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Promoting vegetable intake in preschool children: independent and combined effects of portion size and flavor enhancement

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Abstract

This study investigated the independent and combined effects on preschool children's vegetable intake of serving a larger portion of vegetables and enhancing their flavor. In a crossover design, lunch was served in childcare centers once a week for four weeks to 67 children aged 3-5 y (26 boys, 41 girls). The meal consisted of two familiar vegetables (broccoli and corn) served with fish sticks, rice, ketchup, applesauce, and milk. Across the four meals, we varied the portion of vegetables (60 or 120 g total weight, served as equal weights of broccoli and corn) and served them either plain or enhanced (6.6% light butter and 0.5% salt by weight). All meals were consumed ad libitum and were weighed to determine intake. Doubling the portion of vegetables led to greater consumption of both broccoli and corn (both $p<0.0001$) and increased meal vegetable intake by 68% (mean±SEM 21±3 g). Enhancing vegetables with butter and salt, however, did not influence their intake ($p=0.13$), nor did flavor enhancement modify the effect of portion size on intake ($p=0.10$). Intake of other meal components did not change when the vegetable portion was doubled ($p=0.57$); thus, for the entire meal, the increase in vegetable consumption led to a 5% increase in energy intake (13±5 kcal; $p=0.02$). Ratings indicated that children had similar liking for the plain and enhanced versions of each vegetable (both $p>0.31$). All versions of vegetables were well-liked, as indicated by ≥76% of the children rating them as "yummy" or "just okay". Serving a larger portion of vegetables at a meal was an effective strategy to promote vegetable intake in children, but when well-liked vegetables were served, adding butter and salt was not necessary to increase consumption.

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Declaration of competing interest

The authors have no competing interests to declare.

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Ethical statement

Parents provided informed written consent for the participation of their child as well as their own participation in completing questionnaires. Parents and teachers were financially compensated for their participation. All procedures were reviewed and approved by The Pennsylvania State University Office for Research Protections.

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Keywords

Vegetable intake; Portion size; Preschool children; Energy intake; Liking; Eating behavior

1. Introduction

The majority of children in the United States do not consume the daily amount of vegetables recommended in the United States Department of Agriculture MyPlate guide (Ramsay et al., 2014; U.S. Department of Agriculture, 2011). This inadequate intake has been attributed in part to children's low preference for vegetables (Birch, 1999; Nicklaus et al., 2005). One strategy to promote children's vegetable intake is to increase the portion served at a meal (Kral et al., 2010; Mathias et al., 2012; Spill et al., 2010). While this strategy can be effective, it likely depends upon the palatability of the vegetables. Thus, the aim of the current study was to test the effects of serving a larger portion of vegetables, enhancing their flavor to improve palatability, or combining these strategies at a meal.

Serving larger portions has been shown to increase food intake in both adults and children (Rolls, 2018), but in the context of meals in which the amounts of all foods were increased, vegetables have been found to be more resistant to the effect of portion size (Kling et al., 2016; Rolls et al., 2007; Smethers et al., 2019). These results may have been due to the lower palatability of the vegetables compared to the competing foods served at the meals (Kling et al., 2016). It is possible that serving a larger portion would more effectively encourage vegetable intake if the increase was only applied to vegetables, thus increasing their proportion of the meal as recommended in MyPlate (U.S. Department of Agriculture, 2011). To date, only two studies have investigated this strategy in children. Kral et al. found no effect on vegetable intake of doubling the portion size of vegetables (broccoli and carrots) that were served without any flavoring (Kral et al., 2010). In contrast, Mathias et al. reported an increase in vegetable intake of doubling the portion size of a vegetable (broccoli) that had butter added to enhance the flavor (Mathias et al., 2012). These findings suggest that increasing the proportion of vegetables at a meal can lead to increased intake in young children, but the effect may depend on the palatability of the vegetables.

Vegetables are often the least palatable food group for children (Caporale et al., 2009; Nicklaus et al., 2005), thus, several researchers have attempted to encourage vegetable intake by adding condiments or flavorings to improve the palatability. In one study, when preschool children were served vegetables (celery and yellow squash) with an herb-flavored dip, both liking ratings and vegetable consumption increased compared to when vegetables were served without dip (Savage et al., 2013). Additionally, adding salt was found to increase green bean intake in both toddlers (Bouhlal et al., 2011) and school-age children (Bouhlal et al., 2013). Focus groups in school-aged children also found that children preferred vegetables served with flavorings such as butter and salt (Baranowski et al., 1993), which is in line with parental reports of frequent usage of these condiments (Ahern et al., 2013; Poelman et al., 2015). These results show that enhancing the flavor of vegetables to improve palatability can increase vegetable intake in children, but the effect of combining this strategy with serving a larger portion is not known.

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In the current study in preschool children, we used a 2-by-2 crossover design to test the effect on vegetable intake of either serving a larger portion of vegetables, enhancing their flavor with small amounts of butter and salt, or combining these strategies at a meal. We hypothesized that both increasing the vegetable portion size and enhancing the flavor of vegetables would increase vegetable intake, and that combining these strategies would augment their independent effects. Additionally, we evaluated the influence of children's characteristics on the relationship between these strategies and vegetable intake. The results of this study will identify effective strategies for parents and caregivers to promote children's vegetable intake in order to bring it closer to recommended amounts.

