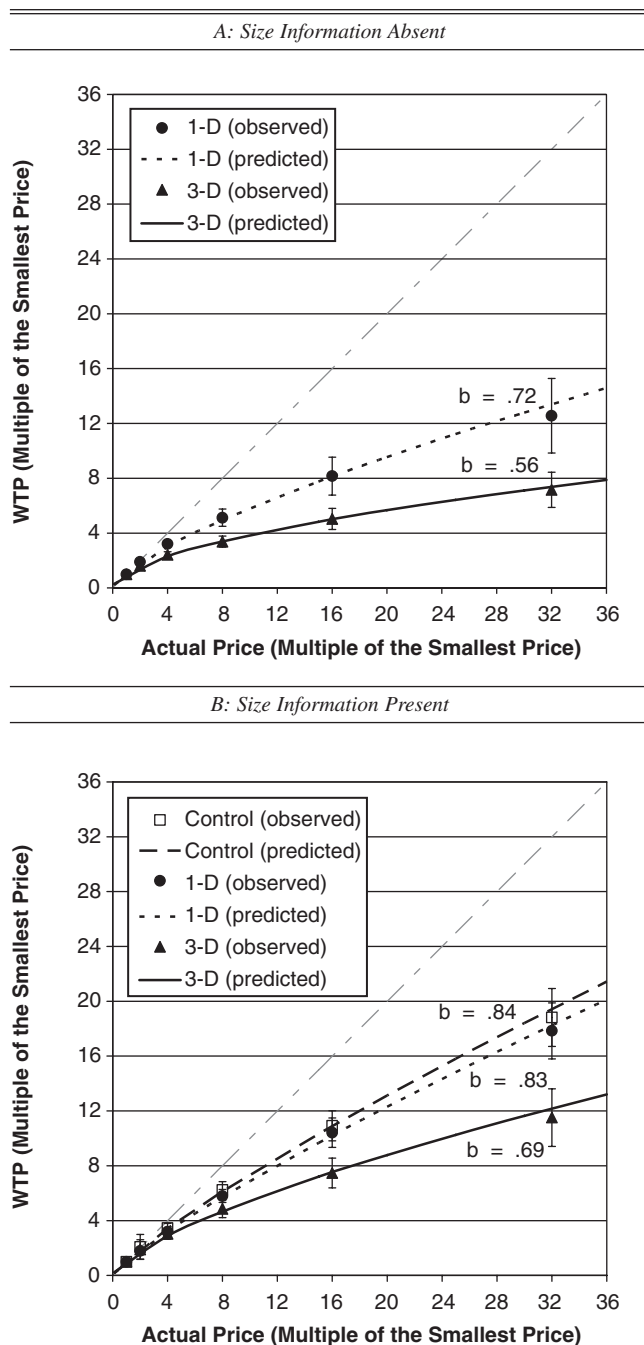


Figure 3

STUDY 2: EFFECTS OF SIZE AND DIMENSIONALITY ON WTP
(OBSERVED GEOMETRIC MEANS, 95% CONFIDENCE
INTERVALS, AND MODEL PREDICTIONS)



pant and for each product, obtaining 324 regressions. Table 2 shows the mean exponent for each product averaged across the respondents in each condition. The superscripts show the results of pairwise *t*-tests indicating whether the exponents were statistically different across conditions. We confirmed the results of these simple statistical tests with a repeated measures moderated regression with three independent variables (capturing the effects of actual size, dimensionality, and availability of size information) and including all two-way and three-way interactions. The

results of the moderated regression appear in the Web Appendix (see <http://www.marketingpower.com/jmrdec09>).

Table 2 and Figure 3 show that in all five conditions, WTP followed an inelastic power function, not a linear function, of the actual size of the product (i.e., all the exponents are statistically less than 1). As we expected, they also show that WTP was less elastic to changes in package size in the 3-D condition than in the 1-D condition for both products, regardless of whether size information was present or absent. In addition, WTP was more elastic when size information was present than when it was absent, indicating that the provision of information on actual sizes reduces the quantity discounts demanded by consumers. However, the effects of dimensionality persisted even when size information was present. As confirmation of this, the moderated regression results show that the availability of size information significantly improved the accuracy of size estimations but did not influence the effects of dimensionality. Finally, there were no differences between the control (no visual information) condition and the 1-D condition when size information was present. This result shows that seeing the products change in one dimension did not change WTP compared with just knowing their sizes, whereas seeing the products change in three dimensions significantly reduced WTP, even though information about the actual sizes of the products was always available.

