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Are you being served? Managing waist and waste via serving size, unit size, and self-serving

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ABSTRACT

Food serving sizes are on the rise and this increase is one factor contributing to both obesity and food waste. Hence, reducing serving size is a potentially effective strategy for lessening overconsumption and food waste—but it carries the risk that consumers may perceive the smaller serving size as too small, lowering satisfaction. This research examines the role of serving size, unit size, and self-serving on the amount of food served, consumed, and wasted, with the main objective of reducing both overconsumption and food waste while maintaining consumer satisfaction. Across four experiments, we demonstrate that consumers who are served food in smaller units consume less but waste more, while consumers who serve themselves food in smaller units consume less and waste less. When self-serving food in smaller units, consumers benefit from pause moments providing decision-making opportunities that draw attention to the serving decision, as reflected in longer serving times and greater overestimation of the served amount of food. Consequently, consumers presented with smaller unit sizes serve themselves less food—resulting in decreased consumption and waste, without lessening consumer satisfaction. These findings offer a wide range of win–win implications that are of relevance to consumers as well as to managers of restaurants, food services, and health professionals.

1. Introduction

Many societies currently face two prominent challenges regarding food consumption: overconsumption and food waste. Overconsumption is a fundamental cause of obesity, which has become a principal health concern in communities across the world. Worldwide, obesity has nearly tripled since 1975 (World Health Organization, 2020). At issue are dietary patterns, which have changed substantially over the last 30–40 years (Cecchini & Warin, 2016). Equally concerning is food waste: one-third of all edible food destined for human consumption is lost or wasted each year within the food supply chain (Gustavsson et al., 2011). Consumers are responsible for up to 65% of the total amount of food waste and are therewith the largest waste contributors (Gustavsson et al., 2011; Block et al., 2016). Waste of food is not only a waste of money. It also has a substantial impact on the environment: domestic food waste boosts greenhouse gas emissions, contributes to the demand for agricultural land, and affects both water and energy consumption (Bajželj et al., 2014; Quested et al., 2013).

Overconsumption and food waste often rise and fall in opposition: when one goes down, the other is likely to go up, and vice versa (Kjærgård et al., 2014; Van Kleef et al., 2015). The main objective of this research is to offer a conceptual model and corresponding empirical evidence on how to reduce *both* overconsumption and food waste while maintaining consumer satisfaction. When discussing food waste, we follow the definition proposed by Yu et al. (2021): food waste is the edible part of food that is disposed of or left on plates after consumption. We focus on the role of serving size (a predetermined amount of food), unit size (the size of the units into which a given amount of food is divided), and the possibility to self-serve the amount of food (differentiating between consumers who serve and thus determine the amount themselves and those who are served a predetermined amount).

Our contributions are threefold. First, we are among the first to empirically test the combined effects of serving size and unit size on food consumption and waste. These two variables both play an important role in the overall eating experience that influences food choice and intake but through different mechanisms and, thus, promote different targets for interventions designed to change consumption patterns (English et al., 2015; Raynor & Wing, 2007). Second, we uniquely demonstrate the role of unit size in reducing both food consumption and waste when consumers serve themselves a preferred amount of food (versus are

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served a predetermined amount) by showing how consumers may be enticed to self-serve a more appropriate amount of food when offered small single units. Third, we offer corroborating evidence for the underlying mechanism that explains these results.

The remainder of this manuscript looks as follows. First, we offer a theoretical framework with hypotheses. Next, we present four studies to test our hypotheses. We end with the general discussion and concrete recommendations for practitioners.

2. Theoretical framework

2.1. Serving-size effect

Serving size—a predetermined amount of food—plays a critical role in the creation of obesity and food waste: as serving size increases, consumption and food waste rise (Freedman & Brochado, 2010; Steenhuis & Vermeer, 2009; Young & Nestle, 2002). People's tendency to consume more when serving sizes are larger has been defined as a "serving-size effect" (Vandenbroele et al., 2019). This effect is widespread and robust across a range of individual and environmental factors (Zlatevska et al., 2014). On average, consumption increases by 35% for a doubling of serving size. Research suggests that the serving-size effect is caused by mindless consumption behavior, whereby consumers rely more on their eyes than their stomachs to determine when to stop consuming. Consequently, regardless of the amount of food that is actually served, they tend to eat most of the food put before them and feel satiated only when their plates are empty (Wansink et al., 2009). Since doubling serving size increases consumption by 35%, by implication food waste also increases (Thyberg & Tonjes, 2016). This is corroborated by research by Von Massow & McAdams (2015), Freedman & Brochado (2010), and for example Vermote et al. (2018).

To summarize, research suggests that serving size positively influences both food consumption and food waste. However, while shrinking the manufacturer's serving size is potentially an effective strategy for reducing overconsumption and food waste, consumers may perceive the new serving size as too small, lowering consumer satisfaction (Vermeer et al., 2010). We therefore research whether and how changing the *unit* size of food—the size of the units into which a given amount of food is divided—could contribute to a reduction in food consumption and waste (English et al., 2015).

2.2. Unit-size effect

Research has shown that presenting the same amount of food in several small units versus a few large units reduces food intake (Scott et al., 2008; Vandenbroele et al., 2019; Van Kleef et al., 2014). For example, two pizzas may be equal in total amount but can differ in unit sizes (four slices vs. eight slices). This phenomenon is known as the unit-size effect (Cheema & Soman, 2008; Van Kleef et al., 2014). The underlying process of the unit-size effect has been explained as a decision bias: partitions provide decision-making opportunities that draw attention to consumption (Cheema & Soman, 2008). Such decision points, or so-called "pause moments," facilitate a moment of reflection on one's own behavior and consequently shift the consumption decision from an automatic choice to a deliberate choice. Additional research complements this view by demonstrating that the unit size of food biases perceptions of quantity and related impulsiveness (Van Kleef et al., 2014). Eating several smaller units of food activates the inference of excessive consumption compared to eating the same amount of food in a larger unit size. This observation can be linked to the suggestion that encountering a pause during consumption facilitates consumption monitoring by increasing consumers' attention to the act of consuming (Cheema & Soman, 2008). Through this increased salience of consumption, consumers may perceive that they have eaten more of smaller unit-sized foods, implying a bias in consumption estimations.

