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Doggy bags and downsizing: Packaging uneaten food to go after a meal attenuates the portion size effect in women

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Abstract

Serving larger portions leads to increased food and energy intake, but little is known about strategies to moderate this response. This study tested how the effect of portion size on meal intake was influenced by providing the option to take away uneaten food in a “doggy bag” (to-go container). Women were randomly assigned to one of two subject groups: a To-Go Group (n=27) that was informed before each meal that their leftover food would be packaged to take away after the meal, and a Control Group (n=26) that was not given this option. In a crossover design, subjects came to the lab once a week for four weeks to eat a dinner composed of five foods. Across meals, the portion size of all foods was varied (100%, 125%, 150%, and 175% of baseline). Results showed that the portion size effect, defined as the trajectory of intake across the weight of food served, differed significantly by subject group (P≤0.025). In the Control Group, increasing the portion size of all foods led to substantial increases in intake (P<0.0001); for every 100 g added to the baseline portion, women in this group consumed an additional mean (±SEM) of 64±12 g of food and 90±19 kcal, until intake leveled off. In contrast, intake of women in the To-Go Group increased by only 17±12 g and 19±18 kcal for every additional 100 g served; these increases did not differ significantly from zero (P>0.15). Thus, the effect of portion size on intake was attenuated in the To-Go Group compared to the Control Group. These data indicate that packaging uneaten food after a meal could be an effective strategy to reduce overconsumption from large portions.

Keywords

Portion size; Doggy bag; To-go container; Energy intake; Food waste; Leftovers

Introduction

When larger portions are served, most individuals consume more food (Rolls, 2014; Hollands, Shemilt, Marteau, Jebb, Lewis, Wei, et al., 2015). This portion size effect leads to

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sustained increases in energy intake that have not been found to be adjusted for at later meals (Rolls, Roe, Kral, Meengs & Wall, 2004) or over multiple days (Rolls, Roe & Meengs, 2007; Kelly, Wallace, Robson, Rennie, Welch, Hannon-Fletcher, et al., 2009). Given the prevalence of large portions of energy-dense foods, paired with their role in the overconsumption of energy and their potential to promote weight gain (Rolls, 2003), strategies to counter the effects of large portions are needed (Livingstone & Pourshahidi, 2014). One suggestion is to "downsize" portions, particularly in restaurant settings (Marteau, Hollands, Shemilt & Jebb, 2015). While this approach may be useful in some cases (Freedman & Brochado, 2010), it has limitations; most notably, the likelihood of consumer resistance (Vermeer, Steenhuis, & Seidell, 2010; Riis, 2014). Larger portions often provide greater value for money (Steenhuis & Vermeer, 2009), and exposure to them inflates portion-size norms (Robinson, Oldham, Cuckson, Brunstrom, Rogers & Hardman, 2016); both of these factors could increase demand for large portions (Ledikwe, Ello-Martin, & Rolls, 2005). Furthermore, according to the majority of restaurant chefs polled in a survey, it is likely that consumers would recognize reductions in portion size (Condrasky, Ledikwe, Flood & Rolls, 2007). Therefore, a decrease in portion sizes in restaurants could negatively influence consumer perceptions of value and result in decreased satisfaction and sales (Vermeer, et al., 2010). An alternative to reducing portions is to provide the option to package leftover food to eat at a later occasion (e.g., in a "doggy bag", hereafter referred to as a to-go container). The influence of this strategy on the portion size effect, however, has not been tested. Thus, the purpose of this study was to determine whether packaging uneaten food for participants to take with them for future consumption would moderate intake in response to increasing portion size. A secondary aim was to assess whether other factors such as subject characteristics (English, Lasschuijt & Keller, 2015) or the development of sensory-specific satiety (Herman, Polivy, Pliner & Vartanian, 2015) influenced the response to large portions.

One way in which packaging food to take away could reduce meal intake is by increasing the value of the food to the consumer by providing part of another meal and by reducing waste. It has been proposed that the portion size effect is driven in part by consumers' desire to get more value for money, motivating them to eat a greater amount when larger portions are available (Steenhuis & Vermeer, 2009). In addition, many consumers have an aversion to waste, particularly for food waste (Bolton & Alba, 2012). A concern for wasting food has been associated with a high prevalence of plate-cleaning (Robinson, Aveyard & Jebb, 2015; Robinson & Hardman, 2016), which also contributes to overeating from large portions (Sheen, Hardman, and Robinson, 2018). Therefore, providing individuals the option of taking uneaten food with them after a meal may be an effective strategy to discourage overeating from large portions, both by retaining food value and by reducing waste. This idea is supported by a study in which a to-go container was provided to half of the subjects at a test meal (Bates & Shanks, 2015); it was found that food and energy intake were significantly reduced in those who could take uneaten food away, compared to those who could not. While the provision of a to-go container can decrease intake at a single meal, it is not known whether this will reduce overconsumption as portions are increased. Furthermore, in the previous study, the container was provided at the start of the meal, which served as an overt behavioral nudge or portion-control motivation (Bates & Shanks, 2015). In the current study, we informed subjects at the beginning of the meal of the option to take uneaten food away, while supplying the packaged food at the end of the meal. Although this method does not eliminate the behavioral nudge, it more closely resembles the common practice in restaurants.

In order to determine whether the response to portion size was influenced by packaging uneaten food to take away, on different occasions we varied the amounts of all foods served at a meal and assessed intake in two subject groups (with and without the to-go option). Because providing food in a to-go container after a meal may maintain value to the consumer and offers an alternative to wasting food, we hypothesized that this strategy would attenuate the effect of portion size on meal intake. Furthermore, the foods served at the meal were selected to vary in properties such as energy density (ED) and market cost in order to determine whether these characteristics influenced the relationships between the experimental variables and intake. We also assessed eating behaviors, perceptions of food characteristics, and consumer attitudes as well as sensory-specific satiety to determine whether the response to packaging leftovers or to portion size was affected by these factors. Developing a better understanding of how the response to portion size is affected by packaging leftovers to take away, as well as whether this response differs across individuals or foods, should aid in the development of strategies to moderate intake from large portions.

