More on the Square: How Dinnerware Shape Influences Portion Size Estimates

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Abstract
This research examines how the shape of dinnerware in service settings influences consumers' portion size estimates and consumption intentions. Across six experimental studies, participants viewed images of food presented on square or round dinnerware and indicated perceived portion size or consumption intentions. The studies varied meal type (e.g., single-item entrée, multi-component meal, and dessert) and dinnerware form (e.g., plates and bowls). Results show that food presented on square dinnerware is consistently perceived as larger than on round dinnerware due to a visual bias in which square shapes are perceived as occupying more space than circles, leading to inflated portion size estimates. In turn, consumption intentions are influenced by dinnerware shape, with square dinnerware increasing the expected quantity consumed when compared to round dinnerware. This work has implications for theory, practice, and societal well-being.

Keywords: dinnerware, shape, portion size, visual framing, consumption, food service

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1. Introduction

Reducing overconsumption has become a U.S. priority due to rising rates of obesity among adults and children alike (Ng *et al.,* 2024). With more than half of all U.S. food spend occurring outside the home (Zeballos *et al.,* 2024), an amount projected to reach $1.5 trillion in 2025, food service establishments are central to consumers' eating habits (National Restaurant Association, 2025). These establishments have the opportunity to make a vast number of decisions that have been shown to impact consumer perceptions and behaviors, even at the subconscious level. This includes decisions beyond menu items, with choices such as music, color, temperature, and dinnerware.

These factors have been shown to influence consumer health and economic outcomes by shaping consumer perceptions such as healthiness (Biswas *et al.,* 2017), tastiness (Lefebvre and Orlowski, 2019), and portion size (Szocs and Lefebvre, 2017). Portion size in particular can have a significant effect on important public policy and industry outcomes such as consumer wellbeing, food waste, and food service establishment profitability (Environmental Protection Agency, 2025; U.S. Food and Drug Administration, 2025; Wansink *et al.,* 2001). This is in part due to perceived portion size acting as a consumption guide, impacting the amount of food consumers eat (Marchiori *et al.,* 2014; Wansink and van Ittersum, 2013; Zlatevska *et al.,* 2014). This highlights the ability for food service establishments to indirectly influence how much consumers choose to eat.

Despite the growing interest in food portion research (Szocs and Lefebvre, 2017; Zlatevska *et al.,* 2014), one way in which consumers' perception of portion size and subsequent consumption may be impacted remained unexplored. Namely, the shape of the plate or bowl on which food is presented may act as a nonconscious visual framing mechanism, amplifying

perceived abundance without any change to actual portion size. This is especially relevant in food service settings, where consumers rarely weigh or measure their food, instead relying on visual heuristics to assess how much they are being served and whether it constitutes good value (Condrasky *et al.,* 2007; Nguyen and Powell, 2014; Ruby *et al.,* 2024).

The influence of dinnerware characteristics on portion perception may be derived from underlying perceptual biases. Prior studies have demonstrated that consumers tend to underestimate portion sizes (Chandon and Wansink, 2007; Ordabayeva and Chandon, 2016; Taylor and Noseworthy, 2021). This tendency seems to be exacerbated by dimensionality bias, systematic biases in spatial perception, as well as the influence of serving vessel shape on visual decision-making (Chandon and Ordabayeva, 2009; Raghubir and Krishna, 1999). The theoretical foundation underlying these biases provides an important context for understanding how dinnerware shape influences portion size estimation.

The present research aims to fill an important gap in food presentation research by examining whether consumers perceive portions as larger on square dinnerware compared to round dinnerware and whether this perception influences actual consumption behavior. Across six studies, we investigate (1) how dinnerware shape systematically affects portion perceptions, (2) whether these effects are driven by an area illusion in which the shape of the dinnerware influences its perceived size, (3) how individual sensitivity to external cues moderates this effect, and (4) how dinnerware shape affects consumption.

By addressing these questions, this research answers calls for additional work on food presentation and strategies to prevent portion size biases (Hagen, 2021; Ordabayeva and Chandon, 2016; Szocs and Lefebvre, 2017). Dinnerware shape serves as a meaningful cue that frames the consumption experience and influences perceived value.

This research introduces dinnerware shape as a visual cue that shapes consumers' portion size perceptions and consumption intentions in food service environments. By showing that square dinnerware is perceived as holding more food than round dinnerware, it extends the literature on visual framing and nonverbal design elements in servicescapes. The findings also broaden the scope of the Delboeuf illusion (Szocs and Lefebvre, 2017; van Ittersum and Wansink, 2012) by demonstrating that not just the size but also the geometric shape of the dinnerware can systematically distort perceived portion sizes. This reveals a new mechanism through which design can influence consumption intentions and perceived value.

2. Literature Background

2.1. Visual Cues in Service Settings

Service environments—particularly in food service establishments—are rich with visual, atmospheric, and contextual cues that shape consumer perceptions and behaviors. From lighting and music to menu layout and dinnerware (Garaus *et al.,* 2023; Kuo and Barber, 2014; Lefebvre *et al.,* 2022; Oakes, 2000), physical and ambient features form the servicescape, directly influencing how consumers experience and evaluate service and the establishment itself (Bitner, 1992). Within the servicescape, even subtle visual design elements carry meaningful weight, guiding expectations about quality, value, quantity, and satisfaction.

