AMERICAN PSYCHOLOGICAL ASSOCIATION

Journal of Experimental Psychology: General

ISSN: 0096-3445

2024, Vol. 153, No. 2, 275–281
https://doi.org/10.1037/xge0001503

Visual Cues and Food Intake: A Preregistered Replication of Wansink et al. (2005)

Alejandra Lopez[1], Alyssa K. Choi[2], Nadia C. Dellawar[1], Brooke C. Cullen[1], Sonia Avila Contreras[1], Daniel L. Rosenfeld[1], and A. Janet Tomiyama[1]

[1] Department of Psychology, University of California, Los Angeles
[2] Department of Psychology, San Diego State University

Imagine a bowl of soup that never emptied, no matter how many spoonfuls you ate—when and how would you know to stop eating? Satiation can play a role in regulating eating behavior, but research suggests visual cues may be just as important. In a seminal study by Wansink et al. (2005), researchers used self-refilling bowls to assess how visual cues of portion size would influence intake. The study found that participants who unknowingly ate from self-refilling bowls ate more soup than did participants eating from normal (not self-refilling) bowls. Despite consuming 73% more soup, however, participants in the self-refilling condition did not believe they had consumed more soup, nor did they perceive themselves as more satiated than did participants eating from normal bowls. Given recent concerns regarding the validity of research from the Wansink lab, we conducted a preregistered direct replication study of Wansink et al. (2005) with a more highly powered sample ($N = 464$ vs. 54 in the original study). We found that most results replicated, albeit with half the effect size ($d = 0.45$ instead of 0.84), with participants in the self-refilling bowl condition eating significantly more soup than those in the control condition. Like the original study, participants in the self-refilling condition did not believe they had consumed any more soup than participants in the control condition. These results suggest that eating can be strongly controlled by visual cues, which can even override satiation.

Public Significance Statement

Results from this study are relevant to public health and science given the influence that the bottomless soup bowls study had on public policy and the skepticism surrounding research from the Wansink lab. We found that what the eyes see plays a significant role in how much people eat and how full they feel. Given the high prevalence of diseases of overconsumption, this study has implications for the regulation of eating behavior.

Keywords: preregistered replication, eating behavior, visual cues, portion size, consumption

Supplemental materials: https://doi.org/10.1037/xge0001503.supp

Imagine eating a bowl of soup for lunch. Spoonful after spoonful, as the minutes pass, you begin to feel pleasantly full as the bowl empties. With a final slurp and the last remnants of soup gone, satiation sets in as your eyes meet the bare bowl—meal complete. But what if the laws of physics had glitched, and this bowl had been refilling itself with soup after every spoonful you took? Would you stop eating at the same time it would normally have emptied, or would such a visual illusion prolong your consumption?

This article was published Online First November 2, 2023.

Alejandra Lopez https://orcid.org/0000-0001-5258-7868

This study was preregistered at https://osf.io/ux42g. An abstract with data from this article was also accepted to be presented as a poster at the Society of Behavioral Medicine 2020 annual meeting. Data from this article have been presented at an undergraduate conference at the University of California, Los Angeles by Sonia Avila Contreras in May 2020. The authors declare no conflicts of interest. Data from this study are available at https://osf.io/dxk5r.

Alejandra Lopez served as lead for data curation, writing–original draft, and writing–review and editing. Alyssa K. Choi served as lead for project administration and contributed equally to methodology and writing–original draft. Nadia C. Dellawar served in a supporting role for investigation, project administration, and writing–review and editing. Brooke C. Cullen contributed equally to project administration and served in a supporting role for writing–review and editing. Sonia Avila Contreras served in a supporting role for investigation, project administration, and writing–review and editing. Daniel L. Rosenfeld served in a supporting role for formal analysis and writing–review and editing. A. Janet Tomiyama served as lead for conceptualization, funding acquisition, and methodology, contributed equally to supervision and writing–review and editing, and served in a supporting role for project administration and writing–original draft. Alejandra Lopez and Alyssa K. Choi contributed equally to formal analysis. Alyssa K. Choi and Brooke C. Cullen contributed equally to investigation. Alejandra Lopez and A. Janet Tomiyama contributed equally to validation.