2. Methods

2.1. Experimental design

A within-subjects crossover design was used to evaluate the effects of increasing the portion size and enhancing the flavor of vegetables on preschool children's vegetable intake at a meal. On one day a week for four weeks, children in their childcare centers were provided with an experimental lunch of two familiar vegetables (broccoli and corn) served with fish sticks, rice, ketchup, applesauce, and milk. Across the four meals, we doubled the portion size of vegetables and enhanced the flavor by adding butter and salt; the other components of the meal were not varied. All food and beverage items were consumed ad libitum and weighed before and after meals to determine intake. The order of the experimental conditions was counterbalanced across the meals by using Latin squares and classrooms were randomly assigned one of the condition sequences by using a random number generator. The meals were separated by a one-week washout period.

2.2. Participants

Participants were 3- to 5-year-old preschool children who were recruited from May to October 2019 by distributing letters to parents in five classrooms at two childcare centers in State College, Pennsylvania, USA. Children were eligible for participation if they were enrolled in the childcare centers for the study duration and did not have any food allergies, food restrictions, or health issues that precluded their participation. Parents provided informed written consent for the participation of their child as well as their own participation in completing questionnaires.

Parents and teachers were not informed of the purpose of the study and were financially compensated for their participation. All procedures were reviewed and approved by The Pennsylvania State University Office for Research Protections. The study is registered at ClinicalTrials.gov (registry identifier NCT03926065).

We conducted a power analysis to determine the sample size needed to detect the effect on vegetable intake of enhancing the vegetables with butter and salt; we expected this effect to be more difficult to detect than that of portion size. The variability in vegetable intake was estimated from a study in which toddlers were served vegetables with different amounts of butter and salt at different lunches (Bouhlal et al., 2011), as well as from our previous studies in 3- to 5-year-old children (Sanchez et al., 2019; Smethers et al., 2019). The

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difference in vegetable intake to be detected was set at 10 g. This amount is about one-third of the minimum vegetable serving size for lunch in this age group (0.25 cup or about 30 g), as required by the Child and Adult Care Food Program (U.S. Department of Agriculture, Food and Nutrition Services, 2017). In order to detect this difference in vegetable intake, the required sample size was estimated to be 49 children using a Type 1 error rate of 5% and a power of 80%. We aimed to enroll more children than this in order to allow for absences and withdrawals.

2.3. Experimental meal

The experimental meal consisted of two vegetables (broccoli and corn) along with fish sticks, rice, applesauce, ketchup, and milk. Details of the types and amounts of the meal items are given in Table 1. Broccoli and corn were chosen because they were familiar to the children; according to the monthly menus of the childcare centers, each of these vegetables was served to children at least once a week. Across the four meals, we served the vegetables at two levels of portion size (100% or 200%) and two levels of flavor enhancement (plain or enhanced by adding butter and salt). The 100% portion size (60 g total weight) was equivalent to approximately 0.5 cup, which is one-third of the recommended daily vegetable intake for children of this age (U.S. Department of Agriculture, 2011); for the 200% portion size, the weight of both vegetables was doubled (120 g total weight). The other foods served in the meal were chosen to be familiar and to have been at least moderately liked by most children in a previous study (Smethers et al., 2019). These other foods as well as the milk were not varied and their portions met the minimum requirements of the Child and Adult Care Food Program (U.S. Department of Agriculture, Food and Nutrition Services, 2017). The experimental meals with baseline (100%) and doubled (200%) portions of vegetables provided approximately 400 and 450 kcal, respectively (Table 1).

The plain vegetables consisted of steamed vegetables without any flavoring, and the enhanced vegetables had 6.6% light butter and 0.5% salt added by weight, which added 10 kcal per 60-g portion. Butter and salt were chosen for flavor enhancement because parents have reported using these condiments frequently (Ahern et al., 2013; Poelman et al., 2015) and focus groups in older children found that children prefer vegetables served with flavorings such as butter and salt (Baranowski et al., 1993). Light butter was used to minimize differences in energy density across conditions (Table 1). The initial amounts considered for the addition of light butter and salt were based on previous research in toddlers (Bouhlal et al., 2011). An informal panel of scientists tasted the different preparations of vegetables to identify amounts of butter and salt that could be detected and that enhanced palatability.

2.4. Meal procedures and assessment

All foods and milk were prepared in the laboratory kitchen from standardized recipes or commercially available products and transported to the childcare centers in warming units or insulated coolers. Children enrolled in the study were served the experimental lunch in the childcare centers at the regularly scheduled time. Children ate at tables with the same group of four to eight children and one teacher, which is standard practice at the childcare centers. Just before the children were seated, individual portions of foods and milk were weighed

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and set at each child's place at the table. The foods were served on a 10-inch-diameter divided plate that provided separate compartments for each vegetable, and the milk was served in a 300-ml transparent cup with a lid and straw. The children were instructed that they could eat as much or as little as they wanted but could not request more of any food or milk. The teachers at the tables were instructed to redirect any conversation about food-related topics and to prevent children from sharing their foods and beverages with each other.