Visual cues are especially influential in dining contexts, where customers often make rapid, heuristic judgments based on what they see, rather than carefully analyzing nutritional content or weighing portion sizes (Condrasky *et al.,* 2007; Ruby *et al.,* 2024; Nguyen and Powell, 2014). The visual presentation of food, including the size, color, shape, and arrangement of the serving vessel, serves as an important extrinsic cue that helps consumers interpret the

experience. These cues not only influence how a meal looks but also affect more consequential outcomes such as perceived value, satisfaction, and consumption behavior (Krishna and Morrin, 2008; Wansink and van Ittersum, 2013).

Beyond size and contrast, another important yet underexplored visual cue influencing portion perception is the shape of the dinnerware itself. Consumers often exhibit systematic biases in spatial perception (Chandon and Ordabayeva, 2009; Raghubir and Krishna, 1999), and early research suggests that consumers tend to overestimate the size of figures with angular boundaries compared to those with curves (Coren and Girgus, 1978; Teghtsoonian, 1965). This illusion may occur because some shapes are easier for the visual system to process and stand out more distinctly from the background. While these features help people estimate surface area more easily, they can also lead to distorted perceptions under certain conditions.

2.2. Cues as Information Guides

Informational cues allow consumers to make heuristic judgments about product aspects they do not have objective information about. These judgments, known as heuristic judgments, are often used as shortcuts in consumer decision making and reduce the cognitive load on consumers. For instance, a relationship between price and quality is well-established, where consumers perceive products that are lower in price as being lower in quality. These shortcuts are often extended to food products. For example, haptic informational cues that indicate a beverage vessel is flimsy lead to perceptions of the product being less tasty (Krishna and Morrin, 2008) and the color of Asian noodles impacted taste perceptions, such that red noodles were perceived as spicier and yellow noodles as more savory (Zhou *et al.,* 2015). These effects are not limited to the intrinsic attributes of the food themselves (e.g., the color of the food) but occur based on

extrinsic information cues such as the packaging and dinnerware. For instance, whether a beverage is served in a glass bottle or can influences taste perceptions (Lefebvre and Orlowski, 2019) and white plates enhance sweetness and flavor intensity (Piqueras-Fiszman *et al.,* 2012).

Consumers often rely on visual and contextual cues to judge whether a meal is sufficiently portioned. Factors such as dinnerware size, food placement, and color contrast can influence how consumers perceive food quantity (Szocs and Lefebvre, 2017; van Ittersum and Wansink, 2012; Wansink and van Ittersum, 2013). For example, consumers perceive portions to be larger on a smaller plate (Wansink and van Ittersum, 2013) or when food is presented horizontally (i.e., food spread out on dinnerware) rather than vertically (i.e., food stacked on dinnerware; Szocs and Lefebvre, 2017), as in the case of an open-faced sandwich. Furthermore, low color contrast between dinnerware and the food served on it, such as serving white Alfredo pasta on a white plate, makes portion sizes more difficult to judge relative to high contrast foods and dinnerware. When portion size judgement is thus impaired, consumers tend to increase serving sizes on large plates while decreasing serving sizes on small plates (van Ittersum and Wansink, 2012).

These visual judgments influence real-world product and consumption evaluations. For example, Raghubir and Krishna (1999) demonstrated that even minor changes in a product's shape or orientation—such as the elongation of a glass—can significantly distort volume perception, with implications for how much consumers believe they are receiving. Similarly, Chandon and Ordabayeva (2009) showed that people consistently judge square or rectangular packages as larger and more voluminous than circular alternatives, despite identical objective dimensions.

These research findings underscore the powerful influence of shape and orientation on consumer judgments of quantity. In food service contexts, such perceptual distortions may be particularly impactful, as consumers rarely have access to objective volume indicators and instead rely on visual heuristics to estimate portion size. This reliance on appearance over measurement opens the door to systematic biases in perception.

In food-related service environments, consumers evaluate value and satisfaction not in isolation but in combination with sensory, emotional, and environmental cues. Service marketing involves deliberately designing and coordinating these cues to influence consumer perceptions and align expectations to ultimately enhance satisfaction and drive desired behaviors. Even subtle physical elements such as menu design, lighting, music, and tableware can significantly influence how customers interpret and evaluate service experiences (Garaus *et al.,* 2023; Kuo and Barber, 2014; Lefebvre *et al.,* 2022; Oakes, 2000). It is likely, then, that dinnerware too plays a direct role in framing the consumption experience and signaling value. In service environments where customers rely on quick, heuristic judgments, understanding the visual biases that shape these impressions is crucial.

2.3. Visual Biases

The way restaurants and other food service establishments present food plays a crucial role in shaping consumer perceptions. Rather than consulting restaurant menus or packaging labels for portion size, consumers rely heavily on their own visual impressions to determine food amounts (Ordabayeva and Chandon, 2016). However, visual perception is subject to four types of biases which influence perceptions of food portions and subsequent consumption decisions. First, consumers are apt to underestimate portion sizes. For example, consumers underestimate

larger meals more than smaller meals, even when provided with information about underestimation bias (Chandon and Wansink, 2007). This effect is magnified when the food is shared (Taylor and Noseworthy, 2021) or in the presence of healthy dishes served with lower calorie sides (Chandon and Wansink, 2007). Second, consumers are subject to dimensionality biases, in which perception of portion size is disproportionately influenced by changes in one, two, or three dimensions, as well as the direction of the dimensions of change. For example, consumers have more difficulty in estimating portion size when a box of candies changes along multiple dimensions (e.g., length and width) than when it is simply doubled in length (Ordabayeva and Chandon, 2016). Third, consumer portion perceptions are affected by food size labels such as "small", "medium", or "large" (Aydınoglu and Krishna, 2011). Lastly, affective reactions to food can result in perceptual biases. For example, greater desire for a food tends to enhance its perceived size (van Koningsbruggen *et al.,* 2011). Importantly, these visual biases affect important consumer outcomes such as price expectations, consumption, satiation, and choice, and marketers are tasked with identifying remedies to these visual biases (Ordabayeva and Chandon, 2016).