Methods

Study Design

In a crossover design with repeated measures, women were served dinner in the laboratory once a week for four weeks. Across weeks, the portion sizes of all foods served at the meal were varied (100, 125, 150, and 175% of baseline) in a counterbalanced order. Subjects were randomly assigned to one of two groups: participants in the To-Go Group were provided with their uneaten food in a container at the end of each meal (and informed of this prior to the meal); in contrast, those in the Control Group were not provided the option to take food away.

All study procedures were approved by the Office of Research Protections at The Pennsylvania State University. Upon completion of the study, subjects were provided with financial compensation for their time as well as information on the purpose of the study.

Subjects

Women between the ages of 18 and 60 were recruited through advertisements for a “dinner feeding study” placed on the university’s research website, in local newspapers, and around campus and in local businesses. Potential subjects were told nothing about the purpose of the study, only that they would be eating dinner in the laboratory on four occasions. Those who met initial eligibility criteria based on a phone screening came to the lab and completed the Eating Attitudes Test (Garner, Olmstead, Bohr, & Garfinkel, 1982), indicated for a variety of foods whether they disliked or would be unwilling to eat any of the foods, filled out a schedule of their availability, had their height and weight measured, and rated the taste of the foods to be served. Women were eligible for the study if they had a body mass index (BMI) between 18.5 and 36.0 kg/m^2, regularly ate three meals per day, liked and were willing to eat the foods served at the meal, and were willing to refrain from drinking alcohol the day before their scheduled experimental sessions. Potential subjects were excluded if they smoked, were athletes in training, were dieting to gain or lose weight, were taking medications known to affect appetite, were pregnant or breastfeeding, had allergies or intolerances to the foods served, reported having a medical condition known to affect eating, or showed signs of disordered eating as indicated by a score ≥ 19 on the Eating Attitudes Test (Garner, et al., 1982).

Fifty-eight women were eligible for participation and were enrolled. Due to lack of data on an effect size, we aimed to recruit a number of women similar to the only other study reporting an influence of packaging on intake (N=50; Bates & Shanks, 2015). We included only women in order to reduce variability in intake and increase statistical power to detect the influence of this novel strategy to address the portion size effect. After enrollment, subjects were assigned to one of two subject groups (To-Go Group or Control Group) using block randomization on the factors of age (18–24.9 or 25–60 years) and body weight status (BMI of 18.5–24.9 or 25.0–36.0 kg/m^2). Within each block, subjects were assigned to a group using a random number generator. In both groups, the order in which portion sizes were served across weeks was counterbalanced using Latin squares, and subjects were randomly assigned a sequence. Of the 58 enrolled subjects, four withdrew from the study prior to completion and one was excluded from analysis for failing to comply with the study protocol. Thus, a total of 53 women (27 To-Go and 26 Control) were included in the analysis.

Test meals

At each of the four experimental sessions, subjects were served a test meal composed of five foods made from commercially available ingredients (Table 1). The same foods were served at each meal; only the amounts were varied. Foods were selected to represent typical meal components. In addition, they ranged in energy density (ED; Rolls & Barnett, 2000) and market cost (range calculated from our recipes: ~$0.40/100 g (orzo) to ~$1.30/100 g (chicken)). The two primary meal components were chicken with sauce (0.99 kcal/g, classified as a low-ED food) and orzo pasta with butter (1.75 kcal/g, classified as a medium-ED food). The test foods were either amorphous or cut into small pieces in order to reduce the risk of a unit bias affecting intake (Geier, Rozin & Doros, 2006), in addition to making it difficult to judge the amounts of food served from week to week.

The amount of food served in the baseline (100%) condition was determined from the average intake of a similar baseline meal consumed by women in a previous study (Zuraikat, Roe, Sanchez, & Rolls, 2018a); this amount was increased in order to provide more food than most women would fully consume, reducing the risk of a false-positive portion size effect. In the other experimental conditions, the portion size of each food was increased to 125%, 150%, and 175% of the baseline amount. The order in which portion size conditions were served was counterbalanced, and there was a one-week washout period between meals. Subjects were also served 1 L of water with each meal. Food and water intake was determined by weighing all items before and after the meal to within 0.1 g (Mettler-Toledo

PR5001 and XS4001S; Mettler-Toledo, Columbus, OH). Energy intake was calculated using information from a standard food composition database (USDA, 2015) and from food manufacturers.

Procedures

Each subject came to the lab once a week for four weeks to eat dinner on the same weekday and at the same time between 5:00 and 6:30 p.m. In order to minimize the risk of subjects learning the study purpose, the factor of packaging uneaten food was varied between subjects, and meals for subjects in the two groups were scheduled on different days. All subjects were asked to consume a normal breakfast and lunch on the day of the test session and to refrain from eating within three hours prior to their scheduled dinner time. Subjects were also asked to refrain from drinking alcoholic beverages the day before their test meal. Subjects completed a brief food diary at the beginning of each test meal to check compliance with these instructions.

Subjects were seated alone in private cubicles (to control for social influences on food intake) and completed pre-meal ratings of hunger, thirst, fullness, and general prospective consumption using 100-mm visual analog scales (VAS; Flint, Raben, Blundell, & Astrup, 2000). For example, to rate general prospective consumption, subjects answered the question "How much food do you think you could eat right now?" using the anchors of "Nothing at all" and "A large amount". Subjects were then given 12 small food samples (<3 g each) comprising the five foods to be served at the meal plus seven foods that were not served at the meal and were selected to vary in sensory properties, such as flavor and texture. Subjects were instructed to taste each sample and use VAS to rate the pleasantness of taste as well as how much of that food they would like to eat (prospective consumption); subjects also completed this same procedure directly after consuming the meal. This task was developed as a variation of the sensory-specific satiety (SSS) paradigm, which is used to assess the change in hedonic value of food that is eaten at a meal in comparison to food that is not eaten. Changes in both pleasantness of taste and prospective consumption of individual foods are used to characterize specificity of satiety (Rolls, Rolls, Rowe & Sweeney, 1981). This component of the experiment was included to determine whether SSS influenced patterns of intake, but also diverted attention from the true purpose of the study.