After all children had finished eating, researchers returned any dropped or spilled food to the correct plate prior to weighing. Food and beverage items were weighed before and after meals in order to determine the amount of each item consumed by each child to the nearest 0.1 g with the use of digital scales (Mettler-Toledo PR5001 and XS4001S; Mettler-Toledo, Columbus, Ohio, USA). Energy and macronutrient intakes were calculated using information from food manufacturers and a standard food composition database (U.S. Department of Agriculture, Agricultural Research Service, 2019).

2.5. Other assessments

Children's food preference and liking were assessed during individual sessions, which were conducted within one week after the final experimental meal. Each child who agreed to participate was seated at a table with a researcher and first completed the pairwise vegetable preference task. In this task, we presented the child with bite-sized samples of the plain and enhanced versions of one vegetable, either broccoli or corn; the order of presenting the vegetables was randomly assigned across children. We asked the child to taste each version of the vegetable (plain and enhanced, in a randomly assigned order). Then we asked the child "Which one do you like better?" and to indicate the preferred version by pointing to the sample. The pairwise task was then repeated for the two versions of the other vegetable. Following this, the child rated their liking of seven of the lunch foods; this assessment included both versions of the two vegetables but excluded the condiment (ketchup) and the beverage (milk). Food liking was evaluated with the use of a 3-point cartoon face scale to rate each food as "yummy," "just okay," or "yucky" (Birch, 1979). After being instructed on the use of the cartoon faces, the child was presented with samples of the foods in a randomly assigned order. The child tasted each sample and indicated the liking rating by pointing to the appropriate cartoon face. After rating all seven foods, the child was asked to rank them from most liked (rank 1) to least liked (rank 7).

Body weight and height were assessed by a trained researcher within one week after the final experimental meal. Children were weighed wearing light clothing and without shoes. Body weight was measured in duplicate to the nearest 0.1 kg with the use of a portable digital scale (model 843; Seca Corporation, Hanover, Maryland, USA) and body height was measured in duplicate to the nearest 0.1 cm with the use of a portable stadiometer (model 214; Seca Corporation, Hanover, Maryland, USA). If the two measurements differed by >0.2 kg for weight or >0.5 cm for height, a third measurement was taken and the measurements were averaged. Body weight and height were used to calculate sex-specific BMI-for-age percentiles and BMI z-scores using a software program based on nationally representative

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data (U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, 2016).

Parents of participating children were provided paper questionnaires about parent and child characteristics, child eating behaviors, and parental feeding practices to be completed at home within one week after the final experimental meal. The demographic questionnaire had 17 items related to characteristics of the family and the child. The vegetable questionnaire had 13 items concerning the frequency of preparation methods, serving, and consumption of vegetables at home; the responses were used to estimate the child's familiarity with the vegetables and preparation methods used in the study. The validated 35-item Children's Eating Behaviour Questionnaire (CEBQ) evaluates eight subscales that relate to eating styles and behaviors of the child, including food fussiness (Wardle et al., 2001). The CEBQ was also completed by one teacher for each child enrolled in the study, based on the child's eating behavior in the classroom. The Child Feeding Questionnaire (CFQ) is a 31-item instrument with seven subscales that include parental feeding practices and attitudes (Birch et al., 2001); in this study, only the subscales for parental monitoring (3 items) and pressure to eat (4 items) were included, based on previous reports of their relevance to children's vegetable intake in a preschool setting (Warkentin et al., 2020). Respondents rated each item on the CEBQ and CFQ on 5-point scales and subscale scores were calculated by averaging the scores for the relevant items.

2.6. Statistical analysis

The primary outcome of this crossover study was children's vegetable intake by weight (g). Secondary outcomes were food and milk intake (g) at the meal, energy intake (kcal) at the meal, and energy density (kcal/g) of the food consumed at the meal. Differences in mean outcomes across the two experimental factors were analyzed using linear mixed models with repeated measures. The fixed factors in the models were the experimental conditions of portion size (100% or 200%) and flavor enhancement (plain or enhanced), as well as study week, classroom, and sex of the child. The interaction between the factors of portion size and flavor enhancement was tested for significance in all models and removed if not significant. Participants were treated as a random effect. The Tukey-Kramer method was used to adjust the significance level for multiple pairwise comparisons between means. Children who left <7 g of vegetables uneaten (a small spoonful) at ≥3 meals were considered to have eaten all the vegetables they were served and vegetable intake was analyzed both with and without these children in order to test whether they influenced the results.

Differences in pairwise preference between the plain and enhanced versions of each vegetable were assessed by a one-proportion z-test. Ordinal logistic regression was used to evaluate whether the distribution of the liking ratings of the vegetables differed significantly between the plain and enhanced versions; results are reported as odds ratios (OR) with 95% confidence intervals (CI). Analysis of covariance with linear mixed models was used to assess the influence of continuous participant characteristics (age, BMI-for-age percentile, BMI z-score, questionnaire subscales, and parental reported BMI) on the relationship between the experimental factors and vegetable intake. Differences between boys and girls in age, body weight, height, BMI-for-age percentile, and BMI z-score were evaluated by

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using t-tests and these subject characteristics are reported as mean ± SD. Outcomes from statistical models are reported as adjusted means ± SEM and the results were considered significant at $p < 0.05$. All data were analyzed with SAS software (SAS 9.4, SAS Institute, Inc., Cary, North Carolina, USA).