While these four types of visual biases have been well-documented, less attention has been paid to how the shape of dinnerware may serve as a visual framing device that systematically alters portion perceptions. In particular, the shape of the dinnerware (e.g., square or round) may distort perceived area and, consequently, influence judgments of how much food is being served.

2.4. Dinnerware Shape as a Visual Framing Device

Research on the relationships between visual stimuli and the sensations and perceptions they evoke has long shown that humans are not accurate in judging space, particularly when it comes to geometric forms. Consumers systematically misestimate product volume based on container shape (Raghubir and Krishna, 1999; Wansink and van Ittersum, 2005). For example, both novices and experts pour more into short, wide glasses than into tall, slender glasses (Wansink and van Ittersum, 2005).

One key finding is that squares are perceived as larger than circles (Anastasi, 1936). This phenomenon is partly explained by differences in spatial boundaries and axis alignment: squares have clear edges and corners, which make their spatial extent easier to process and more salient to the eye (Coren and Girgus, 1978; Teghtsoonian, 1965). Circles, by contrast, lack corners and have curved edges, which offer fewer reference points for estimating space (Chandon and Ordabayeva, 2009). As a result, square dinnerware may be visually interpreted as covering more area than round dinnerware of the same size, subsequently distorting perceptions of how much food it holds.

Although square and round dinnerware can have identical surface areas, consumers frequently perceive squares as taking up more space (Anastasi, 1936). This misperception comes from the way people see and interpret different shapes. Squares, with their defined edges, right angles, and extended horizontal and vertical lines, provide clearer reference points for visual estimation than circles, which lack corners and exhibit continuous curvature (Coren and Girgus, 1978; Teghtsoonian, 1965). Because of the nature of circles, which have no linear boundaries, spatial boundaries appear more compact and less extensive. As a result, consumers overestimate the size of angular shapes like squares compared to curved shapes such as circles, especially when judgments are made quickly or without physical measurement. This perceptual bias has

been demonstrated in several domains, including product packaging and food presentation. For example, consumers consistently judge square containers to be more voluminous than circular ones, even when the actual volume is held constant (Chandon and Ordabayeva 2009).

It is likely, then, that dinnerware shape may act as a nonconscious visual framing mechanism, with food presented on square dinnerware appearing to take up more space, increasing perceived portion size, in comparison to round dinnerware. Stated formally:

> **H1**: Food portion size will appear larger on square dinnerware than on round dinnerware.
>
> **H2:** The effect of dinnerware shape on portion size estimate will be mediated by dinnerware size perception, such that square (vs. round) dinnerware will lead to greater size perceptions, and in turn, greater portion size estimates.

2.5. The Moderating Role of External Eating

Of course, dinnerware shape is only one of many external cues present in food service establishments. Indeed, food service establishments are rich with visual and contextual stimuli. Consumers are exposed to many other elements when eating a meal, such as serving utensils (e.g., their shape, size, and design), arrangement of food (e.g., symmetrically vs. asymmetrically or horizontally vs. stacked; Hagen 2021; Szocs and Lefebvre 2017), menu descriptions (e.g., elaborate vs. brief; Garaus *et al.,* 2023), and atmospheric conditions (e.g., bright vs. dim lighting; Lefebvre *et al.,* 2022). Importantly, the influence of these external cues can have varying effects on consumers' perceptions and eating behaviors depending upon individual differences in reactions to visual cues. One such individual difference is the degree to which one's eating behaviors (including consumption and food choice) are driven by external cues, a trait referred to as external eating (Brignell *et al.,* 2009).

High external eaters are more sensitive to food-related cues in their environment and are more likely to respond to food-related pictures or text rather than internal hunger or fullness cues. For example, high external eaters are more likely to be distracted by such external cues (Brignell *et al.,* 2009) and therefore may be less sensitive to more subtle spatial design elements such as dinnerware shape. In contrast, low external eaters are not as easily distracted by environmental food-related cues and may be better able to tune in to structural and spatial features such as the shape of the dinnerware. This more focused attention may make low eternal eaters more susceptible to perceptual biases, such as overestimating dinnerware shape and portion size. Therefore, we propose:

> **H3:** The effect of dinnerware shape on perceived portion size is moderated by external eating tendencies, such that the effect is stronger for consumers low in external eating compared to those high in external eating.

*2.6. Downstream Consequence*s

Importantly, perceptions about dinnerware can also influence downstream behaviors. For example, studies show that consumption increases by an average of 35% when portion sizes are doubled (Zlatevska *et al.,* 2014). The portion size effect suggests that consumers tend to consume more when presented with larger portions, even when they do not report feeling hungrier (Marchiori *et al.,* 2014; Wansink and van Ittersum, 2013). This effect is particularly relevant to food service environments, where external cues play a central role in portion judgments. Restaurant diners typically consume what they are served (Nguyen and Powell, 2014), making them more susceptible to subtle the influences of these cues on portion perceptions. When portion sizes are increased, consumers increase their caloric intake of food types as broad as packaged snacks (Rolls *et al.,* 2004), casseroles (Rolls *et al.,* 2002), sandwiches (Rolls *et al.,* 2004), and fruits and vegetables (Kral *et al.,* 2009). The portion size effect even

extends to unpalatable foods (Wansink and Kim, 2005) and occurs for both adults and children alike regardless of gender or weight (Kral *et al.,* 2009; Rolls *et al.,* 2002; Rolls *et al.,* 2004)

Given that consumers perceive that meals served on square dinnerware are larger in portion size than that served on round dinnerware, we suggest that square dinnerware also increases consumption intentions. Formally, we propose:

> **H4:** Consumers will report greater intentions to consume more when food is served on square dinnerware compared to round dinnerware.