Correspondence concerning this article should be addressed to A. Janet Tomiyama, Department of Psychology, University of California, Los Angeles, 1285 Psychology Building, 502 Portola Plaza, Los Angeles, CA 90095-1563, United States. Email: tomiyama@psych.ucla.edu

Previous research indicates that satiation—the process that leads to the termination of eating—is shaped by internal and external factors. Internal factors refer to consumers' awareness of internal (or bodily) signals, like feelings of hunger. External factors refer to consumers' perception of food's composition, variety, and quantity (Cornil, 2017). In a seminal study, Wansink et al. (2005) highlighted the role of external factors, and theorized that visual cues may play an important role in regulating eating behavior. Specifically, these authors hypothesized that altering visual cues of the amount of food eaten would influence intake. They further hypothesized that, among participants eating from an imperceptibly self-refilling bowl, estimated consumption and perceptions of satiation would be more influenced by the biased visual cue than by how much soup they actually consume. To test these hypotheses, Wansink et al. (2005) randomly assigned 54 undergraduate students to either a self-refilling bowl or a normal (not self-refilling) bowl condition. As a cover story, participants were told that the aim of the study was to taste test a new recipe of tomato soup. Participants were run in groups of four, with two of them unknowingly eating from self-refilling bowls. For the other two participants, their bowls were refilled by a research assistant once they only had about a quarter of the soup left. Wansink and colleagues found that participants in the self-refilling bowl condition consumed 73% more soup than those in the control condition. After controlling for participant sex, body mass index (BMI), and retrospectively reported baseline hunger, the effect of condition on consumption remained significant, $F(1, 49) = 4.7, p < .05$.[1] Despite that 73% difference in consumption, self-reported estimates of soup intake in ounces and calories were not significantly different between conditions. Additionally, there were no significant differences in perceptions of satiation between the accurate visual cue and the biased visual cue conditions. From these results, Wansink and colleagues concluded that "people use their eyes to count calories and not their stomachs" (p. 98). Results from the bottomless soup bowls study support a portion size effect—the notion that as portion sizes increase, food consumption increases (Rolls et al., 2007). The broader literature has also consistently found support for the portion size effect (English et al., 2015; Peter Herman et al., 2015; Zlatevska et al., 2014). That is, visual cues play an important role in the amount of food individuals consume, regardless of satiation.

However, the veracity of research from the Wansink lab has been called into question in recent years, with 15 of their articles retracted, 14 corrected, and over 50 facing scrutiny. Cornell University conducted an investigation into Wansink's research and concluded that he "committed academic misconduct in his research and scholarship, including misreporting of research data, problematic statistical techniques, failure to properly document and preserve research results, and inappropriate authorship" (Kotlikoff, 2018). Specifically regarding the bottomless soup bowls study, questions have been raised about the transparency of the results. For instance, one researcher found the results reported by Wansink et al. (2005) to be implausible given assumptions extracted from the original article (Heathers, 2018). Moreover, we note that although the study by Wansink and colleagues was designed to run participants in groups of four, the total sample size of 54 is not divisible by four. They also did not disclose how outliers were handled, nor if any participants were removed from the final analyses.

The suspicion cast on this study is important to note because the publication (Wansink et al., 2005) has been highly influential to subsequent research, having been cited 819 times (as of August 14, 2023 according to Google Scholar). According to Wansink's book, titled *Mindless Eating* (2006), it was also widely disseminated among the public and influenced policy (e.g., within the United States Department of Agriculture, the military, and school lunchrooms) and consumers (e.g., motivating the advent of 100-calorie snack packs and mindless eating interventions targeting weight management). Despite this, a direct replication of this study has yet to be published. Thus, we conducted a preregistered direct replication with a larger sample size while mirroring the original methods as closely as possible. We hypothesized that our results would replicate Wansink and colleagues' findings in that participants in the experimental condition would eat significantly more than those in the control condition. In our preregistration, we stated that we would deem the replication successful if we observed at least half ($d = 0.4223$) of Wansink et al.'s original effect size ($d = 0.8446$).