From the above, it follows that smaller units can effectively reduce consumption. However, given that food consumption and waste act as communicating vessels when consumers are served a predetermined amount of food, food waste is likely to increase when the food is supplied in smaller versus larger units. More formally, we hypothesize that reducing unit size will decrease consumption but increase food waste.

H1. People consume less but waste more when they are served food in smaller versus larger units.

Moreover, we propose that unit size moderates the serving-size effect on consumption and food waste. From prior research, we know that serving size can influence eating behavior by altering consumption norms (Wansink & Van Ittersum, 2013): larger servings can perceptually suggest to consumers that it is more appropriate, normal, typical, and reasonable to consume a larger amount of food (Robinson et al., 2019). This application of consumption norms may be relatively automatic and may occur without deliberation (Schwarz, 2014). However, the amount of food consumed can also be influenced by the visual cue of unit size (English et al., 2015). As people who encounter partitions during consumption are more likely to deliberate on the consumption decision (Cheema & Soman, 2008), dividing food into more small units versus a few large units forces consumers to consciously consider the decision to continue consumption more often, reducing the influence of serving size. This leads to the following hypothesis:

H2. The effects of serving size on consumption and waste are moderated by unit size: the effects are less pronounced when unit size is smaller versus larger.

3. Study 1: The effect of serving size and unit size on consumption and waste when consumers are served a predetermined amount of food

3.1. Method

3.1.1. Participants and design

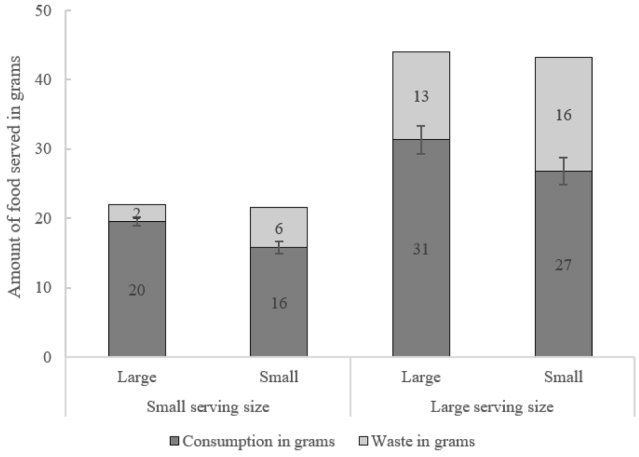
246 students from a European university participated in the IRB-approved experiment in exchange for course credits or monetary compensation. Participants were randomly assigned to one of the 2 (serving size: small vs. large) × 2 (unit size: small vs. large) between-subjects conditions. Forty participants did not consume anything because they were not hungry, leaving a final sample of 206 (45% male; $M_{age} = 21.8$, $SD = 3.0$).

3.1.2. Procedure

As a cover story, participants were asked to evaluate a short movie about a bike ride through America and were offered Oreo cookies as a snack. Upon entering the research lab, participants were either provided with 6 Oreo cookies of 3.6 g (small serving and unit size), 2 Oreo cookies of 11 g (small serving, large unit size), 12 Oreo cookies of 3.6 g (large serving, small unit size) or 4 Oreo cookies of 11 g (large serving and unit size). Participants were told to eat as much as they wanted while watching the short movie. After the movie, participants were requested to dispose of the remaining food in the trash bin. Moreover, we measured how satisfied participants were with the amount of food received and collected participants' demographics. We did not find significant differences in consumer satisfaction across the different study conditions ($p > 0.05$).

3.2. Results

A 2 (serving size) × 2 (unit size) ANOVA revealed a significant main effect of serving size on consumption ($F(1,202) = 61.65$, $p < 0.001$, $\eta_p^2 = 0.23$) and waste ($F(1,202) = 51.18$, $p < 0.001$, $\eta_p^2 = 0.20$). Participants consumed and wasted significantly more when serving size was larger ($M_{consumption} = 29.06$, $SD = 13.95$; $M_{waste} = 14.53$, $SD = 13.89$) versus smaller ($M_{consumption} = 17.70$, $SD = 5.70$; $M_{waste} = 4.11$, $SD = 5.64$) (see Fig. 1), thereby corroborating prior research on serving-size effects (Freedman & Brochado, 2010; Zlatevska et al., 2014).



Note: the vertical axis represents the predetermined amount of food (grams) that participants are served.

Fig. 1. The effects of serving size and unit size on consumption and waste.

Consistent with H1, we also find that unit size significantly influences consumption ($F(1,202) = 8.15$, $p = 0.005$, $\eta_p^2 = 0.04$) and waste ($F(1,202) = 5.96$, $p = 0.015$, $\eta_p^2 = 0.03$). Specifically, in line with our theorizing, we find that participants consumed significantly less when unit size was smaller ($M = 21.25$, $SD = 11.85$) versus larger ($M = 25.28$, $SD = 11.85$) and wasted significantly more when unit size was smaller ($M = 11.04$, $SD = 11.73$) versus larger ($M = 7.40$, $SD = 11.49$). Contrary to expectation, we did not find a significant moderating impact of unit size on the serving-size effect for consumption ($F(1,202) = 0.06$, $p = 0.811$, $\eta_p^2 < 0.01$) or waste $F(1,202) = 0.01$, $p = 0.919$, $\eta_p^2 < 0.01$).

3.3. Discussion

Study 1 replicates prior research on the serving-size effect by demonstrating that serving size positively influences consumption and food waste. Study 1 furthermore contributes to the literature by demonstrating two sides of the same coin: a decrease in unit size reduces consumption but increases food waste when consumers are served a predetermined amount of food. Results yield no evidence for the proposed interaction effect between serving size and unit size. Conceivably the larger serving size was not large enough and therefore people did not try to control their consumption—consistent with prior work showing that the success of unit size in constraining consumption is attenuated when consumers' desire to regulate consumption is low (Cheema & Soman, 2008).

The results from Study 1 suggest that a simple reduction in serving size could effectively reduce overconsumption and food waste. However, manufacturers could run the risk of offering serving sizes that consumers consider too small, reducing consumer satisfaction (Vermeer et al., 2010). A potential solution may be to allow consumers to serve themselves their preferred amount of food. While acknowledging that there is some research that looked at either serving or unit size in the presence of self-serving (Holden et al., 2016; Geier et al., 2006), no studies have been conducted on the combination of the serving- and unit-size effects when consumers serve the food themselves. Therefore, in a follow-up step, we research whether and how serving size and unit size influence the amount of food consumers serve themselves.