2.7. Plan of Studies

These hypotheses are investigated across a series of six studies. Studies 1a-c examine the effect of dinnerware shape on portion size estimate (H1) for three distinct foods: a meal served as a single item, a meal with multiple items, and a desert served in a bowl rather than a plate. Study 2 focuses on the proposed underlying mechanism of dinnerware size perception (H2). Then, Study 3 examines the boundary condition of individual external eating (H3), while Study 4 extends to the downstream behavior of consumption (H4). Implications to theory, society, industry are then discussed.

3. Study 1a

Study 1a examined the direct effect of dinnerware shape on portion size estimate (H1). We proposed that portion estimates would be larger on the square dinnerware than the round dinnerware.

3.1. Participants

One-hundred and twenty-one participants (54% male, avg. age = 39 years) were recruited through Connect by CloudResearch, an online data collection platform (Hartman *et al.,* 2023), in exchange for fair monetary compensation. Participants in this and subsequent studies were required to be over the age of 18 and reside in the U.S. All participants reviewed the consent form approved by the institutional review board prior to beginning the study. Participants were randomly assigned to either the round plate (n = 62) or square plate (n = 59) condition.

3.2. Procedure

Participants were asked to imagine that they had decided to have dinner at a cozy Italian restaurant where the menu item Spaghetti Marinara ("A hearty plate of al dente spaghetti tossed in a robust marinara sauce crafted from ripened tomatoes, fresh garlic, and aromatic herbs, finished with a sprinkle of Parmesan cheese") caught their eye. Then, all participants viewed a short video created for this research using the Sora AI video generator. This was included to enhance realism of the scenario and create a visual restaurant environment that was the same for all participants. The video was from the perspective of the customer viewing the menu with a male waiter in a formal service uniform showing a specials menu and ready to write down the customers' order. Following the video, participants placed their order for the spaghetti marinara. Then, participants were told that the server soon arrived with their plate of spaghetti and were shown an image of a plate of spaghetti, topped with red marinara sauce and garnished with basil. In line with the assigned condition, the spaghetti was presented on either a round or square white plate (see Appendix). After reviewing the image, participants were asked to rate the portion of the spaghetti (1 = *tiny*, 7 = *huge* [Szocs & Lefebvre, 2017; Aydinğlu and Krishna, 2011]) and to indicate their liking for spaghetti in general (1 = *hate it*, 7 = *love it*). Demographic questions completed the study. All study items are provided in the appendix.

3.3 Results

All participants completed the study in full and were included in the final analysis. The results of a one-way ANOVA (SPSS v.29) provided support for H1. Portion size was estimated to be larger when the dinnerware was square (M_{square} = 5.59, SD = 0.79) than when the dinnerware was round (M_{round} = 4.58, SD = 1.00, F (1, 119) = 37.90, $p < .001$). To account for participants' liking of spaghetti, an ANCOVA was conducted with liking included as a covariate. The results remained significant where the estimated portion size was significantly larger for the square dinnerware compared to the round dinnerware ($p < .001$).

4. Study 1b

Study 1b aimed to replicate the effect observed in Study 1a using a different focal food stimulus—a multi-component barbecue meal. While Study 1a featured a single-item meal of spaghetti, Study 1b involved several distinct food items arranged separately on the dinnerware. Testing both meal types is important because single- and multi-item meals may be processed differently in terms of visual attention and spatial integration (Joye *et al.,* 2021). Whereas single-item meals allow for more centralized visual estimation, multi-component meals require consumers to mentally integrate multiple elements across the plate, which could engage different perceptual processes. By demonstrating the effect of dinnerware shape across both meal types, we provide stronger evidence for the robustness and generalizability of the visual framing effect.

4.1. Participants

A total of 101 participants (50% male, avg. age = 37 years) were recruited and completed the study through Connect by CloudResearch in exchange for fair monetary compensation. The study used a between-subjects, single factor design where participants were randomly assigned to one of two experimental conditions (dinnerware shape: round [n = 48] vs. square [n = 53]).

4.2. Procedure

Participants were provided with an online scenario similar to that used in Study 1a. They were told to imagine they had decided to have a meal at a Southern-style smokehouse, where they ordered the "Southern Comfort Plate" with pulled chicken, creamy mac & cheese, crisp green beans, a golden, square buttery cornbread, and two sides of rich, smoky barbecue sauce (full scenario provided in Appendix). They were then told their plate of food soon arrived and were shown an image of the meal. The food items remained exactly the same in both conditions, with only the shape of the metal tray/plate being either round or square to align with the assigned condition. After viewing the image, participants completed the portion size measure and indicated their liking for each of the items included in the meal. Demographic questions completed the study.

4.3. Results

To assess the effect of dinnerware shape on portion size, a one-way ANOVA was conducted. The results revealed a significant effect of dinnerware shape on portion size (M_{square} = 4.13, SD = 1.35 vs. M_{round} = 3.60, SD = 1.90; F(1, 99) = 4.65, p = .03). In support of H1, the square dinnerware led to larger portion size estimates than the same portion size on round dinnerware. To account for participants' liking of each of the food items included in the meal, an ANCOVA was conducted with the liking measures. The effect of dinnerware shape remained significant (p < .03) with none of the liking covariates being significant.