3. Results

3.1. Subject characteristics

There were 67 children from five classrooms at two childcare centers enrolled in the study. All of the enrolled children completed the study and were included in the analyses; their demographic characteristics are shown in Table 2. The children had a mean age of 4.2 ± 0.6 y and a mean sex-specific BMI-for-age percentile of 54 ± 27; 16% of the children were classified as having overweight (N = 9) or obesity (N = 2).

Based on the 66 parents (99%) who provided family information, the racial composition of the sample was 77.3% white, 4.6% black or African American, 7.6% Asian, and 10.6% mixed or another race; the ethnicity of the sample was 10.6% Hispanic or Latino. Seventy-five percent of households had an annual income > $50,000 and 85% of mothers and 78% of fathers had a university degree.

When asked about frequency of serving broccoli and corn at home, 59% of parents reported that they served broccoli more than three times per month and 39% of parents reported that they served corn with this frequency. The remaining parents reported serving these vegetables one to three times per month (33% for broccoli, 43% for corn) or never (8% for broccoli, 18% for corn). When asked about broccoli preparation methods at home, 41% of parents reported that they often or always served it plain and 20% often or always served it with added butter and salt. The remaining parents reported using these preparation methods sometimes, rarely, or never. For corn preparation at home, 30% of parents reported that they often or always served it plain and 30% often or always served it with added butter and salt.

3.2. Vegetable intake by weight and energy

Intake of vegetables at the meal was significantly affected by serving a larger portion ($F_{(1,89)} = 65.73$; $p < 0.0001$) but not by enhancing the flavor ($F_{(1,160)} = 2.37$; $p = 0.13$), as shown in Figure 1. Vegetable intake at the meal increased by 68% (21 ± 3 g) when the portion of vegetables was doubled. This increase is equivalent to approximately one-third of a 0.5-cup serving or 12% of the daily recommended intake for this age group. Children consumed similar amounts of plain and enhanced vegetables (43 ± 3 g and 41 ± 3 g, respectively, across both portions) and the flavor enhancement did not modify the effect of the larger portion on vegetable intake (interaction $F_{(1,162)} = 2.75$; $p = 0.10$). When the nine children (13%) who ate all of the vegetables served at three or more meals were excluded from the analyses, the effect of portion size on vegetable intake remained significant (17 ± 3 g; $F_{(1,92)} = 35.87$; $p < 0.0001$) and the effect of flavor enhancement remained non-significant ($F_{(1,140)} = 1.74$; $p = 0.19$).

When intake of each vegetable was assessed separately, doubling the portion size led to an increase in broccoli consumption of 12 ± 2 g ($F_{(1,97)} = 47.00$; $p < 0.0001$) and an increase in

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corn consumption of 9 ± 2 g ($F_{(1,93)} = 39.47$; $p < 0.0001$). The flavor enhancement, however, had different effects on intakes of broccoli and corn. Children consumed similar amounts of plain and enhanced broccoli (both 24 ± 2 g across both portions; $F_{(1,159)} = 0.15$; $p = 0.69$), but there was a small but significant decrease in corn intake when it was served in the enhanced version (from 20 ± 2 g to 17 ± 2 g across both portions; $F_{(1,153)} = 4.47$; $p = 0.04$).

Although increasing the portion size of vegetables led to an increase in vegetable consumption, the larger portion was also associated with an increase in the amount of uneaten vegetables ($F_{(1,89)} = 213.22$; $p<0.0001$). The mean amount of vegetables left uneaten from the 60-g portions was 29 ± 2 g (48%) and from the 120-g portions was 67 ± 4 g (56%). Children also left food uneaten from the other meal components, with amounts ranging from 4.5 ± 1 g of the 45-g portion of fish sticks (10%) to 26 ± 2 g of the 45-g portion of rice (58%). The mean percentage of uneaten food across the meal components other than vegetables was 31%.

Energy intake from vegetables at the meal was significantly affected by the portion of vegetables served ($F_{(1,185)} = 85.04$; $p < 0.0001$) but not the flavor enhancement ($F_{(1,187)} = 0.30$; $p = 0.58$). Energy intake from vegetables increased by 19 ± 2 kcal when the portion of vegetables was doubled. Children consumed similar energy from plain and enhanced vegetables (36 ± 3 kcal and 37 ± 3 kcal, respectively, across both portions). Thus, doubling the portion of vegetables increased the energy consumed from vegetables, but adding a small amount of light butter to the vegetables did not.

3.3. Meal intake by weight and energy

The total weight of food and milk consumed at the meal (Table 3) was influenced by vegetable portion size ($F_{(1,180)} = 7.39$; $p = 0.007$) but not flavor enhancement ($F_{(1,181)} = 0.36$; $p = 0.55$). Children consumed similar amounts of other meal components (non-vegetable foods and milk) when the vegetable portion was varied ($F_{(1,180)} = 0.33$; $p = 0.57$) or when the flavor enhancement was varied ($F_{(1,180)} = 1.91$; $p = 0.17$). Since doubling the vegetable portion led to consumption of a greater weight of vegetables, the total weight of food and milk also increased by 18 ± 7 g (6%). Total meal weight did not differ significantly when children were served the plain and enhanced vegetables (292 ± 10 and 296 ± 10 g, respectively, across both portions).