4. Study 2: The effect of serving size and unit size on the amount of food consumers choose to consume when serving themselves

4.1. Method

4.1.1. Participants and design

219 students from a European university participated in the IRB-approved experiment in exchange for course credits or monetary compensation (39% male; $M_{age} = 21.0$, $SD = 2.8$). Participants were randomly assigned to one of the 2 (serving size: small vs. large) × 2 (unit size: small vs. large) between-subjects conditions.

4.1.2. Procedure

Participants were asked to serve themselves a preferred amount of gingerbread in a digital environment. They had to imagine the following situation:

> It is 13.00 and you have just finished your regular lunch at the university canteen. You decide to stay at the university until 17.00 to study for your ongoing courses. In between, you take a break to get some coffee/tea and consume a snack. We would like you to select your preferred amount of gingerbread as the snack for that moment. The amount of this snack needs to satisfy your hunger until the next meal.

Participants were exposed to an order menu listing servings of 50 or 100 g of gingerbread, depending on the experimental condition. In the small serving-size condition, the servings consisted of 8 units of 6.25 g (small unit size) or 2 units of 25 g (large unit size). In the large serving-size condition, the servings consisted of 16 units of 6.25 g (small unit size) or 4 units of 25 g (large unit size). Participants could order as many servings of gingerbread as they liked up to a maximum of 800 g. To make sure participants had a realistic idea of the serving size, one serving of gingerbread (depending on the experimental condition) was also provided under a glass bell next to the computer screen of each cubicle. After this task, we asked for participants' satisfaction with the amount of food they ended up serving themselves according to a single-item measure, "I am satisfied with the amount I served" (1 = *strongly disagree*; 7 = *strongly agree*). Finally, we asked for participants' demographics.

4.2. Results

A 2 (serving size) × 2 (unit size) ANOVA revealed that participants served themselves more gingerbread when the serving size was larger ($M = 108.18$, $SD = 27.53$) versus smaller ($M = 72.48$, $SD = 32.97$; $F(1,215) = 75.57$, $p < 0.001$, $\eta_p^2 = 0.26$) (see Fig. 2). The results further revealed a non-significant main effect of unit size on the amount of food participants served themselves ($F(1,215) = 0.58$, $p = 0.448$, $\eta_p^2 < 0.01$). Moreover, the interaction effect also remained non-significant ($F(1,215) = 0.41$, $p = 0.524$, $\eta_p^2 < 0.01$). Lastly, participants were more satisfied with the amount of food they served themselves when serving size was smaller ($M = 5.32$, $SD = 1.39$) versus larger ($M = 4.74$, $SD = 1.55$; $F(1,215) = 8.55$, $p = 0.004$, $\eta_p^2 = 0.04$).

4.3. Discussion

Study 2 shows that consumers serve themselves less (more) food when presented with smaller (larger) serving sizes. Moreover, consumer satisfaction with the amount of food served is highest in the small serving-size condition—consumers are *more satisfied* when they serve themselves *less food*, indicating that apparently consumers can be stimulated to take less food while maintaining consumer satisfaction. Besides, Study 2 reveals a non-significant effect of unit size on the amount of food participants serve themselves. Critically, however, participants could serve themselves their preferred amount of food based on serving sizes. The unit sizes were manipulated as part of a specific serving size. This begs the question of what the effect of single units will be when consumers serve themselves.

4.4. The effect of self-serving based on single units

To date, studies have focused on demonstrating the unit-size effect

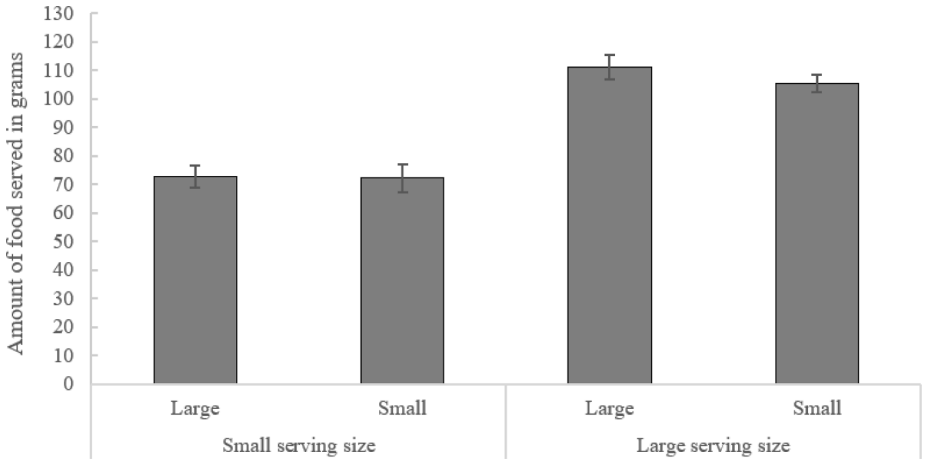


Fig. 2. The effects of serving size and unit size on the amount of food self-served.

for ad libitum food intake (Oldham-Cooper et al., 2017). However, instead of being served a predetermined amount of food, consumers often serve themselves the amount of food they desire to consume. In this setting, consumption is not governed solely by satiation (within a consumption moment) but also by the cognitive activity involved in the serving task (Brunstrom, 2011). On this basis, decisions about the amount of food to serve can be critical for human dietary control. Specifically, the amount of food consumed is highly dependent on the decisions about the amount of food served prior to consumption (Brunstrom, 2011).