5. Study 1c

Study 1c further replicated the effect of dinnerware shape while extending the findings to a different food category and vessel type. Specifically, this study used a dessert item to test

whether the shape-induced portion size effect held for sweet foods that are typically evaluated differently than entrees, which are typically more savory. Importantly, Study 1c extended the investigation to bowl-shaped dinnerware, allowing for an examination of whether the visual framing effect generalizes to curved and deeper dishware forms. Given that bowls are commonly used across a range of service settings, establishing the effect with this type of dinnerware enhances validity and practical relevance of the findings. The study employed a single-factor between-subjects design with two experimental conditions (bowl shape: round [n = 52] vs. square [n = 49]).

5.1. Participants

One-hundred one participants (46% male, avg. age = 40 years) completed the study through Connect by CloudResearch in exchange for monetary compensation. The design remained the same as the first previous studies, changing the focal food to ice cream and the dinnerware to a round- or square-shaped bowl (see appendix for images).

5.2. Procedure

The procedure remained similar to the previous studies. Participants were asked to imagine they had decided to treat themselves to something sweet at a cheerful neighborhood ice cream shop, where they decided to order “Birthday Cake Ice Cream – Three scoops of creamy birthday cake ice cream, bursting with that sweet, nostalgic cake batter flavor. Topped with a generous handful of rainbow sprinkles and nestled in a bowl full of even more colorful crunch. It's like a party in every bite – no cake required!” Participants were then told that their ice cream was ready and an image of the ice cream was displayed either in a round bowl or a square bowl.

After reviewing the image, participants completed the measures of portion, liking, and demographics.

5.3. Results

A one-way ANOVA was conducted to assess the effect of dinnerware shape on portion size estimates. The results lend further support to H1, where the square bowl was perceived as containing a significantly larger portion of ice cream (M_{square} = 5.57, SD = 0.94) than the round bowl (M_{round} = 5.02, SD = 1.09, F(1, 99) = 7.40, p = .01). An ANCOVA was again conducted including participant liking for ice cream in general. The results remained significant ($p < .01$), with liking being non-significant as a covariate.

5.4. Discussion

Across three studies, the results support the primary prediction, that square dinnerware resulted in estimates of the portion size being larger. Each study used distinctive food stimuli (i.e., a single item, multiple items, dessert, plate, metal tray, bowl) demonstrating the robustness and generalizability of the findings. Next, Study 2 examined the proposed underlying mechanism: perceptions of dinnerware size.

6. Study 2

Study 2 sought to examine the mechanism underlying the effect of dinnerware shape on portion size estimates (H2). Through a single factor between-subjects design with two experimental conditions (dinnerware shape: round [n = 50] vs. square [n = 51]), we investigate the indirect effect of dinnerware shape on portion size estimate through perceived size of the dinnerware.

6.1. Participants

Participants were recruited from Connect by CloudResearch in exchange for fair monetary compensation. One-hundred and one participants (44% male, avg. age = 39 years) completed the study.

6.2. Procedure

Following the procedure of the previous studies, participants were told to imagine they had decided to enjoy a leisurely brunch at a charming bistro and one dish catches their eye "Bistro Classic Burger & Fries" with a menu description included. Then, they viewed the same video of the server ready to take their order as in Study 1a. Participants were told that soon the server arrived with their order and said, "enjoy your meal!" as they set down the plate. An image of the meal was then displayed. The meal (burger and fries) remained the exact same in both the square and round dinnerware conditions (see Appendix). After reviewing the image of the meal, participants were asked to complete the single-item measure of portion size and a five-item measure of perceived dinnerware size (e.g., "please rate the size of the plate the food is on." 1 = *very small*/7 = *very large*; 1 = *tiny*/7 = *huge*; Szocs & Lefebvre, 2017; Aydinğlu and Krishna, 2011; a = .96). Measures of liking for burgers and fries, and demographic questions completed the survey.

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6.3. Results and discussion

Main effect. The results of a one-way ANOVA lend further support to H1. The square plate was perceived as containing a significantly larger portion (M_{square} = 4.47, SD = 1.10) than the round plate (M_{round} = 3.90, SD = 1.13, F(1, 99) = 6.61, p = .01). An ANCOVA was again conducted including participant liking for burgers and liking for fries in general. The results remained significant ($p < .05$), with neither food item's liking rating being a significant covariate.

Mediation. To examine the indirect effect of dinnerware shape on portion through perceived dinnerware size, PROCESS Model 4 with 10,000 bootstrap samples was used. The results showed that dinnerware shape (0 = round, 1 = square) had a significant positive effect on dinnerware size (a = .53, $p < .01$), indicating that square dinnerware was perceived as larger in size. In turn, the perceived dinnerware size had a significant positive effect on portion size (b = .72, $p < .01$). The indirect effect was significant (effect = .39, 95% CI [.12, .70]), while the direct effect was non-significant ($p > .34$). Again, the results remained significant when liking for burgers and fries was included in the analysis.

The results provided support for H2, demonstrating how square dinnerware led consumers to rate portion size as larger compared to round dinnerware. This occurs because a square dinnerware was perceived as larger in size, which in turn led to the portion size seeming larger.

7. Study 3

The purpose of Study 3 was to replicate support for the underlying mechanism (H2), while also examining the boundary condition of external eating behaviors. We predicted that the effect of dinnerware shape on portion size estimates would be stronger for low external eating consumers than those high in external eating. A single factor between-subjects design with two experimental conditions (dinnerware shape: round [n = 57] vs. square [n = 63]) was used, with trait external eating behaviors being measured.