Method

Participants

In total, we collected data on 654 participants but excluded 190 due to either participants discovering the true purpose of the study ($n = 168$, or 26%) or experimenter error ($n = 22$, or 3%). Importantly, however, individuals were excluded from analyses if one or more participants in their group inferred the true purpose of the study—resulting in many excluded participants. We note that the results of the inferential tests reported below do not change whether these participants are included or excluded (see the online supplemental materials). A common experimenter error was research assistants forgetting to weigh the soup pots or bowls prior to or after data collection. The final sample size in this study was 464 participants.

Participants (79.7% female, 19.6% male, 0.2% other, 0.2% preferred not to state, and 0.2% did not report on their sex) were recruited from a university's subject pool of undergraduate students. Participants were asked to report their sex with an option to select male, female, prefer not to state, or other—wherein we provided an option for them to further specify. We also asked about their race/ethnicity with the following options: White/Anglo or European American; Black/African American, Caribbean; Asian, Asian American, Pacific Islander; Hispanic/Latino(a); Native American; Arabic/Middle Eastern; Biracial; or Other—both with an option for them to further specify. Individuals participated in the study in exchange for either financial compensation (i.e., $5) or credit toward a psychology course requirement. Participant age ranged from 18 to 54 years old ($M_{age} = 20.47$ years, $SD = 3.10$). Participants reported their ethnicity as Asian (46.1%), White (22.2%), Hispanic (13.1%), Biracial (8.2%), Arabic/Middle Eastern (6.5%), Black/African American (2.4%), and other (1.5%). Participants had an average BMI of 23.47 ($SD = 4.22$).

Apparatus

The apparatus used in this study was built as similar to the original study as possible, comprising a dining table, four bowls, and two large pots at the ends of the table (Wansink et al., 2005). The design

[1] We note that although reporting p-values as $p < .05$ is inconsistent with APA format 7th edition, Wansink et al. (2005) reported it this way in their article, and thus we do not have the exact p-value to report here.

Figure 1
Soup Bowl Apparatus

Note. See the online article for the color version of this figure.

of the apparatus was based on both Wansink and colleagues' description and publicly available videos demonstrating the design. Two of the opposing diagonal soup bowls were regular bowls (used for the accurate visual cue condition), while the other two opposing diagonal soup bowls were identical in the way they looked but were self-refilling (used for the biased visual cue condition). Clear food-grade tubing underneath the table connected the self-refilling bowls to corresponding pots which each contained on average 170.61 ounces of soup. While the self-refilling bowls maintained a consistently full amount of soup by refilling automatically, the normal bowls were refilled manually by research assistants during check-ins every 3 min. Participants were unable to see below the table and were told the pots were for decoration purposes only. Figure 1 displays the apparatus and setup. The online supplemental materials contain detailed instructions on how to construct the apparatus, a list of supplies needed with approximate budget, and a larger collection of photographs.

Procedure

The University of California, Los Angeles Institutional Review Board approved all procedures (IRB19-000075). The procedure was kept as similar to the original study (Wansink et al., 2005) as possible. The study was advertised as a soup tasting study. Participants were scheduled for one of three eating times (11:00 a.m., 12:00 p.m., or 1:00 p.m.) and scheduled in groups of four people. Using a computer-generated randomization schedule, participants were randomized to one of two conditions: accurate visual cue (normal soup bowl) versus biased visual cue (self-refilling soup bowl).

Participants visited the laboratory to complete all questionnaires and procedures. Upon arrival, they were greeted by a research assistant and guided to a room with restaurant decor, bistro music playing, and four bowls (two purple and two green) filled with tomato soup. Seating was based on condition (see Apparatus section).