After completing the pre-meal ratings, subjects were served the test meal. All subjects were instructed to eat and drink as much or as little as they liked, and to indicate that they had finished eating by pushing a button in the cubicle. In addition, subjects from the To-Go Group were informed that any food that they did not eat at the meal would be packaged for them to take away and were shown an example of the restaurant-grade container. Subjects in the Control Group were not given explicit information about what was done with uneaten food, but they were aware that they could not take it away. Each cubicle had a menu describing the meal; for the To-Go Group, the menu included a reminder that uneaten food would be provided in a to-go container. When subjects indicated that they had finished eating, leftovers were collected, weighed, and either packaged or discarded, depending on the group.

Following the meal, subjects rated post-meal hunger, fullness, thirst, prospective consumption, and overall satisfaction with the meal using VAS. In addition, for descriptive purposes subjects were asked to indicate how much money they would *expect* to pay for the meal in a restaurant as well as how much they would be *willing* to pay. Subjects then used VAS to rate the taste and prospective consumption for the same 12 food samples that were rated prior to the meal, completing the SSS paradigm. At the end of final meal, subjects completed a series of computerized tasks described in the next section.

Measures

Eating behaviors and consumer attitudes were assessed by the following questionnaires: the Three-Factor Eating Questionnaire, which measures dietary restraint, disinhibition, and tendency towards hunger (Stunkard & Messick, 1985); the Eating Behavior Questionnaire, which measures behaviors such as satiety responsiveness, food responsiveness, and slowness of eating (Zuraikat, Roe, Smethers, Reihart & Rolls, 2018b); a Price Consciousness Scale, which assesses value-seeking behaviors (Lichtenstein, Ridgway & Netemeyer, 1993); a Frugality Scale, which assess economic behavior and decision-making (Lastovicka, Bettencourt, Hughner & Kuntze, 1999); and a Food Waste Aversion Scale that was developed for this study. An example of a question from this scale is “When food goes to waste, it upsets me” rated on a 7-point scale ranging from “strongly disagree” to “strongly agree.” These measures of eating behaviors and consumer attitudes were included to assess individual differences in the response to packaging uneaten food or to portion size.

In addition, subjects were shown pictures of the 125% portion of the meal and asked to (a) rate (using VAS) the cost and value of each individual food in the pictured meal, and (b) rank (from 1 to 5) the relative taste, healthfulness, calorie content, cost, and value of the individual foods. These questions were included to determine whether the effect of portion size on intake of individual foods was influenced by perceptions of the food properties. Subjects also responded to questions about their perceptions of restaurant portion sizes, influences on the amount of food they typically consume in restaurant settings, how often they eat all of the food at a restaurant meal, and how the availability of a to-go container might influence the amount of food they would eat and the likelihood of taking food away. These data were collected in order to assess subject perceptions of the feasibility, usefulness, and effectiveness of providing to-go containers at restaurants as a strategy to reduce intake. Finally, subjects completed a discharge questionnaire that included questions about demographic characteristics as well as their perception of the purpose of the study. Upon completion of these tasks, subjects were informed of the purpose of the study and were provided with financial compensation for their participation.

Data analysis

The main outcome of this study was the trajectory of the weight of food consumed at the meal in response to increases in the weight of food served (the portion size effect). It was hypothesized that the trajectory of the portion size effect would differ by subject group, specifically, that individuals in the To-Go Group would demonstrate an attenuated response to portion size compared to the Control Group. To test this hypothesis, the response to portion size was characterized by a polynomial equation and analyzed using random coefficients models; previous research has shown that the trajectory of the portion size effect is curvilinear (Roe, et al., 2016). The meal portion size served (total weight of food served at the meal) was treated as a continuous covariate in the model; subject group and study week were included as fixed factors. Subjects were treated as random factors in the model, so that each subject's intake trajectory in response to increasing portion size was modeled separately. Trajectories of intake were centered at the weight of food served in the 100% (baseline) portion condition. Thus, the linear coefficient of the trajectory represents the change in intake (slope) as portions were initially increased from baseline amounts, and the quadratic coefficient characterizes the change in the trajectory of intake (acceleration or deceleration) as portions were increased further. Subject characteristics (e.g. BMI and scores for slowness of eating and price consciousness) were analyzed as covariates in the random coefficients models to determine whether any of these measures affected intake in response to increasing portion size. Other primary outcomes included the trajectories of meal energy intake and meal energy density, which were analyzed using similar statistical models.

The trajectories of intake for the individual foods served at the meal were analyzed as a secondary outcome. Using random coefficients models, we tested whether the trajectory of intake for each individual food was influenced by portion size as well as whether the effect differed by subject group. Ratings and rankings of food properties (e.g. food value and pleasantness of taste) were analyzed as covariates in a single random coefficients model that included all foods in a univariate manner, in order to determine whether the trajectory of intake for an individual food was influenced by any of these measures.

Subject ratings of hunger, fullness, thirst, prospective consumption, and satisfaction after each meal were secondary outcomes, as were post-meal measures of how much subjects expected and were willing to pay for the meals. The effects of portion size and subject group on these ratings were analyzed using linear mixed models with repeated measures. Portion size condition, subject group, and study week were included as fixed effects in the model. Post-meal hunger, thirst, prospective consumption, and fullness ratings were adjusted by including the equivalent pre-meal rating in the model. Sensory-specific satiety was also analyzed using linear mixed models; outcomes were the differences in pre- to post-meal ratings of taste and prospective consumption of the individual foods. The fixed effects in these models were portion size condition, subject group, study week, and whether or not the foods were served at the meal, as well as the interactions between factors.