7.1. Participants

One-hundred and twenty participants (40% male, avg. age = 37 years) were recruited and completed the study through Connect by CloudResearch in exchange for fair monetary compensation.

7.2. Procedure

The procedure followed the same process as the previous studies with the same focal food as Study 2 (i.e., burger and fries). After reviewing the image, participants completed the measures of portion size and dinnerware size (a = .95). Then, they were asked to complete a nine-item measure of external eating behavior (e.g., "If food smells good to you, do you eat more than usual?", "If you see others eating, do you also have the desire to eat?" [1 = *strongly disagree*, 7 = *strongly agree*] van Strien *et al.,* 1986; a = .81), followed by demographic questions.

7.3. Results and discussion

To examine the indirect effect of dinnerware shape on portion size through perceived dinnerware size as conditional on individuals' external eating behavior, PROCESS Model 7 with 10,000 bootstrap samples was used. The results indicated a significant moderated mediation effect (index of moderated mediation = -.22, 95% CI [-.44, -.03]; where the indirect effect was significant for participants low in external eating behavior (effect-1SD = .43, 95% [.16, .72]) but attenuated for those with high external eating behaviors (effect + 1SD = 0.01, 95% CI [-.26, .26]). Further investigation found a significant interaction (a3 = -.36, p = .03) of dinnerware shape and external eating behavior on perceived dinnerware size; dinnerware shape had a significant effect on perceived dinnerware size only when participants were low in external eating behavior (Johnson-Neyman significance value = 4.69; see Figure 1). The effect of

perceived dinnerware size on portion size was significant (b = .61, $p < .001$). Full results can be found in Table 2.

INSERT FIGURE 1 HERE

INSERT TABLE 2 HERE

The results of Study 3 provide additional support for the underlying mechanism of perceived dinnerware size. Further, the results indicate a significant boundary condition of consumer external eating behavior, where those high in external eating are less impacted by the shape of the dinnerware than those low in external eating behavior.

8. Study 4

Given that portion size estimates may impact consumer actions, Study 4 explored the downstream consequences by examining the effect of dinnerware shape on consumption intentions. We predicted that dinnerware shape would affect consumption intentions, such that consumers served on square dinnerware would report higher intentions to consume compared to those served on round dinnerware. This prediction was based on findings from Studies 1a–c and 2, which show that square dinnerware increases perceived portion size. According to prior research on the portion size effect (Marchiori *et al.,* 2014; Wansink and Kim, 2005; Wansink and van Ittersum, 2013), the effect of dinnerware shape should lead to increased consumption.

8.1. Participants

Ninety-nine participants (48% male, avg. age = 40 years) completed the study through Connect by CloudResearch. The study followed the design of the previous studies with two experimental conditions (dinnerware shape: round vs. square).

8.2. Procedure

Participants followed the same procedure as Studies 2 and 3 except the focal food was changed to a burger and onion rings (see Appendix). After viewing the image of the food they ordered, participants responded to "If you had this meal right now, how much would you want to consume?" (1 = *none at all*, 7 = *a lot*; Lefebvre *et al.,* 2019), followed by measures of liking for burgers and onion rings. The study completed with demographic questions.

8.3. Results and discussion

The results of a one-way ANOVA found participants intended to consume significantly more when the meal was served on a square plate ($M_{square} = 5.96$) compared to a round plate ($M_{round} = 5.29$, $F(1, 97) = 4.52$, $p = .04$).

9. General Discussion

Across six studies, we demonstrate that dinnerware shape has important implications for consumer perceptions. Specifically, the work presented here shows that consumers perceive portions served on square dinnerware to be larger than those served on round dinnerware. This effect occurs due to visual biases that decrease accuracy in judging the surface area of the dinnerware. Square dinnerware is interpreted as taking up more space, subsequently influencing perceptions of the portion of food it holds. Importantly, the effect of dinnerware shape is subject to moderation based on individual external eating tendencies, such that the effect is strongest among consumers who are low in external eating. Furthermore, we demonstrate that the effect of

dinnerware shape has important consequences for the amount of food consumed, with those consumers served on square dinnerware suggesting they will eat more of their meals than those served on round dinnerware. See Table 2 for a hypothesis and results summary.

INSERT TABLE 2 HERE

9.1. Theoretical Contribution

This research makes several important theoretical contributions to our understanding of visual perception and portion size estimation. In particular, the findings add to the literature on controllable factors that impact value signaling in service environments. While previous research has identified factors such as dinnerware color and materials or food arrangement as value-signaling cues (Hagen, 2021; Kuo and Barber, 2014; Zhao *et al.,* 2018) this work introduces dinnerware shape as a subtle but powerful visual cue that influences how much consumers believe they are receiving. The shape of the dinnerware frames the food in ways that affect perceived spatial area, which consumers may interpret as a signal of portion size. These findings extend theoretical understanding of how nonverbal design elements contribute to the construction of value perceptions in food service establishments.

Second, this research also advances to the literature on the Delboeuf illusion, a visual bias in which the perceived size of an object is distorted by the surrounding area. While prior work has primarily examined this illusion in the context of plate size or rim width (van Ittersum and Wansink, 2012), our findings suggest that dinnerware shape alone can similarly distort portion size estimates. Specifically, we demonstrate that square dinnerware is perceived as holding more food than round dinnerware due to differences in spatial boundaries. This broadens the scope of Delboeuf-related biases by demonstrating that visual framing based on geometric shape can

distort consumers' perceptions about portion size. In doing so, the work presented here identifies a new mechanism through which the physical design of dinnerware influences portion size estimates and consumption intentions.