As mentioned, participants in Study 2 could serve themselves the preferred amount of food based on serving sizes. The unit sizes were manipulated as part of a specific serving size. Stated differently, the smallest amount of food consumers could select always consisted of multiple units. However, when consumers are allowed to serve themselves, they could simply be presented with single units and asked to serve themselves the amount of food they would like to consume. As described, prior work has suggested that reducing the unit size increases the amount of attention consumers pay to their consumption by providing "pause moments," which facilitate a moment of reflection on one's own behavior (Cheema & Soman, 2008). In Study 1, we found that reducing the unit size lowered consumption, an effect that could be explained by this attention-drawing role of smaller units. In Study 2, the smallest amount of food consumers could select was always a single serving consisting of multiple units, effectively eliminating the opportunity for the units to create a pause. When food units are presented as part of a larger serving size, consumers' cognitive activity associated with deciding how much food to serve themselves is relatively low because the standard-sized servings can serve as a reference point (Robinson & Kersbergen, 2018). Serving size communicates information about what constitutes an appropriate amount to eat (Herman et al., 2015; Kerameas et al., 2015). When food is offered as single units, consumers' cognitive activity associated with deciding how much food to serve themselves will be higher because consumers do not have this guidance of a serving size.

With this in mind, we propose that when consumers are allowed to serve themselves from a supply of smaller versus larger single units of food, they will select a smaller amount of food when confronted with only smaller units. This approach would benefit from the pause moments, which provide decision-making opportunities that draw attention to the serving decision. Every pause facilitates a moment of reflection on the decision of whether to continue serving. As a result, through this increased salience of serving, consumers may perceive that they have served themselves more of smaller unit-sized foods than when serving the same amount of food in a larger unit size. Hence they will stop serving sooner because they have the feeling that they have already served enough. In line with the numerosity heuristic—the overreliance on numerosity as a cue for judging quantity (Pelham et al., 1994)—consumers may overestimate their served amount of food when units are smaller. Based on the above reasoning, we predict:

H3. People serve themselves a smaller amount of food when the food is presented in smaller versus larger single units.

H4. The effect of unit size on the served amount of food will be mediated by attention to the serving decision.

5. Study 3: The effect of single unit size on the amount of food consumers choose to consume when serving themselves

In this study, we investigate the effect of unit size on the amount of food consumers serve themselves when the food is presented in single units (as opposed to serving sizes). Moreover, we included two measures of participants' attention to the serving decision: the amount of time they take to serve and their estimation of the amount of food they have served. Greater attention may be reflected in longer serving times and greater overestimation of the amount of food served.

5.1. Method

5.1.1. Participants and design

124 students from a European university participated in the IRB-approved experiment in exchange for course credits or monetary compensation. Participants were randomly assigned to one of two unit-size conditions (small vs. large) in a between-subjects experimental design. Eleven participants were excluded from the analyses because they did not accomplish the task correctly, leaving a final sample of 113 (42% male; $M_{age} = 20.8$, $SD = 3.2$).[1]

5.1.2. Procedure

The procedure of Study 3 was identical to that of Study 2, except that participants in this study were exposed to an order menu with single units of gingerbread, which were small (6.25 g) or large (25 g). Again, one unit of gingerbread (depending on the experimental condition) was provided under a glass bell next to the computer screen to make sure participants had a realistic idea of the unit size. We recorded the number of gingerbread units participants served themselves along with how long participants took to serve themselves. The experiment continued with measures concerning quantity estimation. Participants were asked to estimate the weight of the amount of gingerbread that they served

[1] One subject did not complete the survey, resulting in missing data for some questions regarding the demographics.

themselves. After this task, we asked for participants' satisfaction with the amount of food they ended up serving themselves with. Consumer satisfaction did not vary across study conditions ($p > 0.05$). Finally, we asked for participants' demographics.

To operationalize the measure of attention to the serving decision, we could not simply use the total amount of time participants took to serve themselves because this time depended on the amount of food they served. Hence, we divided the total amount of time participants took to serve by the amount of food they served, resulting in a time measure per gram. Moreover, quantity estimation was calculated as the estimated served quantity in grams as a percentage of the actual served quantity in grams.

5.2. Results

5.2.1. Amount of food served

A one-way ANOVA revealed a significant main effect of unit size on the amount of food participants served themselves ($F(1,111) = 58.28$, $p < 0.001$, $\eta_p^2 = 0.34$). Participants selected a smaller amount of food when the food was presented in smaller ($M_{grams} = 30.23$, $SD = 13.60$) rather than larger units ($M_{grams} = 59.48$, $SD = 25.14$), in line with H3.

5.2.2. Serving time per gram

A one-way ANOVA revealed a significant main effect of unit size on the time taken per gram ($F(1,111) = 42.43$, $p < 0.001$, $\eta_p^2 = 0.28$). Participants took longer to serve themselves a gram of food when food was presented in smaller ($M_{sec} = 1.18$, $SD = 0.48$) rather than larger units ($M_{sec} = 0.55$, $SD = 0.54$).

5.2.3. Served quantity estimation

A one-way ANOVA revealed a significant main effect of unit size on the served quantity estimation (percentage) ($F(1,111) = 31.89$, $p < 0.001$, $\eta_p^2 = 0.22$). Participants overestimated the quantity of food they served themselves to a larger extent when unit size was smaller ($M_{percent} = 452.66.18$, $SD = 301.14$) rather than larger ($M_{percent} = 216.33$, $SD = 101.89$).

5.2.4. Mediation

We used PROCESS for SPSS v3.5 Model 4 for testing mediation with 5000 bootstrap samples (Hayes, 2017). We included unit size (small vs. large) as the independent variable, amount of food served (in grams) as the dependent variable, and either serving time per gram (in seconds) or served quantity estimation (in percentage) as mediators.

The predicted pathway from unit size to the amount of food served via serving time per gram was supported, as evidenced by the bias-corrected 95% confidence interval for the indirect effects excluding zero (95% CI [7.33, 22.31]; Fig. 3 shows point estimates from the mediation model). Participants presented with smaller unit sizes took longer to serve per gram, and as a consequence served themselves a smaller amount of food than participants presented with larger unit sizes. Moreover, the predicted pathway from unit size to the amount of food served via served quantity estimation was also supported, as evidenced by the bias-corrected 95% confidence interval for the indirect effects excluding zero (95% CI [2.21, 7.76]; see Fig. 3). Participants presented with smaller unit sizes overestimated the quantity of food served, and thus served themselves a smaller amount of food than participants presented with larger unit sizes. With these results, we could confirm that the differential effect of unit size (small vs. large) on the amount of food served was caused by a change in attention to the serving decision (as reflected by longer serving times and greater overestimation). Overall, these results provided support for the mediational pathway of attention to the serving decision as proposed in H4.