After providing informed consent, participants completed a pre-study questionnaire in which they self-reported demographic information, the types of bowls they used at home (e.g., color and size), whether they thought color indicated how food tastes, their favorite and least favorite foods, their favorite color, and the color of their favorite and least favorite foods. As in Wansink et al. (2005), the questions pertaining to color were deployed to misdirect participants as to the true nature of the study hypotheses. Participants were then told they would be given 20 min to try a new soup recipe for lunch. They were told they could enjoy as much soup as they wanted, but that everyone needed to try at least some of the soup. Participants were also instructed not to move the bowl from where it had been placed. Following Wansink and colleagues' study protocol, research assistants wearing aprons came in every 3 min to check in on participants and to refill the control bowls as needed. Based on requests during piloting, we diverged from Wansink et al.'s protocol in that we provided water to participants if they asked for it.

After 20 min, participants completed a poststudy questionnaire paralleling that in the original study (Wansink et al., 2005). Participants estimated how many ounces and calories they thought they ate and answered additional questions on a 9-point Likert scale. Participants responded to items relating to their experience in the study (e.g., "I carefully paid attention to how much I ate") on a scale ranging from 1 (*strongly disagree*) to 9 (*strongly agree*). Additionally, participants responded to satiation-related items (e.g., "How hungry are you right now?") on a scale ranging from 1 (*not at all*) to 9 (*a lot*). We note that our anchors inadvertently

differed slightly from Wansink and colleagues' scale which ranged from 1 (*a little*) to 9 (*a lot*). Two other distractor items were added to maintain the cover story—"How tasty is the soup?" and "How much did you enjoy eating the soup?"—but these items were not analyzed. After completion of the poststudy questionnaires, participants were debriefed, and research assistants measured the postconsumption weights of the pots and the bowls to calculate how much soup was consumed by participants.

Transparency and Openness

This study's design and analysis plan were preregistered at https://osf.io/ux42g. We report all data exclusions (see the online Supplemental Materials), all manipulations, and all measures in this study, and we follow *Journal Article Reporting Standards* (JARS; Kazak, 2018). All data and research materials are available at https://osf.io/8q647/. Data were analyzed using SPSS Version 28.0.0.0.

Results

Table 1 displays results by condition, comparing the current study to Wansink et al. (2005). For a full list of results (including those that were not preregistered by our team), see the online supplemental materials. Participants who ate out of self-refilling bowls consumed 32% more soup than those in the control condition, despite the control group estimating that they ate 53% more (see Figure 2). Moreover, replicating Wansink et al., we found no significant differences in satiation ratings or estimated calories of soup consumed between conditions. Similar to the study by Wansink and colleagues, BMI was not significant when included as a covariate, whereas retrospectively reported hunger was, $F(1, 458) = 14.23$, $p < .001$, $\eta^2 = .03$, such that hungrier participants ate more than those who were less hungry. However, unlike the original study, we found that males ate more than females, $F(1, 458) = 12.85$, $p < .001$, $\eta^2 = .03$. Controlling for sex is particularly important because the original study comprised 72% males (vs. 20% males in our study).

Replicating the correlations observed by Wansink et al. (2005), we found that estimated ounces and calories of soup consumed were positively correlated with actual consumption volume (see Table 2). We also found other correlations that were not significant in Wansink et al. (2005) between actual consumption and several statements (see the online supplemental materials).

Several other findings did not replicate. As noted above, we found a significant effect of condition for estimated ounces consumed, such that the control group estimated they ate more in ounces ($M = 7.47$, $SD = 10.43$) than the experimental group ($M = 4.88$, $SD = 6.02$), $F(1, 460) = 10.31$, $p = .001$, $d = 0.31$. In the original study, there were no differences in estimated consumption between the groups. Whereas Wansink et al. (2005) found no significant difference in nausea ratings between the experimental and control group, we found a significant effect of condition, such that the experimental group reported feeling more nauseated ($M = 2.61$, $SD = 1.96$) than the control group ($M = 2.03$, $SD = 1.51$), $F(1, 461) = 13.10$, $p < .001$, $d = 0.34$. Further, we found a significant difference in responses to the following statement, "I usually eat until I reach the bottom of the bowl." The control group more strongly agreed with the statement ($M = 6.57$, $SD = 2.05$) compared to the experimental group ($M = 6.06$, $SD = 2.27$), $F(1, 462) = 6.47$, $p = .011$, $d = 0.23$