Overall, these analyses show that both size and WTP estimations follow inelastic power functions of actual size, moderated by the dimensionality of the size changes. This raises the question whether size estimations mediate the effects of size change and the effects of the dimensionality of these size changes on WTP. Considering first the effects of size changes, a Sobel (1982) test revealed that size estimations significantly mediated the effects of size change on WTP for both detergent ($z = 26.7, p < .01$) and wool ($z = 22.0, p < .01$). The results of a similar Sobel test revealed that size estimations also significantly mediated the impact of the dimensionality of size changes on WTP for both products (for detergent, $z = -2.6, p < .01$; for wool, $z = -5.1, p < .01$). Thus, both results support the size estimation mediation.

Discussion

In Study 2, we replicated the results obtained in Study 1 and demonstrated that the effects of size changes and their dimensionality hold when people estimate actual products, not just their pictures. We also found that WTP for increasing sizes was mediated by consumers' biased estimations of these sizes and thus followed an inelastic power function with a lower elasticity for 3-D than for 1-D size changes. We also found that making objective size information available reduced quantity discount expectations but did not reduce the effects of dimensionality. This confirms prior findings that people make inferences about product volume from their perceptions of the size of the packages (Lennard et al. 2001). Finally, we found the same quantity discounts when size information was present and products increased in one dimension as in the control condition, when people could not look at the products and only had information about their sizes. This suggests that from the marketer's point of view, increasing products in 1-D offers the best (i.e., lowest) quantity discount possible.

Table 2
STUDY 2: ESTIMATED POWER EXPONENTS IN THE WTP REGRESSIONS

	<i>Size Information Absent</i>		<i>Size Information Present</i>		
	<i>1-D</i>	<i>3-D</i>	<i>Control (No Visual)</i>	<i>1-D</i>	<i>3-D</i>
Detergent	.74 ^a	.57 ^b	.84 ^a	.85 ^{a†}	.71 ^{b†}
Wool	.70 ^a	.55 ^b	.83 ^a	.84 ^{a†}	.71 ^{b†}

†Indicates that within each dimensionality condition, the exponent in the size-information-present condition is statistically different ($p < .01$) from the exponent in the size-information-absent condition (e.g., for detergent in the 1-D condition: .74 in the size-information-absent condition is statistically different from .85 in the size-information-present condition).

Notes: All coefficients are significantly smaller than 1 ($p < .01$). Exponents with different letter superscripts in the same-size-information condition are statistically different from each other ($p < .01$).

The effect sizes for WTP were large. For example, consider the participants' WTP for detergent when objective size information was present (we obtained similar results for wool). In the control condition, when the participants could not look at the products and only knew their sizes, they were willing to pay \$3.13 per kilogram for Size F (\$10 for 3.2 kilograms), which is \$1.87 (–38%) less than the unit price of the reference Size A (\$5 per kilogram). Because these participants did not see the products, this drop represents the quantity discount caused by nonvisual factors, such as diminishing marginal utility and storage costs. However, when the participants saw packages increasing in one dimension, they were willing to pay \$2.94 per kilogram for Size F (\$9.40 for 3.2 kilograms), and so the quantity discount changed very little compared with the control condition. In contrast, when the participants saw packages increasing in three dimensions, they were willing to pay only \$2.01 per kilogram for Size F (\$6.45 for 3.2 kilograms), which is \$2.99 (–60%) less than the unit price of Size A. In other words, visual biases increased quantity discounts by 60%, from \$1.87 to \$2.99. Using the fitted model to predict WTP across a broad range of size increases, we found that visual biases increase quantity discount by up to 69% for a standard 5-kilogram pack of detergent.

By demonstrating that dimensionality influences WTP and not just size estimations, Study 2 alleviates the concern that these are simple response biases arising from the use of unfamiliar units or somewhat artificial tasks. Still, consumers do not necessarily estimate the size of the products or how much they are willing to pay for them when making purchase decisions. It could also be assumed that the results would have been different with other measurement units, such as centiliters, rather than grams. In addition, the reference size in Studies 1 and 2 was always the smallest size, and thus participants judged the magnitude of product supersizing. It remains to be determined whether dimensionality also influences people's estimations of the magnitude of product downsizing.

To address these concerns, we need to examine the effects of the dimensionality of product resizing on how much product people use, not just on their estimation of size or WTP. We do this in Study 3 by using a magnitude production task rather than the magnitude estimation task used in Studies 1 and 2. In magnitude estimation tasks, the stimuli are given, and participants are asked to estimate the magnitude of the size changes. In magnitude production tasks, the magnitude of the size change is given, and participants are asked to change the size of objects to match these size

changes (e.g., “pour enough liquid to triple the reference amount”).