5.3. Discussion

Consistent with our theorizing and H3, Study 3 demonstrates that the unit-size effect does significantly reduce the amount of food consumers serve themselves when they are presented with a supply of single units of food. Moreover, consumer satisfaction did not differ between the two conditions, suggesting that the amount of food consumers serve themselves can be reduced without lessening consumer satisfaction. The results of this study contrast with those of Study 2, which suggests that the unit-size effect on the amount of food self-served remains non-significant when consumers are presented with a supply of servings. However, the smallest amount of food consumers could select here always consisted of a single serving comprising multiple units, effectively eliminating the opportunity for the units to create a pause moment. In Study 3, when consumers are allowed to serve themselves from a supply of single units of food, serving from smaller units drew greater attention to the serving decision than did serving from larger units, as reflected in longer serving times and greater overestimation of the served amount of food. Consequently, through this attention-drawing role of smaller units consumers served themselves less food, in support of H4.

In Studies 2 and 3 we measured self-serving intentions. That is, participants were behind a computer when asked to indicate how much they would like to serve themselves. Moreover, actual consumption and food waste were not measured. Therefore, we conducted Study 4, which measures actual self-serving behavior, consumption, and food waste.

6. Studies 4A and 4B: The effect of unit size and self-serving on real consumption and waste behavior

In Study 4, we sought to provide additional evidence for H3 that unit size influences the amount of food consumers serve themselves, and the subsequent effects on actual food consumption and waste. We contrast these results with the situation in which consumers are served a predetermined amount of food consisting of either smaller or larger unit sizes. A similar design was used in research by Hagen et al. (2017, Study 5).

6.1. Method

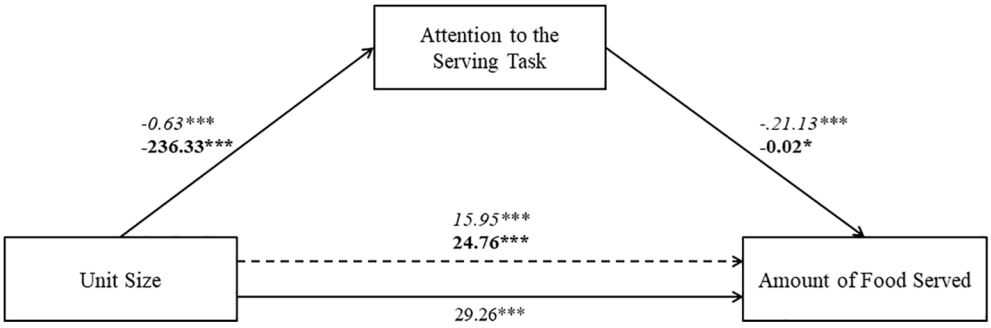
6.1.1. Participants and design

237 students from a European university participated in one of two parallel and by the IRB-approved experiments in exchange for course credits or monetary compensation. In Study 4A, participants were presented with a food supply of single units (unit size: small vs. large) and asked to serve themselves a preferred amount of food ($N = 120$; 39% male; $M_{age} = 22.2$, $SD = 2.8$).[2] In Study 4B, participants were offered a serving of food consisting of small versus large unit sizes of food ($N = 112$; 47% male; $M_{age} = 21.9$, $SD = 2.9$). Participants were randomly assigned to one of the experiments and experimental conditions.

6.1.2. Procedure

As a cover story, participants were asked to evaluate a short history movie and were offered treacle waffles as a snack. In Study 4A, participants received instructions to serve themselves a preferred number of treacle waffles before watching the movie, during which they could consume the self-served amount of food. The food, approximately 200 g, was presented on a tray in a separate cubicle where participants could serve themselves without any distractions. The food was presented in either small units (8.2 g) or large units (41 g). In Study 4B, participants were immediately shown their place in the cubicle and presented with the food (a tray with 82 g of treacle waffles) consisting of either small or large unit sizes. Participants were told to eat as much as they wanted while watching the short movie. After the movie, all participants were asked to dispose of the remaining food in the trash bin. Finally, we asked for participants' demographics and checked how satisfied they were

[2] Five participants were excluded from the final analyses because they refused to serve themselves any food.



Note: this mediation model consists of two separate analyses. The first coefficient (in italics) represents the mediation by "serving size in time." The second coefficient (in bold) represents the mediation by "served quantity estimation."
***p<0.001, **p<0.01, *p<0.05

Fig. 3. Meditation model depicting the process by which unit size influences the amount of food served. Coefficients are unstandardized regression coefficients from the PROCESS model.

with their food. Consumer satisfaction did not differ between study conditions ($p > 0.05$). Next to assessing consumption and waste in grams, we also calculated the percentage of food consumed and wasted.

6.2. Results—Study 4A

6.2.1. Amount of food served

A one-way ANOVA revealed that participants served a smaller amount of food when food was presented in smaller units ($M = 28.24$, $SD = 15.36$) versus larger units ($M = 48.19$, $SD = 17.53$; $F(1,118) = 44.12$, $p < 0.001$, $\eta_p^2 = 0.27$), consistent with H3.

6.2.2. Consumption

A one-way ANOVA showed that participants who served themselves with smaller single unit sizes consumed significantly less food ($M = 26.65$, $SD = 16.57$) than those who served themselves with larger single unit sizes ($M = 45.18$, $SD = 20.14$; $F(1,118) = 30.51$, $p < 0.001$, $\eta_p^2 = 0.21$). The main effect of unit size on consumption in percentage was non-significant ($F(1,118) = 0.09$, $p = 0.766$, $\eta_p^2 < 0.01$). Participants consumed about the same proportion of the amount of food they served themselves when unit size was smaller ($M = 91.87$, $SD = 23.51$) versus larger ($M = 93.11$, $SD = 21.91$).

6.2.3. Food waste

A one-way ANOVA revealed a non-significant main effect of unit size on waste in grams ($M_{small} = 1.60$, $SD = 4.49$; $M_{large} = 3.02$, $SD = 9.18$; $F(1,118) = 1.17$, $p = 0.281$, $\eta_p^2 = 0.01$) and in percentage ($M_{small} = 8.13$, $SD = 23.51$; $M_{large} = 6.89$, $SD = 21.91$; $F(1,118) = 0.09$, $p = 0.766$, $\eta_p^2 < 0.01$).