Table 1
Visual Cues Unknowingly Influence Overconsumption

	Visual cues of consumption							
	Accurate visual cue—Wansink et al. (2005)	Accurate visual cue—Current study	95% CI	Biased visual cue—Wansink et al. (2005)	Biased visual cue—Current study	95% CI	*F* value—Wansink et al. (2005)	*F* value—Current study
Actual consumption volume								
Ounces	8.5 ± 6.1	8.87 ± 6.24	[8.10, 9.69]	14.7 ± 8.4	11.71 ± 6.34	[10.88, 12.58]	8.99**	23.64***
Calories	154.9 ± 110.3	196.68 ± 138.33	[179.74, 214.96]	267.9 ± 153.5	259.73 ± 140.59	[241.25, 278.93]	8.99**	23.64***
Participant-estimated consumption volume								
Ounces	8.2 ± 6.9	7.47 ± 10.43	[6.13, 8.78]	9.8 ± 9.2	4.89 ± 6.02	[4.06, 5.67]	0.46	10.31**
Calories	122.6 ± 101.0	133.03 ± 121.33	[118.32, 149.12]	127.4 ± 95.6	115.15 ± 118.38	[99.31, 130.99]	0.03	2.55
Consumption monitoring								
I carefully paid attention to how much I ate	4.9 ± 2.3	4.21 ± 1.81	[3.98, 4.44]	5.3 ± 2.4	4.40 ± 2.06	[4.12, 4.68]	0.69	1.14
Self-perceptions of satiety								
How hungry are you right now?	3.4 ± 2.1	4.00 ± 1.99	[3.75, 4.25]	3.0 ± 1.9	3.72 ± 2.13	[3.45, 4.02]	0.63	2.06

Note. Values are $M \pm SD$. Shaded columns denote the current replication study. CI = confidence interval.
** $p < .01$. *** $p < .001$.

Table 2
Correlations With Actual Consumption Volume

Estimated consumption volume	Those eating from normal soup bowls ($n = 246$)	Those eating from self-refilling soup bowls ($n = 218$)	All participants ($n = 464$)
Estimated ounces of soup consumed	$r = .36$***	$r = .30$***	$r = .28$***
Estimated calories of soup consumed	$r = .41$***	$r = .37$***	$r = .36$***

*** $p < .001$.

Moreover, responses to the statements "I usually eat until I reach the bottom of the bowl," $r(461) = .13$, $p = .004$, and "I always try to clean my plate (or bowl) at home," $r(461) = .11$, $p = .020$ were significantly and positively correlated with actual consumption volume. Some other within-condition correlations also failed to replicate (see the online supplemental materials).

Given that the original study by Wansink et al. (2005) was conducted in the Midwest, we also tested to see if participants who reported being from the Midwest showed different results compared to individuals from elsewhere; we found no significant interaction. Given that we offered water whereas the original study did not, we also conducted analyses controlling for water consumption. Doing so did not change the pattern of results, where the experimental group ate more than the control group, $F(1, 461) = 24.15$, $p < .001$.

Discussion

The purpose of this study was to attempt to directly replicate findings from Wansink et al. (2005). Given the impact this study has had on public policy and the issues surrounding the scientific misconduct of the Wansink lab as well as questions raised about this study specifically, we saw great value in such a replication study. The results of the present study did replicate the key finding from Wansink et al.—participants that ate from the imperceptibly self-refilling bowl ate more than those eating from the regular bowl.

The effect size we observed (32% more soup consumption, or $d = 0.45$), was a little over half of that observed in the original study (73% more soup consumption, or $d = 0.84$). This observation reflects a more general trend whereby effect sizes tend to be smaller in replication studies (Anderson & Maxwell, 2017). In our preregistration, we had indicated that a successful replication would be defined as "If our results show that the experimental (biased visual cue) group consumed significantly more soup than the control (accurate visual cue) group, but their estimated consumption and satiation ratings were not significantly different between groups. In terms of the size of the effect, we will consider the effect replicated if the difference in the two groups in terms of consumption is at least half of the original effect (i.e., Cohen's $d = 0.4223$)." While participants in the control group estimated that they ate significantly more soup than did those in the experimental group, these results are still consistent with Wansink and colleagues' hypotheses. We therefore deem this replication successful.