The magnitude production procedure also enables us to examine the effects of dimensionality on overusage and, thus, to address more directly the social welfare implications of these biases. Although prior studies have shown that the elongation of a glass influences how much volume people pour and how much they consume (Raghubir and Krishna 1999; Wansink and Van Ittersum 2003), they do not ask participants to produce different volumes of product. In addition, these studies use cylindrical glasses in which the amount of liquid poured increases in one dimension (height) only. In Study 3, we address these issues by analyzing how much volume people pour into (supersizing goal) or out of (downsizing goal) (1) cylindrical containers in which volume changes in one dimension (height only) and (2) conical containers in which volume changes in three dimensions (because both the height and the diameter change as product is poured into or out of the container).

STUDY 3: EFFECTS OF RESIZING DIMENSIONALITY ON CONSUMPTION DOSAGE

In Study 3, we examine how the dimensionality of the change in product volume in a given container influences how much people produce when they are supersizing or downsizing a dose. Drawing on the results of Studies 1 and 2, we expect that changes in volume will appear larger in cylindrical (1-D) containers (because only the height of the product changes) than in conical (3-D) containers (because all three dimensions of the product change). In turn, the underestimation of 3-D volume change will lead consumers to add more volume when supersizing an existing dose in a 3-D container than in a 1-D container. It will also lead consumers to remove more volume when downsizing an existing dose in a 3-D container than in a 1-D container. In other words, because 3-D volume changes appear smaller, we expect consumers to add or remove more volume in conical (3-D) containers than in cylindrical (1-D) containers.

Method

Forty-seven participants were recruited near a large urban university to participate in a study about the design of containers in return for two candies. The study used a 2 × 2 between-subjects design with resizing dimensionality (one dimension versus three dimensions) and resizing goal (supersizing versus downsizing instructions). The participants individually entered a room, where they saw three containers with initial doses of three products—infant medicine, vodka, and a cocktail—displayed on the table. The

infant medicine container had graduations to measure poured volume, and the vodka and cocktail containers did not have any marks for measurement. Table 3 shows the dimensions and pictures of the containers. In the 1-D condition, the containers were a 100-milliliter cylindrical glass for vodka, a 250-milliliter cylindrical glass for cocktails, and a 20-milliliter dispensing syringe for infant medicine. In the 3-D condition, the containers were a 100-milliliter conical glass for vodka, a 250-milliliter conical glass for cocktails, and a 20-milliliter conical serving cup for infant medicine. On the same table, there were also three jugs containing additional infant medicine, vodka, and cocktail. We chose large opaque jugs to ensure that participants would monitor the change in volume in the containers and not the changes of volume in the jugs.







In the supersizing goal condition, a small dose of each product was already in the containers, and the participants were asked to triple this dose by pouring additional product from the jug into the container. In the downsizing goal con-

dition, a large dose of each product was already in the containers, and the participants were asked to divide it by three (i.e., to decrease the volume to one-third of the initial dose) by pouring out the excess volume into the jug. In both conditions, the participants were allowed to add and remove product from the containers as often as they needed until they achieved the desired volume.

Results and Discussion

We used an analysis of variance with the final amount of product left in the containers as the dependent variable and dimensionality, goal, and their interaction as fixed factors. After verifying that there were no interactions with product type, we pooled the data across the three product replications and rescaled the volumes as a multiple of the smaller dose (the initial dose in the supersizing condition and the target final dose in the downsizing condition). If people are accurate in their estimations, the rescaled final volume should be three in the supersizing condition and one in the

Table 3
STUDY 3: STIMULI DIMENSIONS AND PICTURES

<i>Dimensions</i>	<i>Cylindrical Containers (1-D Condition)</i>		<i>Conical Containers (3-D Condition)</i>	
<i>Vodka Glass</i>				
Volume (ml)	100		100	
Height (cm)	11.0		4.6	
Bottom diameter (cm)	2.1		2.0	
Top diameter (cm)	2.1		8.5	
<i>Cocktail Glass</i>				
Volume (ml)	250		250	
Height (cm)	7.5		6.6	
Bottom diameter (cm)	6.2		1.3	
Top diameter (cm)	6.2		12.0	
<i>Measuring Container for Infant Medicine</i>				
Volume (ml)	20		20	
Height (cm)	9.6		3.6	
Bottom diameter (cm)	2.1		2.9	
Top diameter (cm)	2.1		3.8	

Notes: All dimensions are about the usable volume area (i.e., excluding the stems); cm = centimeters, and ml = milliliter.

downsizing condition. Figure 4 shows the final volume left (rescaled) in the 1-D and 3-D containers in the supersizing and downsizing conditions.