6.3. Results—Study 4B

6.3.1. Consumption

A one-way ANOVA revealed that participants who received food in smaller unit sizes consumed significantly less food in grams ($M = 43.59$, $SD = 25.40$) than those who received the same amount in larger unit sizes ($M = 59.23$, $SD = 21.25$; $F(1,110) = 12.57$, $p = 0.001$, $\eta_p^2 = 0.10$), consistent with H1. In terms of percentage, we also found a significant main effect of unit size on consumption ($F(1,110) = 12.49$, $p = 0.001$, $\eta_p^2 = 0.10$). Participants consumed a smaller proportion of the received amount of food when unit size was smaller ($M = 53.28$, $SD = 31.15$) versus larger ($M = 72.41$, $SD = 25.98$).

6.3.2. Food waste

As the served amount of food in Study 4B was constant, the results of the effect of unit size on consumption had a reversed impact on food waste. Participants wasted significantly more when unit size was smaller ($M = 38.18$, $SD = 25.35$) compared to larger ($M = 22.56$, $SD = 21.19$), consistent with H1. Also, participants wasted a larger proportion of the received amount of food when unit size was smaller ($M = 46.72$, $SD = 31.15$) versus larger ($M = 27.59$, $SD = 25.98$).

6.4. Results—contrasting studies 4A and 4B

In assessing the results of Studies 4A and 4B, it is critical to note that the studies differ on more than one factor. While Study 4A presents only small versus large single unit sizes and allows participants to serve themselves, Study 4B presents a predetermined amount of food that differs in unit size and is served to participants. The main objective of contrasting the two studies is to test whether the effects of unit size on consumption and food waste differ across study designs.

6.4.1. Consumption

To test whether unit size and study design influence consumption, we conducted a 2 (unit size: small vs. large) × 2 (study design: 4A vs. 4B) ANOVA (Fig. 4a). The results showed that participants consumed significantly less when unit size was smaller ($M = 34.53$, $SD = 22.69$) rather than larger ($M = 52.20$, $SD = 21.79$; $F(1,228) = 38.61$, $p < 0.001$, $\eta_p^2 = 0.15$). In addition, we found a significant main effect of the two studies' designs on consumption (in grams) ($F(1,228) = 31.67$, $p < 0.001$, $\eta_p^2 = 0.12$). Participants consumed significantly less in Study 4A ($M = 35.45$, $SD = 20.50$) than in Study 4B ($M = 51.54$, $SD = 24.57$). This result is most likely driven by the possibility to self-serve the amount of food (vs. being served a predetermined amount). Lastly, the interaction

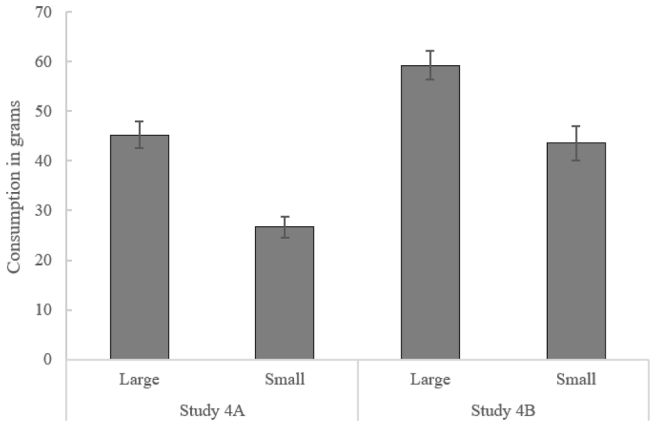


Fig. 4a. Estimated consumption in grams.

between unit size and study design was not significant with respect to consumption (in grams) ($F(2,228) = 0.27$, $p = 0.603$, $\eta_p^2 < 0.01$). Importantly, however, in Study 4A participants served themselves the preferred amount of food. Therefore, a more valid test is whether the percentage of food consumed differed across conditions.

The results revealed a significant main effect of unit size ($F(2,228) = 9.04$, $p = 0.003$, $\eta_p^2 = 0.04$) and a significant main effect of study design ($F(2,228) = 76.61$, $p < 0.001$, $\eta_p^2 = 0.25$) on consumption in percentage. Moreover, we found a significant interaction between unit size and study design on consumption in percentage ($F(2,228) = 6.97$, $p = 0.009$, $\eta_p^2 = 0.03$). Simple main effects analysis showed that participants consumed a significantly higher percentage of the food when they served themselves (irrespective of unit size; $p = 0.792$). Participants consumed around 92% on average of the food they served themselves, leaving little room for food waste. While the percentage of food consumed was lower when participants received a serving of food, the results suggested that in this condition smaller unit sizes actually reduced the percentage consumed even further (increasing food waste) ($p < 0.001$). Fig. 4b shows the results.

6.4.2. Food waste

A 2 (unit size: small vs. large) × 2 (study design: 4A vs. 4B) ANOVA revealed a significant main effect of unit size on waste (in grams) ($F(1,228) = 10.09$, $p = 0.002$, $\eta_p^2 = 0.04$). Participants wasted significantly more when unit size was smaller ($M = 18.65$, $SD = 25.36$) compared to larger ($M = 12.79$, $SD = 19.01$). In addition, we found a significant main effect of the two studies' designs on waste (grams) ($F(1,228) = 157.61$, $p < 0.001$, $\eta_p^2 = 0.41$). Participants wasted significantly less food in Study 4A ($M = 2.27$, $SD = 7.18$) than in Study 4B ($M = 30.23$, $SD = 24.51$). Moreover, we found a significant interaction between unit size and study design on waste in grams ($F(1,228) = 14.53$, $p < 0.001$, $\eta_p^2 = 0.06$). Simple main effects analysis showed that participants wasted significantly less food in Study 4A (when they served themselves), irrespective of the unit size ($p = 0.648$). While the amount of food wasted was higher in Study 4B (when participants received a serving of food), the results suggested that in this condition smaller unit sizes increased the amount wasted even further ($p < 0.001$). In terms of percentage, the results of the effect of unit size and study design on consumption have a reversed impact on food waste.