For all linear mixed models, the *F*-statistic and its denominator degrees of freedom were adjusted using the Kenward-Roger approximation, and multiple comparisons between means were adjusted using the Tukey-Kramer method (Littell, Milliken, Stroup, Wolfinger & Schabenberger, 2006). Independent sample *t*-tests and chi-squared test of proportions were used to examine whether subject characteristics differed between subject groups. All analyses were conducted in SAS version 9.4 (SAS Institute, Cary, NC, USA). For outcomes of the random coefficients and linear mixed models, means are reported with SEM; all results are considered significant at $P<0.05$.

Results

Subject characteristics

Subject groups did not differ significantly in any of the measured characteristics, including body weight, body mass index (BMI), age, estimated energy needs, and scores for price consciousness and waste aversion (Table 2). Overall in both groups, average age was 29±12 y and average BMI was 25±4 kg/m^2. The proportion of women with overweight or obesity was 36%, and 54% had an annual household income > $50,000. The racial composition of the 50 subjects (94%) who reported this information was 82% White, 14% Asian, and 4% Black; 8% of participants were Hispanic or Latino. The distribution of weight status, income, race, and ethnicity did not differ between subject groups. On average, the taste of all of the foods was rated highly (VAS ratings collected at screening (mm) - chicken: 78.4±2.1; orzo: 53.5±3.2; broccoli: 66.6±2.7; garlic bread: 73.6±2.6; grape: 81.5±2.5). In addition, mean taste ratings did not differ between subject groups (all P>0.18).

Meal intake by weight

The portion size effect, defined as the change in weight of food consumed in response to increasing portion size, differed significantly between the two subject groups (Figure 1A). Specifically, there were differences between groups in both the linear coefficient (interaction $F(1,139)=7.57$, $P=0.0067$) and the quadratic coefficient (interaction $F(1,105)=5.91$, $P=0.017$) of the intake trajectories. In the Control Group, the trajectory of food intake in response to increasing portion size was curvilinear. As portions were initially increased from baseline amounts, there was a significant linear increase in the weight of food consumed (mean slope 0.64±0.12; $t(139)=5.31$, $P<0.0001$). Thus, for every 100 g added to the baseline meal, control subjects consumed an additional 64 g of food. This linear increase was modified by a significant deceleration in intake as portions were increased further, indicated by a negative quadratic coefficient of −0.00086±0.0003 ($t(105)=-3.29$, $P=0.014$). In contrast, the trajectory of food intake in the To-Go Group was linear. The slope was 0.17±0.12, meaning for every additional 100 g added to the baseline meal, food intake increased by 17 g, which was not significantly different from zero ($t(139)=1.47$, $P=0.14$). The quadratic coefficient also did not differ significantly from zero (0.000032±0.0003, $t(105)=0.12$, $P=0.90$). Thus, the effect of portion size on the weight of food consumed at the meal was attenuated in the To-Go Group compared to the Control Group. This result was not affected by the order in which portions were presented.

The mean weight of food packaged to take away in the To-Go Group was 165±18 g in the 100% condition, 280±19 g in the 125% condition, 391±17 g in the 150% condition, and 507±20 g in the 175% condition, representing 29%, 40%, 47%, and 52% of the amount served at the meal, respectively. None of the subjects in the To-Go Group declined to take away their uneaten food from any meal.

Meal energy intake

Similar to the outcome of intake by weight, the pattern of meal energy intake in response to increasing portion size differed significantly between the two subject groups (Figure 1B). In particular, the trajectories of meal energy intake differed between groups in both the linear coefficient (interaction $F(1,144)=7.39$, $P=0.007$) and the quadratic coefficient (interaction $F(1,105)=5.20$, $P=0.025$). In the Control Group, energy intake showed a curvilinear response to portion size. The linear coefficient as portions were initially increased was 0.90±0.19 ($t(144)=4.85$, $P<0.0001$) indicating a 90 kcal increase for every 100 g added to the baseline meal. The linear increase was modified by a deceleration in intake as portions were increased further, characterized by a quadratic coefficient of −0.0012±0.0004 ($t(105)=-2.97$, $P=0.0036$). Thus, in control subjects, increasing portion size led to an initial increase in energy intake followed by a lessening in the rate of increase as portions were further increased. In contrast, the To-Go Group showed a linear response to portion size. The linear coefficient for the To-Go Group was 0.19±0.18 ($t(144)=1.05$, $P=0.30$), and the quadratic coefficient was 0.00009±0.0004 ($t(105)=0.23$, $P=0.82$). These coefficients demonstrate that for every 100 g increase in the portion served, energy intake for the To-Go Group increased by 19 kcal, which did not differ significantly from zero. Thus, for subjects in the To-Go Group, energy intake in response to increasing portions was moderated compared to controls. The trajectories of the two groups showed the greatest difference in energy intake (mean 105±47 kcal) at the meal with 150% portions (Control Group: 776±37 kcal versus To-Go Group: 671±29 kcal; $t(51)=2.25$, $P=0.029$). The difference in intake between the two groups was non-significant (mean 73±59 kcal) at the meal with the largest portions (Control Group: 759±48 kcal versus To-Go Group: 686±34 kcal; $t(51)=1.25$, $P=0.22$).

Meal energy density consumed

The energy density consumed at the meal was not affected by the portion sizes served ($F(1,125)=0.24$, $P=0.62$) nor by the subject group ($F(1,125)=0.09$, $P=0.77$). For both groups, as portions were increased, the trajectory of meal ED consumed was linear and the slope did not differ significantly from zero. Across portions, the average meal ED consumed by both groups was 1.46±0.01 kcal/g. Thus, the proportions of lower- and higher-ED foods consumed at the meals were similar across portion size conditions and between subject groups.