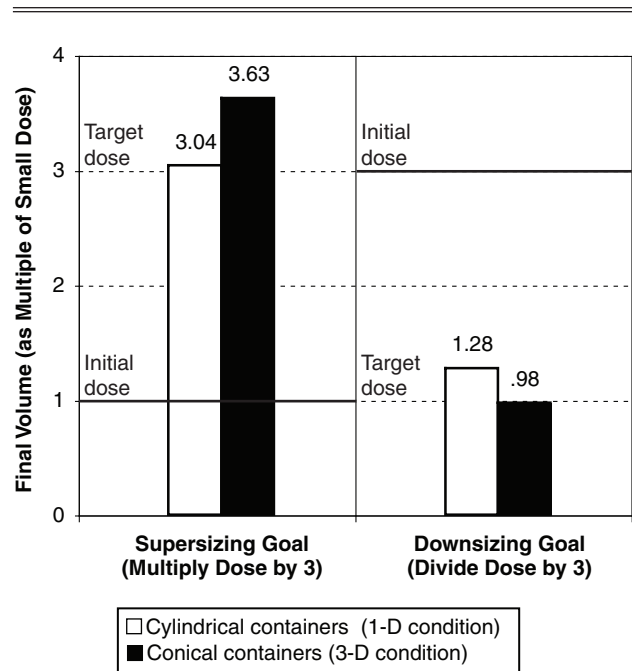
In the supersizing condition, in which participants were told to triple the dose, they poured a greater (product) volume into the 3-D (conical) containers than into the 1-D (cylindrical) containers and thus were left with more product in the 3-D containers ($M = 3.63$ times the initial dose) than in the 1-D containers ($M = 3.04$; $p < .005$). In the downsizing condition, in which the participants were told to leave only one-third of the initial dose, they poured out more and left less product in the 3-D containers ($M = .98$ times the target dose) than in the 1-D containers ($M = 1.28$; $p < .003$). The interaction between consumption goal and resizing dimensionality was statistically significant ($F(1, 136) = 17.2$, $p < .001$). The main effect of resizing was significant because more volume was left in the supersizing condition than in the downsizing condition ($M = 3.36$ versus $M = 1.12$; $F(1, 136) = 425.8$, $p < .001$), but the main effect of dimensionality was not statistically significant ($F(1, 136) = 1.8$, $p = .18$).

Overall, the results of Study 3 reinforce those of Studies 1 and 2 in showing that changes in product size appear smaller when they occur in all three dimensions than when they only change in one dimension. In addition, Study 3 shows that these results hold even when people are not asked to produce a numeric estimate of the magnitude of size change but are asked to increase or decrease the amount of product itself. This provides additional evidence that dimensionality indeed influences perceived size changes and not just their expression on a response scale. Finally, Study 3 shows that the effects of dimensionality hold for both supersizing and downsizing decisions (i.e., when people try to increase and also when they try to decrease product volume). This raises the issue of whether the dimensionality of product size change may also influence consumers' likelihood of supersizing or downsizing their purchases. We address this issue with two sales experiments in Study 4.

STUDY 4: EFFECTS OF RESIZING DIMENSIONALITY ON CONSUMERS' SUPERSIZING AND DOWNSIZING PURCHASE DECISIONS

Building on Studies 1, 2, and 3, we expect that dimensionality will have the following effects on supersizing and downsizing purchase decisions when consumers do not have a fixed consumption goal and, all else being equal, prefer more product to less: When choosing between a supersized and a regular-size package, consumers will be more likely to choose the supersized package when it is supersized in one dimension than in three dimensions because the size increase will appear larger in the 1-D condition. Conversely, when choosing between a downsized and a regular-size package, consumers will be more likely to choose the downsized package when it is downsized in three dimensions than when it is downsized in one dimension because the size decrease will appear smaller in the 3-D condition than in the 1-D condition. We examine these hypotheses in two field experiments involving real products, size changes of typical magnitude, and actual purchases. Study 4a examines supersizing decisions, and Study 4b examines downsizing decisions.