6.5. Discussion

Consistent with the results of Study 3, Study 4A demonstrates that unit size significantly influences the amount of food consumers serve themselves when they are being presented with a supply of single units of food. Consumers serve themselves a smaller (larger) amount of food when presented with smaller (larger) unit sizes (H3) while consumer satisfaction remains the same. This response resulted in a decrease in food consumption and waste—a win–win. Looking at the percentage of food consumed and wasted, we can conclude that consumers eat almost all the food they serve themselves.

Consistent with expectations and Study 1, Study 4B demonstrates that a decrease in unit size reduces consumption but increases food waste when consumers receive a serving of food (H1). The percentage of food consumed and wasted exhibits the same pattern: consumers consume less but simultaneously waste more of their serving when it is presented in smaller compared to larger units.

Lastly, we contrast Studies 4A and 4B to see how self-serving based on single units results in lower consumption and waste amounts. While acknowledging the limitations of Studies 4A versus 4B, consistent with earlier findings on the unit-size effect (Cheema & Soman, 2008; Vandenbroele et al., 2019), the results confirm that people consume less when food is presented in smaller versus larger units. In addition, we extend this finding by allowing consumers to serve themselves the preferred amount of food, which transfers the unit-size effect to a lower level of consumption (see Fig. 5). Consumption already decreases when consumers are served food in smaller rather than larger units, but this effect is even more successful when consumers serve themselves their preferred amount of food based on smaller rather than larger single units.

In Study 4A, the unit-size effect on consumption in grams is driven by the effect of unit size on the amount of food served. Consumers serve themselves a smaller amount of food when the food is presented in smaller versus larger single units and eat almost all the food they serve themselves. In Study 4B, the unit-size effect on consumption in grams is driven by the effect of unit size on consumption in percentage. The amount of food served was consistent across conditions and consumers ate less of the serving when unit size was smaller compared to larger. Together, these findings explain the non-significant effect of unit size on food waste when consumers serve themselves and the increase in food waste when consumers are served food in smaller compared to larger units.

Taken together, these results demonstrate that the unit-size approach can be an effective intervention that creates a win–win solution for reducing both food consumption and food waste. Offering consumers relatively small units and allowing them to serve themselves lowers the amount of food selected, consumed, and wasted but maintains consumer satisfaction.

7. General discussion

Although substantial research on nutrition clearly indicates the role of serving size in the creation of obesity and food waste (Young & Nestle, 2002), insights into reversing the negative influence of serving size are scarce and urgently needed (Steenhuis & Vermeer, 2009). Past research

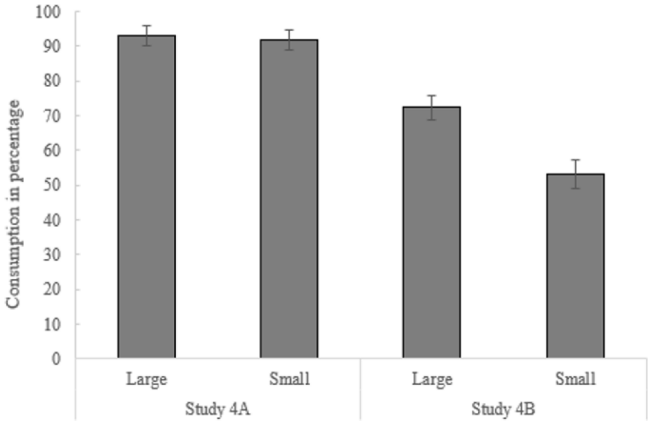


Fig. 4b. Estimated consumption in percentage.

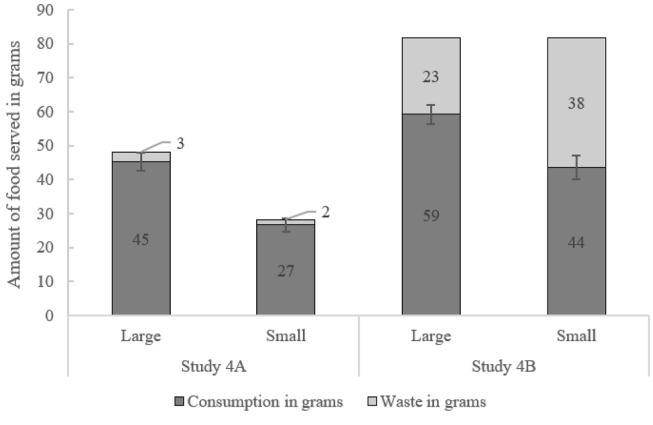


Fig. 5. The effects of unit size and study design on amount ot food served, consumed, and wasted.

on the serving-size effect suggests that serving size positively influences both food consumption and food waste (Freedman & Brochado, 2010; Zlatevska et al., 2014). Hence, reducing serving size is a potentially effective strategy for lessening overconsumption and food waste—but it carries the risk that consumers may perceive the smaller serving size as too small, lowering satisfaction (Vermeer et al., 2010). This research sought a way of reducing food consumption and waste without lessening consumer satisfaction. Drawing on the literature on food unit size, we suggested that dividing a serving into several small units can effectively reduce consumption. However, this approach may also increase food waste, as consistent with H1, we find that offering food in smaller unit sizes decreases consumption but increases food waste when consumers are served a predetermined amount of food. We find no evidence for the proposed interaction effect between serving size and unit size (H2). A potential solution is to allow consumers to serve themselves their preferred amount of food, and in three lab experiments (Studies 2–4), we investigate whether and how serving size and unit size influence the amount consumers serve themselves. Overall, our findings demonstrate that merely offering consumers smaller versus larger units of food (without a specified serving size) significantly reduces the amount of food consumers serve themselves (H3), lessens food consumption, and minimizes food waste while maintaining consumer satisfaction. Process measures in Study 3 reveal that self-serving from smaller units draws greater attention to the serving decision, as reflected in longer serving times and greater overestimation of the served amount of food. This attention-drawing role of smaller units leads consumers to serve themselves less food (H4).

This research contributes to the growing stream of literature on how the food environment, such as package size (Scott et al., 2008), serving size (Zlatevska et al., 2014), and unit size (Geier et al., 2006) affects food consumption behavior. In this literature, the prevailing notion seems to be that consumption is governed by physiological and psychological events that occur during and toward the end of a consumption moment. An alternative perspective on consumption behavior is that consumption is not governed solely by satiation but also by the cognitive activity involved in the serving task, before actual consumption begins (Brunstrom, 2011). This strategy optimizes effort, minimizes food wastage, and protects against hunger and the impulsivity to consume more than planned (Brunstrom, 2011). On this basis, decisions about the amount of food to serve are critical for human dietary control. Despite the significance of these decisions, relatively little is known about the basis on which they are made (Brunstrom et al., 2010). This study considers the role of the unit size of food as a determinant of the calories that end up on our plates, in our stomachs, and in our waste bins.