Ratings of hunger, satiety, and meal properties

Despite different patterns of intake between subject groups, none of the ratings assessed after the meal differed significantly between groups (all $P>0.08$), indicating that packaging uneaten food to go did not affect assessments of hunger, fullness, and meal properties (perceived meal cost; willingness to pay). Additionally, despite increasing intake, serving larger portions of all foods at the meal did not affect ratings of hunger, fullness, thirst, or satisfaction following the meal. Portion size did, however, have a small but significant effect on post-meal ratings of general prospective consumption ($F(3,66)=4.75$, $P=0.005$); for example, increasing portions by 75% led to a decrease in subject ratings of the amount of food they could consume following the meal (from 10.3±2.0 mm to 5.6±1.0 mm) in both groups. Increasing portion size of the meal also influenced the amount of money subjects expected that the meal would cost in a restaurant ($F(3,72.6)=9.20$, $P<0.0001$) as well as how much they would be willing to pay for the meal in a restaurant ($F(3,74.9)=8.46$), $P<0.0001$). For both groups, subjects expected the meals with larger portions to cost more (e.g. $2.47±0.50 more for the largest compared to the smallest portion), but they were also willing to pay more (e.g. $1.96±0.46 more for the largest compared to the smallest portion).

Sensory-specific satiety

At this meal composed of multiple foods, subjects exhibited SSS as assessed by ratings of prospective consumption. The decline in pre- to post-meal ratings for the foods eaten at the meal was greater than for those that were not eaten ($F(1,2476)=354.98$, $P<0.0001$; Figure 2). For the ratings of taste, this difference (eaten: −8.2 mm vs. uneaten: −7.0 mm) did not reach significance ($F(1,2478)=2.94$, $P=0.09$). Notably, SSS did not differ between the Control Group and To-Go Group across meals (prospective consumption: $F(1,2475)=0.00$, $P=0.95$; taste: $F(1,2474)=0.36$, $P=0.55$) despite different patterns of intake. Moreover, serving larger portions of food had no significant influence on SSS (prospective consumption: $F(3,2473)=0.89$, $P=0.45$; taste: $F(3,2472)=0.84$, $P=0.47$). For example, at the baseline meal, mean intake was 406±12 g and the change in ratings of prospective consumption as a measure of SSS was 18.8±2.0 mm. At the meal with the largest portions, despite a greater intake of 497±18 g ($t(48.3)=-6.06$, $P<0.0001$), prospective consumption as a measure of SSS was similar to that at the baseline meal (17.9±2.0 mm; $t(150)=-0.47$, $P=0.96$). Thus, when served larger portions, subjects consumed a greater amount of food for a similar change in ratings of prospective consumption.

Influence of subject characteristics

Most of the measured subject characteristics did not have a significant influence on the trajectory of intake as portion sizes were increased. For both groups, the portion size effect did not differ across age, BMI, body weight, height, estimated energy requirements, restraint, disinhibition, hunger, or scores for satiety responsiveness, food responsiveness, frugality, or waste aversion. In addition, when the three subjects who correctly identified the purpose of the study were excluded from the analysis, the influence of packaging uneaten food on the portion size effect remained significant. There were, however, two characteristics that significantly influenced the portion size effect: slowness of eating (a subscale of the Eating Behavior Questionnaire; Zuraikat, et al., 2018b) and price consciousness (Lichtenstein, et al., 1993). The effect of slowness of eating on the trajectory of intake differed by subject group ($F(1,49.8)=5.16$, $P=0.028$). In the To-Go Group, slowness of eating scores had no influence on the portion size effect ($t(49.9)=0.54$, $P=0.59$), which was already attenuated by packaging uneaten food to take away. In the Control Group, however, slowness of eating scores were inversely related to the slope of the portion size effect ($t(49.8)=-2.54$, $P=0.014$). Thus, women in the Control Group who reported being slower eaters had a moderated intake of larger portions compared to those who were faster eaters. For the characteristic of price consciousness, scores were positively related to the slope of the portion size effect in both groups, despite different patterns of intake ($F(1,51.3)=4.80$, $P=0.033$). Subjects with higher levels of price consciousness had a greater increase in intake in response to larger portions than those with lower price consciousness.

Intake of individual foods

The effect of portion size on intake of the individual foods differed between the subject groups for the two primary components of the meal: chicken with sauce ($F(1,105)=4.33$, $P=0.04$) and pasta with butter ($F(1,105)=5.16$, $P=0.03$), as shown in Table 3. In response to larger portions, subjects in the Control Group consumed a greater weight of both the low-ED chicken (t(131)=2.72, P=0.007) and the medium-ED pasta (t(136)=2.75, P=0.007), whereas subjects in the To-Go Group had no difference in intake of either food (chicken: t(131)= −0.20, P=0.84; pasta: t(136)=−1.33, P=0.19). For the other three foods served at the meal (broccoli, garlic bread, and grapes), there was a significant effect of portion size on intake (all $P < 0.005$ for linear coefficient), and this effect did not differ between groups. Thus, differences in the pattern of intake for the two primary meal components contributed to group differences in overall meal intake.

Rankings of food cost (P=0.43), value (P=0.34), healthfulness (P=0.08), and calorie content (P=0.17) of the individual foods had no significant influence on the trajectories of intake of the foods as portions were increased. Similarly, ratings of food cost did not affect the response to portion size of the individual foods served at the meal. However, two food characteristics approached (but did not reach) statistical significance for influence on the slope of the portion size effect: the relative taste ranking (P=0.062) and the relative market value of the food (P=0.066). The effect of portion size showed a trend to be greater for foods ranked highest in taste and those rated as having higher value, such as chicken, which 78% of women reported to have the highest value of the foods served at the meal.

Perceptions of restaurant portion sizes and the influence of taking food to go

Although 80% of the women reported that they felt restaurant portions were excessively large, 84% reported that when dining out they finished all of the food served *at least* some of the time (sometimes, most of the time, or always), with half of these individuals reporting that they did so most of the time or always. When asked how their intake at a restaurant is influenced by the availability of a to-go container, 47% reported that they eat less food compared to when there is no option to take leftovers to go. Moreover, 63% of participants stated that their likelihood of taking food to go increases when it is obvious that there is more food served than can be eaten.