Figure 4
STUDY 3: PRODUCT VOLUME LEFT IN CYLINDRICAL (1-D) OR CONICAL (3-D) CONTAINERS IN SUPERSIZING OR DOWNSIZING USAGE DECISIONS



Study 4a: (Supersizing)

Method. To examine the effects of dimensionality on supersizing decisions, we sold two brands of beer and cider to graduate students before a movie viewing. When participants arrived, a research assistant directed them to one of three booths located next to the three entrances of a campus auditorium. (However, because one booth was located next to the main entrance of the auditorium, it received a disproportionate share of the participants.) To manipulate the size and shape of the two brands of beer and cider in a rigorous manner, students were not shown the actual beer and cider bottles, but rather two mugs specially designed for the purpose of the experiment, which had labels that clearly indicated their volume. The students were told that each mug corresponded to one of the two brands of beer and to one of the two brands of cider, that both brands were available for sale at \$1.20, and that the beer or cider they purchased would be brought to them later in the auditorium. The price of the products never changed.

There were three between-subjects conditions. In the booth with the control condition, both mugs contained 22 centiliters. In the two other booths, the target brand's mug contained 33 centiliters, 50% more than the 22 centiliters of the mug of the other brand (which was the same as in the control condition). In the booth with the 1-D supersizing condition, the target brand's mug was the same diameter but 50% taller than the control mug. In the booth with the 3-D supersizing condition, the target brand's mug was different in height and diameter from the control mug (for the dimensions of the mugs, see Table 4). After placing their orders, the students received the brand of their choice (in a bottle,

because this was more convenient) when they were seated in the auditorium.

Results. In a pretest, we asked 11 participants to estimate the size of the supersized mug in the 1-D and 3-D supersizing conditions. The supersized mug appeared significantly larger in the 1-D than in the 3-D condition ($M = 35.0$ centiliters versus $M = 29.8$ centiliters; $t = 2.7, p < .05$), showing that the dimensionality manipulation was successful. None of the participants ordered more than one beer or cider, and we obtained 43 usable choices. After verifying that the effects of the dimensionality manipulations were not statistically different for the two products, we pooled the data across the beer and cider. As Table 4 shows, the choice share of the target brand was 55% in the control condition. When the target brand was supersized in one dimension, its choice share reached 100%, a statistically significant increase over the control condition ($\chi^2(1) = 6.0, p < .01$). When the target brand was supersized in three dimensions, however, its choice share was 68%, which was not statistically different from the control condition ($\chi^2(1) = .6, p = .44$). The difference between the 1-D and the 3-D conditions was also statistically significant ($\chi^2(1) = 4.1, p < .05$). These results support our prediction that supersizing in one dimension attracts more consumers than supersizing in three dimensions.

Study 4b: Downsizing

Method. In Study 4b, we examined the effects of dimensionality on downsizing decisions using a procedure that clearly established the reference size for the target brand in all conditions. We used this procedure to increase the chances that the participants would notice that the downsized product was smaller than usual. We also used publicly available packaging of two familiar products (Coke and popcorn) rather than purpose-built mugs to test the robustness of the effects of dimensionality.

Study 4b was a field experiment with two between-subjects conditions (1-D downsizing versus 3-D downsizing) and two between-subjects replications (Coke and popcorn). Forty-seven participants were recruited near a large

urban university and were compensated with a product voucher. We told the participants that as an additional reward for their participation in an unrelated study, they would have the opportunity to buy a bottle of Coke and a box of local popcorn brands at a discounted price at the end of the experiment. We then showed them a menu with two beverage options, a 50-centiliter bottle of Diet Coke (\$.80) and a 50-centiliter bottle of regular Coke (\$.60), and two popcorn options, a 33-ounce (94 centiliters) box of Baseball brand popcorn (\$.50) and the same 33-ounce box of Baff popcorn (\$.40). The purpose of this first phase was to establish the 50-centiliter bottle and the 33-ounce cubic box as the reference sizes. The sizes of the packages were always shown on the labels (in ounces and centiliters), and the prices were the same in all conditions.

After participants completed an unrelated task, we told them that we had run out of the 50-centiliter regular bottle of Coke and of the 33-ounce box of Baff popcorn but that smaller sizes were still available, albeit at the same price as the regular sizes. Thus, the participants chose between a 50-centiliter bottle of Diet Coke and a 33-centiliter can of regular Coke and between a 33-ounce box of Baseball popcorn and a 22-ounce box of Baff popcorn. For both products, the downsized package was 33% smaller than the normal-size package shown in the first phase and still available for the nontarget brands (Diet Coke and Baseball popcorn). As Table 4 shows, the downsized 33-centiliter can of regular Coke had either the same diameter but a lower height (1-D downsizing condition) or both a smaller diameter and height than the 50-centiliter bottle (3-D downsizing condition). The downsized box of popcorn either had a 33% shorter height than the normal-size box (1-D condition) or was smaller in all three dimensions (3-D condition). The participants marked their choices and provided their WTP for the two normal-size brands. They were then debriefed, handed their voucher and their choices of Coke and popcorn, and dismissed.