Energy intake at the meal (Figure 2) was influenced by vegetable portion size ($F_{(1,182)} = 5.72$; $p=0.02$) but not flavor enhancement ($F_{(1,182)} = 2.69$; $p = 0.10$), similar to the effects on meal intake by weight. Energy intake from the non-vegetable meal components did not differ when the vegetables were varied in portion size ($F_{(1,181)} = 1.58$; $p = 0.21$) or flavor enhancement ($F_{(1,181)} = 2.69$; $p=0.10$). Since doubling the vegetable portion resulted in greater energy intake from vegetables, total meal energy intake also increased by 13 ± 5 kcal (5%). Meal energy intake did not differ significantly when the children were served the plain and enhanced vegetables (274 ± 9 and 282 ± 9 kcal, respectively, across both portions). The overall energy density of food consumed at the meal was independently influenced by the experimental factors (Table 3): food energy density was decreased (5%) by serving the larger portion of vegetables compared to the smaller portion ($F_{(1,182)} = 15.89$; $p < 0.0001$) but was

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increased (4%) by serving the vegetables enhanced with butter and salt compared to plain ($F_{(1,182)} = 10.69$; $p = 0.0013$).

3.4. Food preference and liking ratings

Food preference and liking assessments were completed by 61 (91%) of the enrolled children; the other six children declined to participate or were absent. The pairwise vegetable preference task showed that the proportion of children who preferred the enhanced vegetables (57% for broccoli, 53% for corn) and the proportion who preferred the plain version (43% for broccoli, 47% for corn) did not differ from that expected by chance (50%) for either broccoli ($Z = -1.07$; $p = 0.14$) or corn ($Z = -0.53$; $p = 0.30$). The children's preferences from the pairwise task did not influence the effects of portion size ($F_{(1,140)} = 0.21$; $p = 0.65$) or flavor enhancement ($F_{(1,117)} = 0.95$; $p = 0.33$) on intake of vegetables.

Similar to the findings from the preference task, the children's liking ratings did not differ significantly for the plain and enhanced versions of broccoli (OR = 0.79; CI = 0.49-1.25; $p = 0.31$) or corn (OR = 0.99; CI = 0.54-1.79; $p = 0.96$). Both versions of broccoli and corn were well-liked, as indicated by ≥76% of the children rating them as "yummy" or "just okay" (Table 4). The children's liking ratings for the versions of broccoli and corn did not influence the effects of portion size on intake of vegetables ($F_{(2,191)} = 0.44$; $p = 0.65$). Similarly, the liking ratings for the vegetables did not influence the effect of flavor enhancement ($F_{(2,150)} = 0.45$; $p = 0.64$) on vegetable intake.

Although children rated the vegetables as well-liked, when they ranked their liking of all the foods served at the meal, they gave higher rankings to the other meal components (Table 4). Logistic regression analysis of the ranking for all seven foods indicated that the children ranked their liking higher for fish sticks (OR = 8.79; CI = 3.76 - 20.56; $p < 0.0001$) and applesauce (OR = 11.50; CI = 4.70 - 28.15; $p < 0.0001$) than for the highest-ranked vegetable (enhanced corn). In addition, there was no difference in the distribution of liking rankings between the highest-ranked and the lowest-ranked vegetable (OR = 0.48; CI = 0.22 - 1.04; $p = 0.062$).

3.5. Influence of subject characteristics

Analysis of covariance indicated that the effects of portion size and flavor enhancement on vegetable intake were not influenced by the child characteristics of sex, age, race, ethnicity, BMI z-score, or age- and sex-specific BMI percentile (all $p>0.10$). In addition, parental characteristics (reported BMI, income, education, and employment status) did not influence the relationship between the experimental factors and vegetable intake (all $p>0.10$). Children's familiarity with the four versions of the vegetables, as assessed by parental report of the frequency of preparation methods at home, did not influence the effects of portion size ($F_{(2,159)} = 1.56$; $p = 0.21$) and flavor enhancement ($F_{(2,140)} = 1.95$; $p = 0.15$) on intake of vegetables.

In contrast, two measures of children's eating behavior and parental practices did influence vegetable intake in response to increased portion size. Parental ratings of food fussiness from the CEBQ affected the relationship between portion size and vegetable intake (Figure 3). When the portion was doubled, children who were rated higher in food fussiness had

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smaller increases in vegetable intake than children who were rated lower in fussiness ($F_{(1,79)}$ = 4.77; p = 0.03). For example, children with higher food fussiness (a mean score of 4 on the 5-point scale) increased vegetable intake by 11 ± 5 g ($t_{(78)}$ = −2.31; p = 0.023) when the portion was doubled, whereas children with lower food fussiness (a mean score of 2) had a larger increase of 28 ± 5 g ($t_{(78)}$) = −6.02; p < 0.0001). Results were similar for the ratings of food fussiness made by the children's teachers ($F_{(1,84)}$) = 7.12; p = 0.009). Additionally, ratings of parental use of pressure to eat from the CFQ influenced vegetable intake in response to increased portion size of vegetables. When a larger portion was served, children whose parents reported providing greater pressure to eat had smaller increases in vegetable intake than children whose parents provided less pressure ($F_{(1,80)}$ = 9.45; p = 0.003). For example, when the portion size of vegetables was doubled, children with higher parental pressure to eat (a mean score of 4 on the 5-point scale) had no significant change in intake (7 ± 5 g; $t_{(79)}$ = −1.41; p = 0.16), but children with lower parental pressure to eat (a mean score of 2) increased intake by 26 ± 3 g ($t_{(80)}$ = −7.62; p < 0.0001).