Discussion

The option to take away uneaten food for later consumption influenced food and energy intake when participants were served larger portions at a meal. Women who were told they would be provided with their leftovers in a to-go container after the meal showed an attenuated response to the typically robust effect of portion size on intake. Moreover, although women in the To-Go Group ate less than Controls as portions were increased, their lower intake did not result in less fullness or satisfaction after the meals, reducing the likelihood that they would compensate by eating more at subsequent meals. Thus, providing an option to take away uneaten food from a meal could be an effective strategy to reduce overconsumption from large portions.

In showing that the effects of portion size on intake were attenuated by packaging uneaten food to go, we extended the previous finding that intake at a single meal was reduced by provision of a to-go container (Bates & Shanks, 2015). In addition, the effect observed in this study did not rely on providing subjects with the container before the meal as in the earlier study; simply making subjects aware of the option to take food away was sufficient to counter the cues provided by the amount of food served. Packaging leftovers after the meal is a more typical practice than providing a box in advance and shifts the focus of the intervention from a behavioral prompt to a means of reducing waste. Therefore, while our method did not eliminate the possibility of a behavioral nudge, it is likely that the effectiveness of the strategy relates to its ability to increase the value of a meal and reduce waste. Previous research has investigated portion size interventions directly related to monetary value, such as varying the price paid for a meal (sunk cost; Zuraikat et al., 2018b) or the price per unit (value vs linear pricing; Harnack, French, Oakes, Story, Jeffrey & Rydell, 2008), which have been found to have little effect on intake. The results of the studies using a to-go container, however, show that this strategy that indirectly increases value, as well as directly reducing waste, is effective in moderating intake from large portions.

In addition to the reduction in intake and waste, a benefit of packaging uneaten food is that it is unlikely to provoke consumer resistance, since it does not limit choice, nor does it eliminate the greater value typically associated with larger portions (Steenhuis & Vermeer, 2009). However, despite these moderating effects, this strategy should not be regarded as a comprehensive solution to the problem of overconsumption from large portions. In this study, when the largest portion was served, there was a convergence of intake between the To-Go Group and Controls, such that the option to take away leftovers no longer reduced intake. When served excessively large portions, individuals could be at risk for overeating despite taking away sizeable amounts of food. Downsizing is needed in these situations to address the risk of overconsumption. Our data also suggest that modest reductions of very large portions are unlikely to reduce consumer satisfaction. Thus, while packaging uneaten food for a later occasion can be useful to counter the portion size effect within a range of portion sizes, it will likely be most effective as a complementary strategy to downsizing.

It has been proposed that the portion size effect could be related to the development of sensory-specific satiety (SSS; Herman, Polivy, Pliner & Vartanian, 2015), which is a component of meal termination (Rolls, 1986). We found that subjects experienced SSS as evaluated by ratings of prospective consumption, but not by ratings of taste. Notably, ratings of prospective consumption have been found to be more sensitive than ratings of taste in assessing SSS (Bell, Roe & Rolls, 2003; Miller, Bell, Pelkman, Peters & Rolls, 2000; Rolls & McDermott, 1991). The finding of SSS in a meal composed of multiple foods is of interest, given that SSS is usually offset by food variety (Rolls, 1986). However, four of the five meal components were savory, and this similarity could have reduced variety effects in the meal, since larger contrasts in flavor (e.g. salty versus sweet) lead to more pronounced specificity of satiety (Rolls, et al., 1981; Rolls & McDermott, 1991). Of particular interest is that SSS was not influenced by the portion served nor by whether leftovers were packaged to go. As a result, as portions were increased subjects consumed more food for a similar decrease in ratings of prospective consumption. A congruent finding was observed in a previous study testing a single food: the change in pre- to post-meal ratings of palatability did not differ as intake increased with larger portions (Rolls, Morris & Roe, 2002). These results suggest that the portion of available food determines how much food will be consumed before its desirability declines enough to contribute to the termination of eating. Clearly, portion size is a primary determinant of intake, even overriding processes related to meal termination.

In common with many other studies, the effect of portion size in this experiment was not found to be influenced by most subject characteristics (Hollands, et al., 2015). However, we did find that subjects who scored higher in price consciousness had a stronger response to portion size than those lower in this attribute. This finding adds to our understanding of the role of value in the portion size effect at an individual level: those who are more concerned with maximizing monetary value were more susceptible to overeating from larger portions, even when provided with a to-go container. It is likely that these individuals are more averse to wasting money, which is distinct from wasting food (Bolton & Alba, 2012). Therefore, the risk of overeating in individuals high in price consciousness may be amplified in settings in which value pricing is used, since consumers with higher responsiveness to price would be expected to select larger portion sizes (McCall & Bruneau, 2010). We also observed that in control subjects, self- identified slow eaters were less responsive to increases in portion size than fast eaters. Slower eating has been found to relate to lower energy intake in general (Robinson, Almiron-Roig, Rutters, de Graaf, Forde, Smith, et al., 2014), but had not previously been related to the portion size effect. Notably, slowness of eating has similarities to satiety responsiveness (Hunot, Fildes, Croker, Llewellyn, Wardle & Beekman, 2016), which was previously found to affect the relationship between portion size and intake (Zuraikat, et al., 2018b). We speculate that the mechanism by which slowness of eating reduces intake from large portions is related to having more time to process and respond to cognitive or internal satiety cues. Continued investigation of the relationship between eating behaviors and the portion size response can aid in the development of individualized interventions to reduce susceptibility to this effect.

A secondary aim of this study was to assess influences on intake of the individual foods served at the meal. Packaging leftovers attenuated the effect of larger portions on intake of chicken and pasta, but for the other meal components, intake did not depend on whether the uneaten food was packaged after the meal. This finding suggests that the influence of packaging leftover foods is related to the properties or perceptions of the foods. For example, this strategy may be most effective with foods that reheat well, or foods that are highly valued, such as meats (Drewnowski & Darmon, 2005). Additionally, the relative palatability and perceived value of foods might be found to influence the portion size effect in a larger sample of participants, although these effects did not reach statistical significance in the current study. Previous research has found that foods ranked higher in taste exhibit larger portion size effects (Roe, et al., 2016; Zuraikat, et al., 2018a), and our data were trending in the same direction. Similar to taste rankings, there was a trend for larger portion size effects in foods perceived to have the greatest value, such as the chicken. The role of these food-related characteristics should be examined further by replicating this study in a larger sample of both men and women. This would clarify how the influence of packaging uneaten food on the response to portion size is affected by food properties such as taste and value, as well as helping to determine how results differ between individuals.