Results and discussion. In a pretest, we asked 11 participants to estimate the size of the downsized cans of beer and cider and boxes of popcorn in the 1-D and 3-D conditions.

Table 4
STUDY 4: CHOICE SHARES AND STIMULI DIMENSIONS

Product	Dimensions and Choice Shares	Regular Size	1-D Resizing	3-D Resizing
<i>Study 4a: Supersizing</i>				
Mugs (beer and cider)	Volume (cl)	22	33	33
	Height (cm)	11.3	16.9	6.2
	Bottom diameter (cm)	5.0	5.0	7.5
	Top diameter (cm)	5.0	5.0	9.0
	Choice share of supersized brand (%)	55	100	68
<i>Study 4b: Downsizing</i>				
Coke	Volume (cl)	50	33	33
	Height (cm)	23.2	11.4	14.6
	Diameter (cm)	6.3	6.3	5.6
	Choice share of downsized brand (%)	—	35	64
Popcorn	Volume (oz)	33	22	22
	Height (cm)	12.0	7.8	10.1
	Length (cm)	9.0	9.0	7.9
	Width (cm)	9.0	9.0	7.9
	Choice share of downsized brand (%)	—	62	75

Notes: cl = centiliter, cm = centimeter, and oz = ounce.

As we expected, the downsized packages were perceived as smaller in the 1-D than in the 3-D condition ($M = 45.8$ centiliters versus $M = 52.7$ centiliters; $t = -2.7$, $p < .01$). This pattern was also observed for each product individually. After verifying that there were no interactions between the manipulations and the product categories, we pooled the data across Coke and popcorn for the purpose of the statistical analyses. As we expected, the choice share of the downsized brands was significantly higher in the 3-D condition ($M = 69\%$) than in the 1-D condition ($M = 48\%$; $\chi^2(1) = 4.2$, $p < .05$). Similarly, participants were willing to pay significantly less for the regular-size brands when the target brand was downsized in the 3-D condition (\$.86) than when it was downsized in the 1-D condition (\$1.10; $F(1, 90) = 4.0$, $p < .05$). These results support our prediction that downsizing attracts more consumers when it is done in three dimensions than in only one dimension.

Overall, Study 4 shows that the dimensionality of package resizing influences consumers' preferences for supersizing and downsizing in actual purchase decisions. In Study 4a, although the actual volumes were always clearly marked, offering 50% more beer and cider for free did not lead to a statistically significant increase in choice share in the 3-D condition. In contrast, when the products were supersized in one dimension, their choice share nearly doubled, and all the buyers chose them. In Study 4b, although we used well-known brands and package sizes, the choice share of the downsized brand was 44% higher when it was downsized in three dimensions than when it was downsized in one dimension.

The effects of dimensionality on consumers' size perceptions, price expectations, usage, and purchase decisions raise the question whether marketers are aware of the effects of dimensionality and apply different quantity discounts when package or portion sizes increase in one dimension than when they increase in three dimensions. We examine this issue in Study 5 by surveying quantity discounts for larger product sizes in four categories.

STUDY 5: SURVEY OF MARKETPLACE QUANTITY DISCOUNTS OFFERED FOR 1-D AND 3-D PRODUCT RESIZING

Method

The goal of Study 5 is to examine whether quantity discounts are similar for products with packages and portions that increase in one dimension as for products with packages and portions that increase in three dimensions. To achieve this goal, we measured the prices of different sizes of products in four categories: cosmetics, beverages, snacks, and fast-food sandwiches. We chose these categories on the basis of a prestudy, which indicated that they each include products that increase in both one dimension and three dimensions. For example, in the cosmetics category, we obtained data on the retail price of travel-size shaving creams that either are simply shorter than the regular size or have both a lower height and a smaller diameter than the regular size (e.g., Edge versus DawnMist shaving creams in Table 5).