9.2. Practical Implications

Importantly, these shape-based biases carry meaningful implications for both consumer wellbeing and managerial decision-making in service settings. For consumers, misperceptions of portion size can lead to changes in satisfaction, satiety, and consumption behavior (Cobo *et al.,* 2022; Ruby *et al.,* 2024; Zlatevska *et al.,* 2014). A meal that appears larger is more likely to be perceived as a good deal, more satisfying, and more filling, even when the actual quantity of food is unchanged. For service providers, this creates a strategic opportunity. Plate design may serve as a powerful tool to influence portion perceptions, satisfaction, and subsequent consumption. Rather than reducing actual portion sizes, an approach that can negatively impact satisfaction (Ruby *et al.,* 2024), service providers can leverage subtle interventions to influence portion perceptions, by opting for square rather than round dinnerware, food service operators may be able to present smaller or standardized portions in a way that appears more generous, enhancing customer perceptions of value while simultaneously supporting portion control goals. This approach aligns with broader efforts in the hospitality industry to promote healthier eating behaviors, reduce food waste, and maintain profitability, all while preserving the customer experience (Ruby *et al.,* 2024). Dinnerware shape, therefore, represents a low-cost, high-impact lever that operators can adjust to subtly guide consumer perceptions and behaviors.

9.3. Societal Implications

From a services marketing perspective, our findings demonstrate how service providers making seemingly minor design decisions can create value for not only their own businesses but for broader societal outcomes. Societal implications span across multiple service sectors, from empowering individual consumers to make more informed decisions to enhancing healthcare delivery experiences and improving institutional food provisions.

For individual consumers, awareness of how dinnerware shape influences portion size estimates provides important information for making better-informed decisions about at-home dining, as well as restaurant experiences. This knowledge enables consumers to strategically select personal dinnerware for their homes that supports health goals, whether to feel more satisfied with smaller portions or to avoid overconsumption. Additionally, an enhanced understanding of these biases can help diners determine whether restaurant portion sizes meet their needs or if their perception is influenced by presentation.

Healthcare and wellness providers can utilize awareness of how dinnerware shape influences portion perception to provide better recommendations for their patients while enhancing the overall effectiveness of their nutrition counseling services. Such recommendations can lead to sustainable behavior changes that are not dependent on willpower or restrictive dieting. This approach also allows healthcare providers to differentiate their services by offering practical interventions that patients can easily implement in their daily lives.

For institutional service providers such as hospitals, schools, and senior centers, the findings presented here offer additional opportunities that can improve service delivery through the implementation of dinnerware standards that simultaneously advance nutritional objectives and maintain customer satisfaction. Dinnerware standardization could be valuable in settings where consumers have limited control over their dining environment, allowing institutions an

opportunity to positively influence consumption behaviors without restricting food options. This approach could enable institutional food service managers to address nutritional goals through design rather than relying on menu modifications or educational interventions.

9.4. Limitations and Future Research

The above work is not without limitations. First, the studies we report were conducted with U.S.-based participants. Prior research suggests that cultural factors, such as self-construal, often influence spatial estimations. Because consumers with independent self-construal rely heavily on heuristics and biases when making these judgements, while those with interdependent self-construal are more likely to incorporate multiple perspectives (Krishna *et al.,* 2008), one could infer that the results reported here might fail to replicate with interdependent consumers. Future research examining cultural differences such as construal level could generate interesting insights.

Second, our studies focused primarily on entrees as the food stimuli. While entrees represent a significant portion of food service decisions and are often the most visually substantial part of a meal, it remains unclear whether the observed effects of dinnerware shape on portion size estimates would generalize to other food orders, such as appetizers. These courses often differ in both size and visual presentation. Unlike individual entrees, appetizers are often shared, which may influence how the shape of the dinnerware impacts portion size perceptions. For appetizers, the impact of dinnerware shape may vary depending on factors such as the visual complexity of the dish, its plating, or consumers' expectations regarding appropriate portion sizes. Future research should explore whether the shape-induced framing effects

observed for here for entrees extend to other courses within a typical restaurant experience, such as appetizers.

A third limitation is that our experiments utilized digital images rather than presenting actual food, which can limit the validity of our findings. After reading a short scenario and watching a video of a server taking their order, participants in our studies viewed photographs of their order on dinnerware. While this approach is common in food perception research and has been shown to produce reliable effects on portion estimation and consumer judgements (e.g., Chandon and Wansink, 2007; Szocs and Lefebvre, 2017; Ordabayeva and Chandon, 2016), this experience does not account for the tactile and depth cues which are present in actual dining situations. Prior studies have found that multisensory imagery which incorporates taste, smell, and texture, in addition to visual imagery, impacts choice and consumption (Cornil and Chandon, 2016). Standardized images such as those utilized in this research allow for controlled experimental conditions; however, the findings may not truly capture how dinnerware shapes portion perception in authentic dining conditions, where other sensory cues such as temperature and scents are present. Future studies could examine these effects using actual food presentations in a dining environment such as a restaurant or lab to determine whether perceptual biases translate into differences in consumption behavior. Finally, the shape of the dinnerware on which a meal is served may not only influence how much food a consumer believes they are getting but also may affect how generous, upscale, or satisfying the service feels. Future work can explore additional service perceptions based on dinnerware shape perceptions.