Development of strategies to moderate intake from large portions is a primary goal of public health agencies (Raynor & Champagne, 2016; NIDDK, 2016). This study presents one of the clearest demonstrations of an environmental intervention that attenuates the response to portion size. The portion size effect has been shown to persist despite interventions such as extended training in portion control (Zuraikat et al., 2018a), provision of portion options

(Zuraikat, Roe, Privitera & Rolls, 2016), information about serving size (Reily & Vartanian, 2016), and mindfulness training (Cavanagh, Vartanian, Herman & Polivy, 2013). Providing the opportunity to take away food after a meal is practical and relatively easy to implement in settings such as restaurants, worksite cafeterias, and dining halls, and as shown here, can be an effective strategy to reduce intake from large portions. It is noteworthy that participants were made aware prior to the meal of the option to take away uneaten food; the timing of this nudge towards healthy behavior may be an important step in maximizing efficacy of the provision of packaging and should be tested in restaurant settings. A further benefit of this strategy is its potential to reduce food waste without having to restrict portion sizes. Thus, providing the option to take away uneaten food could help to address concerns related to overconsumption of energy (Swinburn, Sacks, Hall, McPherson, Finegood, Moodie & Gortmaker, 2011) and food waste (EPA, no date; Venkat, 2011) by reducing intake from large portions at a meal.

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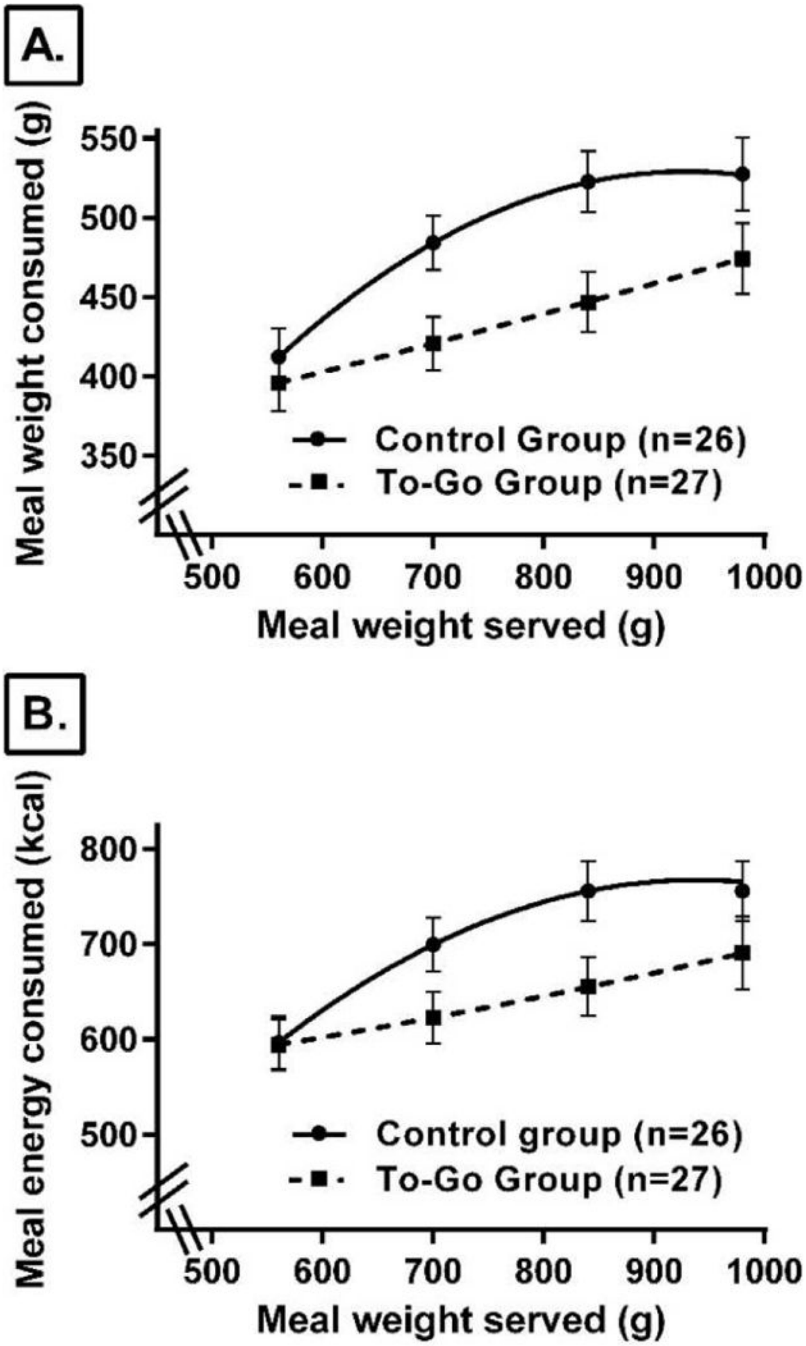

Fig. 1:

The effect of increasing the portion size of all foods at the meal on the modeled trajectory of meal intake (the portion size effect) differed by subject group for both (A) the weight of food consumed ($P \leq 0.017$) and (B) energy intake ($P \leq 0.025$). Means and trajectories from the random coefficients model are shown. For subjects in the Control Group, increasing meal size led to an initial linear increase in the weight and energy consumed at the meal (both $P<0.0001$) that was modified by a deceleration in intake characterized by a negative quadratic coefficient (both $P<0.02$). In the To-Go Group, increases in portion size led to linear increases in food and energy intake that were not significantly different from zero ($P>0.14$).