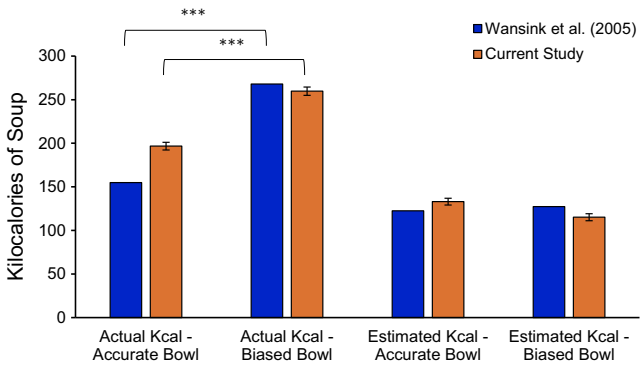
Not all of Wansink's secondary analyses replicated, however. One possible explanation for a lack of replication in all results from the original study may be the substantial difference in sample size. The Wansink et al. (2005) study had a sample size of 54 participants, whereas the present study had a sample size of 464 participants, offering more power to detect differences or correlations that went undetected in the original study. Of note, however, is that not all results followed the same direction as Wansink and colleagues' study; thus, some correlations may have been spurious.

We found that just over a quarter of participants had to be excluded because one or more of the participants in that four-person group guessed the true nature of the study. However, it remains unknown how many participants were excluded in the original study, as Wansink et al. (2005) did not report on exclusions. It is possible that the paradigm, while extremely novel and creative, is nonetheless simply difficult to employ without suspicion. Nonetheless, Supplemental Analyses that included all participants yielded the same pattern of findings ($d = 0.47$).

Taken together, these findings generally replicated Wansink et al.'s (2005) original results, wherein participants in the self-refilling soup bowls condition consumed significantly more ounces and calories of soup than did those in the control condition. However, in our replication study, participants in the control condition estimated that they ate significantly more ounces than those in the experimental condition, which does not directly replicate Wansink et al. but supports their theoretical position. Of note is that our large sample size provided much more power than the original Wansink et al. study. In addition to the sample size, another strength of our replication study is that we preregistered our hypotheses and did not deviate from our registered analyses.

Results from this study suggest that eating in social settings, when combined with biased visual cues, may lead to unintentional overconsumption. Overconsumption of foods—specifically those containing high levels of sodium, processed meat, and unprocessed red meat—is associated with cardiometabolic disease-related death (Micha et al., 2017). Overconsumption of sugar sweetened

Figure 2
Biased Visual Cues Provided by Self-Refilling Soup Bowls Increased Intake but Not the Perception of Intake



Note. See the online article for the color version of this figure.
*** $p < .001$.

beverages has also been consistently associated with Type 2 diabetes and cardiovascular disease (Arsenault et al., 2017). Given that Type 2 diabetes and cardiovascular disease are some of the leading causes of death worldwide (World Health Organization, 2020), understanding the mechanisms underlying overconsumption and how to target it is imperative. This study provides evidence that overconsumption may be more likely when biased visual cues are provided. Of note, the finding that satiation ratings did not differ across conditions is promising for reducing food overconsumption. This finding suggests that perhaps counterintuitively, abiding by designated portion sizes may not affect how satiated individuals perceive themselves to be. This could further be harnessed to educate consumers that they can feel satiated with smaller portions. Moreover, despite pervasive negative societal stereotypes that higher BMI individuals always eat large amounts of food, we did not find that BMI was a significant predictor of eating, and the effect size was estimated at 0.000. Given recent calls to move away from the "calories in calories out" model of weight gain and obesity (Ludwig et al., 2021), this null finding is intriguing.