In total, we collected information on the retail price and size of 70 pairs of products (each pair consisting of two sizes of the same product) by conducting price audits at supermarkets in a large U.S. city and for U.S. online retail-

ers. We measured the sizes of cosmetics, beverages, and snacks in centiliters and the sizes of fast-food sandwiches in calories, in the absence of a standardized unit in this category. We then computed two elasticity measures for each of these 70 observations. The first is the arc elasticity of prices with respect to change in product size; that is, $(\Delta P/\bar{P})/(\Delta S/\bar{S})$, where ΔP and ΔS are, respectively, the change in retail price and in size and \bar{P} and \bar{S} are, respectively, the average retail price and the average size of the two products. To allow for a direct comparison with our experimental results, we also computed the power exponent for each pair as follows: $\ln(P_L/P_S)/\ln(S_L/S_S)$, where P_L and P_S are the retail prices of the large and small package of the pair and S_L and S_S are the sizes of the large and small packages of the pair. The correlation between both measures was .99.

Results and Discussion

For each category, Table 5 provides the average arc elasticity of retail price with respect to change in size and the average power exponent when products increase in one dimension versus three dimensions. Across categories, both the elasticity and the power exponent were well below 1, indicating that prices increase more slowly than sizes and, thus, that companies offer quantity discounts. We examined both dependent variables using an analysis of variance with dimensionality, product category, and their interaction. As we expected, the size elasticity was higher for products that increase in one dimension ($M = .90$) than for products that increase in three dimensions ($M = .57$; $F(1, 62) = 20.2$, $p < .001$). The results also revealed a significant main effect of product category ($F(3, 62) = 3.3$, $p < .03$), but the interaction with dimensionality was not statistically significant ($F(3, 62) = 1.2$, $p = .31$). We obtained the same results when analyzing the power exponents. Notably, the exponent values were relatively similar to those we obtained in the size-information-present condition in Study 2. For products increasing in one dimension, the mean exponent was .88 in Study 5 versus .83 in Study 2. For products increasing in three dimensions, it was .55 in Study 5 versus .69 in Study 2.

In summary, the field survey provides additional evidence that the dimensionality of product resizing influences the magnitude of the price discounts retailers offer for larger quantities. These results suggest that the size and shape biases documented in the three experimental studies are strong enough to influence actual pricing practices in a competitive environment. Alternatively, it may be that marketers (like consumers) are more sensitive to size changes when they occur in one dimension than when they occur in three dimensions but are not aware of their own biases. Next, we address the implications of these studies for consumer research and public policy.

GENERAL DISCUSSION

The key finding of this research is that product size changes appear smaller when the product package or portion changes in all three dimensions (height, width, and length) than when it changes in only one of these dimensions. Specifically, we show that (1) size estimations follow an inelastic power function of the actual size of these products, (2) size estimations are even less elastic when product sizes change in three dimensions than when they change in

one dimension, and (3) the effect of dimensionality is not reduced by making size information available. As a result, consumers expect (and marketers offer) steeper unit price discounts when packages and portions are supersized in three dimensions than when they are supersized in one dimension, they pour more product into and pour more product out of conical containers (in which volume changes in three dimensions) than cylindrical containers (in which volume changes in one dimension), and they are more likely to supersize and less likely to downsize when package and portion sizes change in one dimension than when they change in three dimensions.

These visual biases had important consequences in our studies. Increasing product packages or portions along all three dimensions rather than along only one dimension reduced size estimations by up to 68%; decreased the unit

price people were willing to pay for larger sizes by up to 57%; led people to pour in 19% more vodka, alcoholic cocktail, and infant medicine; reduced the likelihood of buying supersized alcoholic beverages by 32%; and increased the likelihood of buying a downsized cola and popcorn by 21%. Moreover, these effects were robust and found across food and nonfood products and across different modes of representations (pictures or actual products), in a laboratory and in a competitive market setting, and even when information about the actual size of the products was present.

Implications for Researchers and Consumers

An important issue for further research is to investigate the various mechanisms that may underlie the effects of dimensionality. Raghubir (2007) created a typology of the

Table 5
STUDY 5: SIZE ELASTICITIES OF PRICES IN FOUR CATEGORIES

	<i>Cosmetics</i>	<i>Sandwiches</i>	<i>Beverages</i>	<i>Snacks</i>
<i>Size Elasticity of Retail Prices</i>				
1-D resizing	.98	.93	.61	.78
3-D resizing	.55	.64	.41	.59
<i>Power Exponent</i>				
1-D resizing	.97	.90	.61	.75
3-D resizing	.52	.63	.39	.57
<i>Descriptive Statistics</i>				
N	31	22	7	10
Average price (\$)	6.44	6.31	2.09	2.67
Average size ^a	53.11	1.26	120.08	20.24
<i>Examples</i>				

1-D resizing



3-D resizing



^aUnits are centiliters, except for sandwiches, which are in units of 1000 calories.