Given the substantial role that portion size plays in influencing consumption, research that identifies subtle, scalable strategies to guide portion perceptions holds significant societal and commercial value. With nearly 75% of adults and 33% of children in the United States

classified as overweight or obese, the health consequences are widespread and costly (Ng *et al*., 2024; Tarasenko, 2024). At the same time, food service establishments must ensure that consumers are satisfied with the value they receive (Ruby *et al.,* 2024). Visual cues such as dinnerware shape offer a promising solution, as they can nudge consumers toward more moderate consumption without diminishing the perceived portion size. Prior research has shown that smaller portions can reduce overeating and improve long-term health outcomes (Geier *et al*., 2006; Ordabayeva and Chandon, 2016; Tarasenko, 2024). The findings highlight the potential for design-based nudges to support both consumer well-being and business outcomes. We hope that future research continues to explore how perceptual and contextual cues can help consumer satisfaction with healthier decision-making in service settings.

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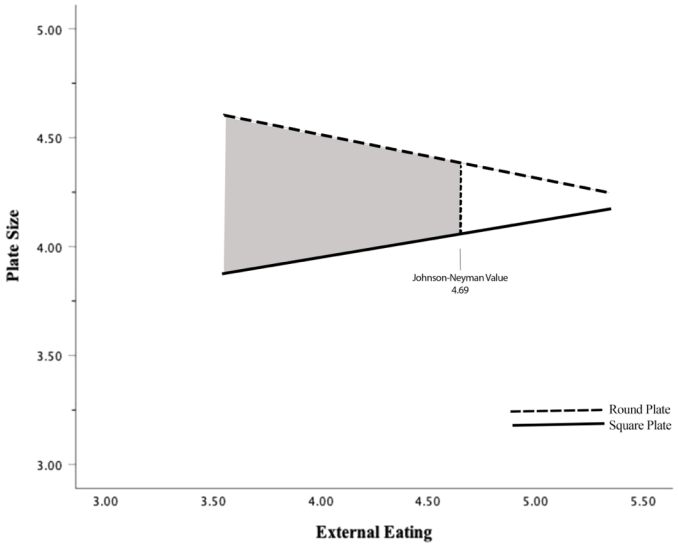
Figures

Figure 1. Study 3 Interaction



Source: Created by the authors.

Tables

Table I. Study 3 Moderated Mediation Analysis Results

	Coefficient	SE	t	p-value	95% C.I.
Perceived Size (Size)					
Constant	3.27	0.59	5.53	< 0.01	2.10, 4.44
Dinnerware Shape (DS)	2.10	0.78	2.59	0.01	0.47, 3.56
External Eating (EE)	0.17	0.13	1.32	0.19	-0.09, 0.42
DS*EE	-0.36	0.17	-2.16	0.03	-0.70, -0.03
Low EE (-1SD)	0.70	0.22	3.20	< 0.01	0.27, 1.13
High EE (+1SD)	0.02	0.22	0.10	0.92	- 0.41, 0.46
Johnson-Neyman Value - 4.69					
Portion Size (PS)					
Constant	1.70	0.36	4.69	< 0.01	0.99, 2.42
Dinnerware Shape (DS)	-0.11	0.15	-0.73	0.47	-0.40, 0.19
Perceived Size (Size)	0.61	0.09	7.07	< 0.01	0.44, 0.58
Indirect Effect DS → Size → PS	**Effect**	**BootSE**	**BootLLCI**	**BootULCI**	**Significant?**
Low EE (-1SD)	0.43	0.14	0.16	0.72	Yes
High EE (+1SD)	0.01	0.13	-0.26	0.26	No
Index of Moderated Mediation	**Effect**	**BootSE**	**BootLLCI**	**BootULCI**	**Significant?**
EE	-0.22	0.11	-0.44	-0.03	Yes

Note: PROCESS Model 7, 10,000 bootstrap samples
Dinnerware Shape: *0 = round, 1 = square*

Table 2. Hypothesis & Results Summary

Hypothesis	Studies Tested	Supported?	Results
H1: Plate Shape → Portion Size Estimate	1A 1B 1C	Yes Yes Yes	Square plates lead to larger portion size estimates.
H2: Plate Shape → Plate Size → Portion Size Estimate	2 3	Yes Yes	Square plates are perceived as being larger, in turn, increases portion size estimates.
H3: Plate Shape*External Eating → Plate Size → Portion Size Estimate	3	Yes	The mediation is significant only for those who are low external eating.
H4: Plate Shape → Consumption	4	Yes	Square plates lead to greater consumption.

Appendix

Measures

Portion Size – All Studies

"Please rate the size of the portion of spaghetti in the order."

1 = *Tiny*, 7 = *Huge*

Perceived Size – Studies 2 (α = 0.96) and 3 (α = 0.95)

"Please rate the size of the plate the food is on."

Very small/Very large

Tiny/Huge

Minuscule/ Gigantic

Little/ Massive

Diminutive/ Immense

External Eating Behavior – Study 3 (α = 0.81)

"Please indicate the degree to which you agree or disagree with the following statements:"

(1) If food smells good to you, do you eat more than usual?

(2) If food smells and looks good, do you eat more than usual?

(3) If you see or smell something delicious, do you have a desire to eat it?

(4) If you pass by a bakery, does that make you feel like buying something yummy?

(5) If you walk past a snack bar or a café, do you have a desire to buy something delicious?

(6) If you see others eating, do you also have the desire to eat? (r)

(7) Can you resist eating delicious foods?

(8) Do you eat more than usual when you see others eating?

(9) When preparing a meal are you inclined to eat something?

Consumption – Study 4

"If you had this meal right now, how much would you want to consume?

1 = *None at all*, 7 = *A lot*

Stimuli in Study 1a

Stimuli in Study 1b

Stimuli in Study 1c

Studies 2 and 3