Fig. 2:
The decline in ratings of prospective consumption from before to after meals for samples of foods that were either eaten or uneaten at the meal. Sensory-specific satiety (defined as the difference in decline between the eaten and uneaten foods) was not influenced by subject group (P=0.17) or portion size condition (P=0.48), thus the combined results are presented. For both the eaten and uneaten foods, mean ratings of prospective consumption declined after the meal compared to before. However, the decline in ratings of prospective consumption, one marker of the specificity of satiety, was greater for the five foods eaten at the meal than for the seven foods that were rated but not eaten at the meal (P<0.0001). Means with different letters were significantly different.

Table 1:

Composition of test meals served to 53 women

Meal component	Energy density (kcal/g)	100% portion sizes		125% portion sizes		150% portion sizes		175% portion sizes	
		Weight (g)	Energy (kcal)	Weight (g)	Energy (kcal)	Weight (g)	Energy (kcal)	Weight (g)	Energy (kcal)
Chicken breast, baked with creamy parmesan sauce[a]	0.99	150	149	188	186	225	223	262	260
Orzo pasta[b] with butter and garlic	1.75	130	228	162	284	195	341	228	398
Broccoli with butter	0.71	120	85	150	107	180	129	210	149
Garlic bread[c]	3.89	80	311	100	389	120	467	140	545
Grapes	0.69	80	55	100	69	120	83	140	97
Entire meal	1.48	560	828	700	1035	840	1243	980	1449

[a] Campbell Soup Company, Camden, NJ, USA; modified by adding ½ cup water per 311 g packet.

[b] Barilla USA, Northbrook, IL, USA.

[c] Pepperidge Farm Inc, Norwalk, CT, USA.

Table 2:

Subject characteristics of 53 women[1]

Variable	To-Go Group (n=27)	Control Group (n=26)	Significance of group difference[2] (P-value)
Weight (kg)	67.1 ± 13.8	66.6 ± 9.6	0.87
Body mass index (kg/m^2)	24.5 ± 4.7	24.7 ± 3.8	0.85
Age (years)	27.1 ± 10.1	30.9 ± 13.5	0.24
Energy requirement (kcal/d)[3]	2015±179	1973 ±125	0.33
Dietary restraint score[4] (range 0–21)	8.1 ± 4.4	5.9 ± 3.9	0.07
Disinhibition score[4] (range 0–16)	7.4 ± 4.0	5.9 ± 3.3	0.16
Hunger tendency score[4] (range 0–14)	5.7 ± 3.5	5.2 ± 3.0	0.56
Satiety responsiveness score[5] (range 1–5)	2.9 ± 0.6	2.9 ± 0.6	0.98
Food responsiveness score[5] (range 1–5)	2.7 ± 1.1	2.3 ± 0.9	0.19
Slowness in eating score[5] (range 1–5)	2.8 ± 0.9	2.5 ± 0.8	0.25
Price consciousness score[6] (range 1–7)	4.8 ± 0.9	4.7 ± 1.1	0.57
Frugality score[7] (range 1–7)	5.7 ± 0.7	5.9 ± 0.7	0.33
Food Waste Aversion score[8] (range 0–7)	4.4 ± 1.2	4.7 ± 1.3	0.42

[1]Values are mean ± SD unless otherwise indicated.

[2]Analyzed using independent samples t-tests.

[3]Energy requirements estimated from sex, age, height, weight, and activity level (Institute of Medicine, 2002).

[4]Scores from the Eating Inventory (Stunkard & Messick, 1985).

[5]Scores from the Eating Behavior Questionnaire (Zuraikat, et al., 2018b).

[6]Score from the Price Consciousness Scale (Lichtenstein, et al., 1993).

[7]Score from the Frugality Scale (Lastovicka, et al., 1999).

[8]Score from the Food Waste Aversion Scale (developed for this study).

Table 3:

Individual and total food intake (g) and meal energy intake (kcal) at test meals by 53 women according to subject group[1]

Food item	Control Group (n = 26) Portion size served				To-Go Group (n=27) Portion size served				Portion size effect[2] (P-value)		Group influence on portion size effect (P-value)[3]
	100%	125%	150%	175%	100%	125%	150%	175%	Linear coefficient	Quadratic coefficient	
Chicken with sauce	107.4±6.7	115.1±8.5	131.2±9.2	122.4±10.6	101.6±6.4	99.8±7.2	109.2±6.3	115.2±6.6	0.07	0.05	<0.04[4]
Orzo pasta with butter	91.4±7.2	109.4±8.5	117.4±9.5	121.4±11.2	97.5±6.2	93.2±6.0	92.5±7.5	103.3±8.0	0.31	0.94	<0.03[4]
Broccoli	93.7±5.4	109.2±6.6	126.0±8.6	113.4±9.6	83.2±6.4	98.3±7.9	105.6±9.0	105.9±9.1	<0.0001	0.001	>0.22
Garlic bread	57.6±4.0	62.7±5.2	75.3±5.8	72.2±6.2	59.7±4.2	58.2±4.8	71.3±5.9	66.7±6.4	0.0005	0.02	>0.38
Grapes	67.1±3.7	75.5±5.5	85.3±6.5	93.3±8.2	53.2±6.2	70.3±6.9	70.8±9.1	81.8±10.1	0.005	0.34	>0.91
Total meal food intake	417.0±16.1	471.9±19.0	535.1±21.7	522.7±29.3	395.3±17.7	419.8±18.9	449.3±17.1	473.0±20.5	<0.0001	0.9	<0.017[4]
Total meal energy intake (kcal)	602.8±26.6	679.0±31.9	776.4±37.1	759.4±48.3	599.4±26.5	606.7±26.8	671.0±28.9	686.0±34.2	<0.0001	0.82	<0.025[4]

[1]Values are (raw) mean ± SEM.

[2]Significance of the linear and quadratic coefficients of intake trajectory as portions were increased, as assessed by a random coefficients model.

[3]Group difference in the linear and quadratic coefficients of the intake trajectory as portions were increased, as assessed by a random coefficients model.

[4]Significant group difference in both the linear and quadratic coefficients of the portion size effect: linear increase followed by deceleration in intake for the Control Group compared to non-significant change in intake for the To-Go Group.