4. Discussion

The current study showed that serving a larger portion of vegetables at a meal promoted vegetable intake in preschool children. Doubling the portion of vegetables increased total vegetable intake by 68% or 21 g and the increase was seen for both broccoli and corn. This increase corresponds to approximately one-third of a serving, which is 12% of the recommended daily intake for this age group (U.S. Department of Agriculture, 2011). Enhancing the flavor of vegetables with a small amount of butter and salt, however, did not significantly influence their intake nor the effect of portion size on intake. This is likely explained by the similar ratings of liking and preference for the plain and enhanced versions of each vegetable. Thus, increasing the portion size of vegetables at a meal was an effective strategy to increase vegetable intake in preschool children. In contrast, adding a small amount of butter and salt as a specific strategy to improve palatability did not increase ratings of liking and was not needed to encourage consumption of a larger portion in children who were familiar with these vegetables.

Although serving larger portions consistently increases children's intake of most food groups (Fisher et al., 2007; Smethers et al., 2019), the effects of portion size on vegetable intake have been variable (Kral et al., 2010; Spill et al., 2010). Previous studies found that when the portion size of vegetables was increased along with other competing foods, children had greater consumption of all foods except vegetables (Kling et al., 2016; Smethers et al., 2019). To limit the influence of competing foods, and in line with MyPlate recommendations (U.S. Department of Agriculture, 2011), we served a larger portion of vegetables without changing the portions of other meal components, which resulted in a substantial increase in vegetable intake (21 g; 68%). Two previous studies in young children similarly tested the effect of increasing the portion size of vegetables at a meal; in the study that served plain vegetables (Kral et al., 2010), portion size did not increase intake, but in the study that served buttered vegetables (Mathias et al., 2012), portion size did increase intake (12 g; 37%). It is possible that the variability in these results was attributable to improved palatability of the buttered vegetables (Mathias et al., 2012), but the addition of butter did not affect the liking or preference for the vegetables served in the current study. These

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findings highlight that the effect of portion size on vegetable intake is likely to depend on the types and amounts of vegetables served as well as on individual differences in the relative palatability of meal components (Roe et al., 2016; Zlatevska et al., 2014; Zuraikat et al., 2019).

The present study indicates that flavor enhancement was not necessary to increase consumption of familiar vegetables. Conversely, previous studies have found that flavor enhancement can increase vegetable intake in toddlers (Bouhlal et al., 2011) and school-age children (Bouhlal et al., 2013). There are a number of possible explanations for differences in the effect of flavor enhancement on vegetable intake. The amounts of specific flavorings have differed considerably across studies. For example, a previous study varied the levels of salt added to green beans and found a dose-response effect on children's vegetable intake such that levels from 0 to 0.6% increased vegetable intake, whereas higher levels (0.6% to 1.2%) decreased intake (Bouhlal et al., 2013). In the present study, we added an amount of salt (0.5%) that was within the range that increased vegetable intake in the previous study, but we found no change in liking ratings for the enhanced vegetables nor any increase in vegetable intake. It is possible that since both vegetables were already well-liked by the children, there may have been little room for improvement in palatability. Furthermore, we added an amount of butter (6.6%) that was slightly higher than the highest amount (5%) used in the previous study in toddlers (Bouhlal et al., 2011), but neither study found an effect of added butter on vegetable intake. It may be that an even higher amount of butter is required to substantially change intake, although dietary guidelines recommend consuming vegetables that are limited in added butter and salt (U.S. Department of Health and Human Services and U.S. Department of Agriculture, 2015). In line with recommendations, the current findings suggest that adding butter and salt is not necessary to promote children's intake of familiar well-liked vegetables.

Serving a larger portion of vegetables can have variable effects on meal energy intake, likely related to the relative palatability of the other meal components or the energy density of the vegetables. For example, in a previous study, an increase in vegetable consumption from doubling the portion of vegetables at a meal did not influence children's energy intake because of a compensatory decrease in intake of the main dish (Mathias et al., 2012). In contrast, the current study found a 5% (13 kcal) increase in energy intake when the vegetable portion size was doubled, which was at least partly due to the lack of change in consumption of other, better-liked, meal components. In addition, we served corn as one of the vegetables, which has a higher energy density (1.3 kcal/g) than the buttered broccoli (0.6 kcal/g) used in the previous study (Mathias et al., 2012). Thus, in the current study, the increased intake of a vegetable that is comparatively higher in energy density (Rolls et al., 2010), combined with the lack of a compensatory decrease in intake of other meal components, led to a small increase in meal energy intake. Although adding vegetables to a meal can lead to a substantial increase in vegetable intake, when excess energy intake is a concern, substituting larger portions of vegetables for competing foods would be a better strategy (Rolls et al., 2010).