The results of this study add to the longstanding literature on cognitive and sensory controls of eating behavior (Davidson et al., 2019). Along with other known factors like bite size/frequency and postingestive learning, the effect of visual cues on eating is theorized (English et al., 2015) to be one mechanism driving the "portion size effect"—the tendency for people to eat more when served larger portions (Peter Herman et al., 2015; Zlatevska et al., 2014). As individuals use visual cues to determine when a portion has been completed, the misleading cues we presented to the experimental group likely drove their eating behavior. Although we examined eating behavior concurrently with biased visual cues, a study by Brunstrom et al. (2012) investigated the role of postmeal memory on hunger using a peristaltic pump that either refilled or drained a soup bowl. Using a 2 (actual soup consumed: 300 vs. 500 ml) × 2 (perceived soup consumed: 300 vs. 500 ml) design and diverging from the current results, they found that immediately after eating, hunger ratings were a result of the actual amount of soup consumed. Two to three hours after eating, however, hunger ratings were instead a result of the perceived amount of soup consumed.

Work from the Wansink lab has come under scrutiny for scientific misconduct, leading ultimately to Wansink's resignation from Cornell University (Servick, 2018). However, the entire field of psychology is undergoing what has been called a "replication crisis" (Open Science Collaboration, 2015), with much of the failure to replicate attributable not to outright misconduct as seems to have been the case with Wansink's lab, but to questionable research practices like p-hacking (Simmons et al., 2016; in which Wansink has also been accused of engaging; Lowe, 2018). In addition to improving scientific practices, such as engaging in preregistration (Bosnjak et al., 2022; Stewart et al., 2020) and data sharing (Martone et al., 2018), a key way to ensure trustworthy science is to conduct replications. Because Wansink's work has had an outsized impact on policy, and because of the unusual methods used, here we elected to engage in a direct replication. Direct replications, which strive to follow the original methods exactly, are one important tool in the replication toolbox (Simons, 2014). Conceptual replications, in which the hypothesis is tested using different methods, manipulations, or populations, are another important tool (Stroebe & Strack, 2014). Therefore, future conceptual replication studies of the visual cue effect replicated here would be useful, like using the clever soup-draining design created by Brunstrom et al. (2012). Further work replicating other studies from the Wansink lab will also be important, given the large impact they too have had on research and policy.

Constraints on Generality

Despite our larger sample size compared to Wansink et al.'s study (2005), our sample similarly comprised university undergraduates. The difference between undergraduates and the general population is a longstanding problem in psychology (Nature Neuroscience, 2010). Although we do not necessarily have reason to believe that basic visual processes would differ between undergraduates and the general population, replication is nonetheless warranted in nonstudent samples. Our findings are also constrained to those in the United States in this historical period, where large portion sizes (Hosni & Giannakas, 2022) and cultural norms like cleaning one's plate (Lorenz et al., 2017) are prevalent. The effect size, therefore, may be inflated in the United States. The materials used in this study, clearly, are highly unique and not generalizable to normal eating situations. Nonetheless, we expect that replications that use nonsoup foods would be successful. Participants were tested in groups of four and ate with strangers. Given known effects of eating in groups versus alone (Clendenen et al., 1994) and possibly of eating with friends/family versus strangers (Ruddock et al., 2019), replication is warranted in other eating settings.

Context

As researchers who study eating behavior, we have always been enamored by "the soup bowl study," as it is colloquially known. The senior author would use Wansink et al. (2005) in her undergraduate courses to illustrate the fun and creative side of research. When the controversy surrounding (and eventual resignation of) Wansink occurred, the perfect opportunity arose for us to replicate this important finding. Working off of the original article and YouTube videos where Wansink showed the actual apparatus, we collaborated with our department's shop unit (led by Kevin Nguyen, who was more accustomed to engineering apparatuses for rodent and pigeon experiments) to recreate the never-ending soup bowls. Overall, this project was extremely valuable in that it taught our undergraduate research assistants about the importance of replication in a fun way and provided important replicability data for research that has had an outsized effect on public policy.

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Received July 14, 2022
Revision received August 14, 2023
Accepted September 4, 2023 ■