Notes: We computed elasticity as $(\Delta P/P)/(\Delta S/S)$; we computed power exponent as $\ln(P_L/P_S)/\ln(S_L/S_S)$.

sources of visual biases, which suggests that both the amount and the locus of attention devoted to the stimuli play an important role. Evidence supporting the amount of attention explanation comes from Folkes and Matta (2004), who find that packages that receive more attention because of their unusual shape are perceived as larger. Because commercial packages and portions typically increase in three dimensions, they may receive less attention than packages that increase in one dimension. This suggests that the effects of dimensionality can be reduced by controlling or manipulating the amount of attention or by habituating consumers to packages supersized in one dimension.

It is also possible that changes in the locus of attention mediate the effects of spatial dimensionality. For example, as Krider, Raghubir, and Krishna (2001) note, people might just consider the changes in one dimension and disregard changes in the other dimensions. Some people may focus on changes in two dimensions (i.e., in surface areas) rather than changes in volume. This would explain why people respond differently to changes in the size of squares and circles (Krider, Raghubir, and Krishna 2001). Thus, further research should examine the effects of dimensionality for objects with different shapes because this influences the relationship between changes in surface area and changes in dimensionality. This also implies that dimensionality effects may be reduced by asking people to estimate the size of each dimension (i.e., height, width, and length) separately and by giving them computational aids to convert these 1-D estimates into weight or volume estimates. Finally, if dimensionality changes the locus of attention, we would expect to find effects on aesthetic evaluations (Raghubir and Greenleaf 2006) and on brand evaluations (Orth and Malke-witz 2008).

Finally, it would be worthwhile to study the effects of conceptual (versus spatial) dimensionality. For example, people may be more sensitive to changes in price or quality when they occur along one dimension than when they occur along one, two, or more than two dimensions (e.g., in each part of a three-part tariff). Building on this idea, it would be worthwhile examining the effects of dimensionality on sensations such as volume of sound, intensity of color, or concentration of flavor. In all these cases, it would also be important to examine how consumers react when they find out that marketers have been leveraging dimensionality effects to conceal or enhance attribute changes and whether they adapt to such effects of time and usage. This is particularly important in light of Sprott, Manning, and Miyazaki's (2003) finding that some larger sizes actually carry higher unit prices and that the success of these quantity surcharges is largely due to consumers' unawareness of their existence.

Implications for Marketers and Policy Makers

Downsizing package and portion sizes is one of the most effective methods of reducing overeating (Ledikwe, Ello-Martin, and Rolls 2005). One difficulty with downsizing is that consumers do not like smaller portions because they think that they are less economical (Wansink 1996). Another difficulty is that the lower net price of downsized products reduces average spending per customer and may not be compensated by an increase in the number of customers. Finally, marketers are concerned about consumers' reactions if they find out that the brand has surreptitiously

increased unit prices by downsizing product quantity. Indeed, the restaurant chain Ruby Tuesday eliminated downsized items from its menu just five months after their introduction because they led to a 5% sales loss. For marketers who are concerned about the negative impact of product downsizing, our results suggest that consumers underestimate the magnitude of the size reductions. The results also provide a simple way to make downsizing appear smaller than it really is.

For example, Condrasky and colleagues (2007) find that 76% of executive chefs believe that customers would notice if the restaurant decreased portion sizes by 25%. Using the exponents obtained in Study 1 as an illustration, we predict that a 25% downsizing would actually look like a 22% reduction ($1 - .75^{.87}$) if it were 1-D, but only a 17% reduction ($1 - .75^{.63}$) if it were 3-D. Furthermore, the results suggest that it would be better to increase unit prices by downsizing packages than by increasing prices. Consider a scenario in which a restaurant needs to increase its unit price by 50% because of mounting costs. It could either keep portion sizes constant and increase price by 50% or decrease portion size by 33% and keep the price constant. The results of Study 2 suggest that a 33% downsizing would actually only lead to a 20% decrease in WTP, which is likely to have less effect on sales than a 50% price increase.

The results also have implications for policy makers and marketers seeking to promote sustainable consumption and to reduce the overconsumption of potentially harmful products, such as alcohol or infant medicine (which, in the latter case, could be fatal if overdosed). Our findings indicate that the overconsumption of these products may be partially due to the conical shape of the containers typically used for these products. To prevent overdosing and waste, policy makers should promote the use of standardized 1-D containers for infant medicine, cylindrical measuring cups for detergent, and perhaps even cylindrical glasses in bars. In general, the results suggest that marketers and policy makers should examine whether the dimensionality of package and portion resizing influences not just how much people buy but also how much they use and consume.

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