Studies aimed at promoting children's vegetable intake have found that individual differences such as liking of vegetables influence the response. For example, in one study

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that served vegetables with the meal, the effect of increased portion size on vegetable intake was only found in children who rated the vegetable as “yummy” (Mathias et al., 2012). In another study that served raw carrots as a first course of a meal, the children’s liking ratings did not influence the effect of larger portions on vegetable intake (Spill et al., 2010); this finding was consistent with the current study. This discrepancy may be due to differences between populations in the children’s familiarity and liking of vegetables, or to imprecision in the method for assessing liking. Although we did not find effects of children’s liking ratings, we did find effects of parental scores for the children’s eating behaviors. Children with higher scores for overall food fussiness had smaller increases in vegetable intake when the portion was doubled and smaller intakes overall, which is in line with previous findings that fussier children consume fewer vegetables (Gibson & Cooke, 2017). Another characteristic associated with the effectiveness of increasing vegetable portion size was parental pressure to eat; children with higher scores had little or no increase in vegetable intake when the larger portion was served. This is consistent with previous findings that parental pressure to eat specific foods is associated with an unfavorable effect on target food intake (Galloway et al., 2005; Johnson, 2016). These results suggest that promoting vegetable intake of children who are fussier eaters or have higher parental pressure can be more challenging and may require additional effort or targeted interventions.

A strength of this study is the ecological validity of the design, in that children were served the meals in their own classrooms at their regularly scheduled lunchtime. In addition, the meal included foods commonly served to children in the school setting. However, the intake assessment included only a single meal, and thus tested a limited range of foods. There was little diversity among the children with respect to race and ethnicity; additionally, the parent’s high level of education and above-average incomes likely influenced vegetable familiarity, liking, and intake. Because low-income populations have less access to vegetables as well as lower consumption (Di Noia & Byrd-Bredbenner, 2014), a more diverse sample of children is needed to generalize these results to a broader population. Although the study used a validated approach to assess young children’s food liking (Birch, 1979), this method may not have been sensitive enough to determine whether the flavor enhancement of the vegetables was distinguishable to the children. Finally, besides substantially increasing vegetable intake, serving a larger portion led to a greater amount of uneaten vegetables, which in some settings may be unacceptable for economic or environmental reasons (Cohen et al., 2013). Vegetables were not the only food left uneaten; children also did not consume one-third of the other meal components. An effective strategy for reducing food waste can be substituting extra vegetables for other meal components (Rolls et al., 2010), rather than adding them to the meal as in the present study.

This is the first study to test whether increasing the portion size of vegetables, enhancing their flavor to improve palatability, or combining these strategies increases vegetable intake in preschool children. While serving a larger portion of vegetables significantly increased their intake, adding typical flavor enhancers such as butter and salt was not necessary to increase intake of familiar, well-liked vegetables. Future studies should investigate other approaches to making vegetables more palatable to children, such as serving them with herbs and spices (Fritts et al., 2018) or varying the method of preparation (Poelman et al., 2013). It is likely that the effectiveness of promoting vegetable intake by serving larger

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portions depends on the children's liking for the vegetables. In conclusion, these results support MyPlate advice (U.S. Department of Agriculture, 2011) to increase the proportion of vegetables served at meals, which is a strategy that can be implemented in homes, restaurants, and childcare settings to bring children's vegetable intake closer to recommended amounts.

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The authors' responsibilities were as follows — HED: design of the experiment, collection and analysis of data, and writing of the manuscript; LSR: design of the experiment, analysis of data, and writing of the manuscript; KLK: design of the experiment; CES: design of the experiment, collection of data; BJR: design of the experiment and writing of the manuscript. All authors read and approved the final manuscript.

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References

Ahern SM, Caton SJ, Bouhlal S, Hausner H, Olsen A, Nicklaus S, Møller P, & Hetherington MM (2013). Eating a rainbow. Introducing vegetables in the first years of life in 3 European countries. Appetite, 71, 48–56. 10.1016/j.appet.2013.07.005 [PubMed: 23891674]

Baranowski T, Domel S, Gould R, Baranowski J, Leonard S, Treiber F, & Mullis R (1993). Increasing fruit and vegetable consumption among 4th and 5th grade students: results from focus groups using reciprocal determinism. Journal of Nutrition Education, 25(3), 114–120. 10.1016/S0022-3182(12)80567-X

Birch LL (1979). Dimensions of preschool children's food preferences. Journal of Nutrition Education, 11(2), 77–80. 10.1016/S0022-3182(79)80089-8

Birch LL (1999). Development of Food Preferences. Annual Review of Nutrition, 19(1), 41–62. 10.1146/annurev.nutr.19.1.41

Birch LL, Fisher JO, Grimm-Thomas K, Markey CN, Sawyer R, & Johnson SL (2001). Confirmatory factor analysis of the Child Feeding Questionnaire: a measure of parental attitudes, beliefs and practices about child feeding and obesity proneness. Appetite, 36(3), 201–210. 10.1006/appe.2001.0398 [PubMed: 11358344]