7.1. Practical implications

Individual behavior change is difficult to achieve without addressing the context in which people make decisions, indicating that changing one's environment is often easier than changing one's mind. The results of this research offer opportunities for consumers and organizations to structure food environments so that one can eat well while wasting less. The best approach to reduce or eliminate the perils of large servings may be to simply allow consumers to serve themselves their preferred amount of food in relatively small units. Self-serving has a dual influence: (a) it lessens the amount of food served and consumed, and (b) it diminishes the amount of food wasted since consumers consume a large share of food they served themselves. This result is also financially attractive, as consumers acquire less food and minimize waste.

The implications of our results for waistlines, food waste, and wallets are also of substantial importance to managers of restaurants, food services, and health professionals, who have to consider competition and profitability on one hand and better nutrition and reasonable serving sizes on the other (Wansink & Van Ittersum, 2013). A cost-saving strategy for these managers would be to reduce the amount of food people acquire but do not eat. Out-of-home consumption is responsible for the second largest amount of food waste at the consumption level and thereby is a large contributor to food costs for restaurants and other food services (Bräutigam et al., 2014; Monier et al., 2010). By offering consumers smaller single units and allow them to serve their preferred amount of food, they (a) take a smaller amount of food and (b) waste less food. In addition to saving food costs, self-serving smaller versus larger unit sizes can also be used strategically to nudge people to serve a healthier meal.

7.2. Limitations and future research

While providing novel insights into the effect of unit size on the amount of food consumers serve themselves, one possible limitation of the current research is that we measured self-serving intentions instead of actual behavior in some studies. This could make the effect more conservative because there is no urge for consumers to control the amount of food they serve themselves due to the lack of subsequent consumption. Although we also demonstrate the effect of unit size on actual serving behavior, we recommend further research on the strength of the effects in real-life settings. Moreover, the mechanism underlying the effect of unit size on the amount of food consumers serve themselves suggests paths for future exploration. In line with Cheema and Soman (2008), it has been suggested that reducing the unit size increases the number of pause moments, providing decision-making opportunities that draw attention to the serving decision. Every pause facilitates a moment of reflection on one's own behavior. This attention-drawing role of smaller unit sizes is demonstrated in two process measures from Study 3. In particular, results showed that participants took longer to serve when food was presented in smaller rather than larger units. An interesting question for future research then becomes whether the time between serving actions changes over the course of the self-serving process. Specifically, we speculate that the average time between serving the next unit increases as more units have been served because the pauses in the last phase of the serving process are critical to evaluate whether to continue serving or not. Conversely, a drop in self-control may also play a role as more units have been served, potentially canceling out the existence of longer pauses at the end of the serving process. Future empirical work is needed to gain a deeper understanding of the rate of serving over time.

Future research might also explore the boundary conditions of the unit-size effect. A unit should be of some minimal and reasonable size to have an impact on consumption behavior (Geier et al., 2006), yet no studies have actually investigated within which range of sizes units are reasonable and thus relevant. For example, a single M&M is not substantial enough and therefore not considered as a reasonable unit; bite-size cookies of M&M's are. With the growing popularity of smaller food units nowadays (e.g., mini-Oreos, mini-donuts, and mini granola and chocolate bars), this is becoming even more important in order to discern whether the unit-size effect may occur or not.

Studies on granularity typically keep the amount of food provided equal but divide the serving into many small parts (fine granularity) or a few large parts (coarse granularity). In the current study, we primarily focus on the partition of food into more smaller versus fewer larger units by manipulating the size of the food units. In contrast, marketing research tends to manipulate the size of the food packages, such that similarly sized units are grouped together into more smaller or fewer larger packages (Coelho do Vale et al., 2008; Scott et al., 2008). This distinction between operationalization modes is important because it elucidates the contradictory effects of food granularity on consumption (Roose et al., 2017). Moreover, extant research illustrating these contradictory effects has suggested and confirmed a moderating role of restrained eating, in that the paradoxical effect (i.e., increased consumption in response to smaller food packages) is most pronounced for restrained eaters compared with unrestrained eaters (Coelho do Vale et al., 2008; Holden & Zlatevska, 2015; Scott et al., 2008). However, with regard to partitioning, the effect is most pronounced for

unrestrained eaters who seem to consume less from multiple, small units compared with fewer, large units (Roose et al., 2017). In our studies, we also account for restrained eating using the restrained eating subscale of Herman and Polivy (1980). Yet, consistent with Roose et al. (2017), we could not confirm that restrained eating served as an additional moderating variable. Further research is needed to gain a deeper understanding of how to best measure restrained eating and its moderating role in the context of partitioning.

Lastly, consumers can pursue health via food consumption in two main ways: changing what they eat (e.g., an apple vs. a chocolate muffin) or how much they eat (e.g., one serving vs. two servings) (Liu et al., 2019). In the current study, we examine food consumption and waste in terms of how much people consume and waste, and we do this for a relatively less healthy food type (cookies). In the future, it would be interesting to see if the same results emerge for more healthy food types. If so, the intake of healthier food types (e.g., fruit or vegetables) can be encouraged by providing larger servings and/or unit sizes. Past research found that larger portion sizes of healthy snacks would lead to increased consumption, but larger unit sizes were not examined (Werle et al., 2019). Also useful would be the inclusion of both more and less healthy food types to determine how people can be stimulated to choose more healthily—with respect to food type or quantity or both—when they serve themselves their preferred amount of food. Virtual reality (e.g., virtual food buffet) is a promising research method to investigate such research questions regarding food choices because the food environment (i.e., the types of food available) can be easily manipulated (Ung et al., 2018).

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CRediT authorship contribution statement

Amber Werkman: Conceptualization, Methodology, Formal analysis, Writing – original draft. **Jenny van Doorn:** Writing – review & editing, Supervision. **Koert van Ittersum:** Writing – review & editing, Supervision.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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