Bouhlal S, Chabanet C, Issanchou S, & Nicklaus S (2013). Salt Content Impacts Food Preferences and Intake among Children. PLOS ONE, 8(1), e53971. 10.1371/journal.pone.0053971 [PubMed: 23342052]

Bouhlal S, Issanchou S, & Nicklaus S (2011). The impact of salt, fat and sugar levels on toddler food intake. British Journal of Nutrition, 105(4), 645–653. 10.1017/S0007114510003752

Caporale G, Policastro S, Tuorila H, & Monteleone E (2009). Hedonic ratings and consumption of school lunch among preschool children. Food Quality and Preference, 20(7), 482–489. 10.1016/i.foodaual.2009.04.008

Cohen JFW, Richardson S, Austin SB, Economos CD, & Rimm EB (2013). School lunch waste among middle school students: Nutrients consumed and costs. American Journal of Preventive Medicine, 44(2), 114–121. 10.1016/i.amepre.2012.09.060 [PubMed: 23332326]

Di Noia J, & Byrd-Bredbenner C (2014). Determinants of fruit and vegetable intake in low-income children and adolescents. Nutrition Reviews, 72(9), 575–590. 10.1111/nure.12126 [PubMed: 25091630]

Fisher JO, Liu Y, Birch LL, & Rolls BJ (2007). Effects of portion size and energy density on young children's intake at a meal. The American Journal of Clinical Nutrition, 86(1), 174–179. 10.1093/ajcn/86.1.174 [PubMed: 17616778]

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Fritts JR, Fort C, Quinn Corr A, Liang Q, Alla L, Cravener T, Hayes JE, Rolls BJ, D'Adamo C, & Keller KL (2018). Herbs and spices increase liking and preference for vegetables among rural high school students. Food Quality and Preference, 68, 125–134. 10.1016/i.foodqual.2018.02.013

Galloway AT, Fiorito L, Lee Y, & Birch LL (2005). Parental pressure, dietary patterns, and weight status among girls who are "picky eaters." Journal of the American Dietetic Association, 105(4), 541–548. 10.1016/i.iada.2005.01.029 [PubMed: 15800554]

Gibson EL, & Cooke L (2017). Understanding Food Fussiness and Its Implications for Food Choice, Health, Weight and Interventions in Young Children: The Impact of Professor Jane Wardle. Current Obesity Reports, 6(1), 46–56. 10.1007/s13679-017-0248-9 [PubMed: 28205158]

Johnson SL (2016). Developmental and Environmental Influences on Young Children's Vegetable Preferences and Consumption. Advances in Nutrition, 7(1), 220S–231S. 10.3945/an.115.008706 [PubMed: 26773030]

Kling SMR, Roe LS, Keller KL, & Rolls BJ (2016). Double trouble: Portion size and energy density combine to increase preschool children's lunch intake. Physiology & Behavior, 162, 18–26. 10.1016/i.phvsbeh.2016.02.019 [PubMed: 26879105]

Kral TVE, Kabay AC, Roe LS, & Rolls BJ (2010). Effects of Doubling the Portion Size of Fruit and Vegetable Side Dishes on Children's Intake at a Meal. Obesity, 18(3), 521–527. 10.1038/obv.2009.243 [PubMed: 19680238]

Mathias KC, Rolls BJ, Birch LL, Kral TVE, Hanna EL, Davey A, & Fisher JO (2012). Serving Larger Portions of Fruits and Vegetables Together at Dinner Promotes Intake of Both Foods among Young Children. Journal of the Academy of Nutrition and Dietetics, 112(2), 266–270. 10.1016/i.iada.2011.08.040 [PubMed: 22741168]

Nicklaus S, Boggio V, & Issanchou S (2005). Food choices at lunch during the third year of life: high selection of animal and starchy foods but avoidance of vegetables. Acta Paediatrica, 94(7), 943–951. 10.1111/i.1651-2227.2005.tb02015.x [PubMed: 16188819]

Poelman AAM, Delahunty CM, & de Graaf C (2013). Cooking time but not cooking method affects children's acceptance of Brassica vegetables. Food Quality and Preference, 28(2), 441–448. 10.1016/i.foodqual.2012.12.003

Poelman AAM, Delahunty CM, & de Graaf C (2015). Vegetable preparation practices for 5–6 years old Australian children as reported by their parents; relationships with liking and consumption. Food Quality and Preference, 42, 20–26. 10.1016/i.foodqual.2015.01.005

Ramsay SA, Eskelsen AK, Branen LJ, Armstrong Shultz J, & Plumb J (2014). Nutrient Intake and Consumption of Fruit and Vegetables in Young Children. ICAN: Infant, Child, & Adolescent Nutrition, 6(6), 332–344. 10.1177/1941406414549622

Roe LS, Kling SMR, & Rolls BJ (2016). What is eaten when all of the foods at a meal are served in large portions? Appetite, 99, 1–9. 10.1016/i.appet.2016.01.001 [PubMed: 26767612]

Rolls BJ (2018). The role of portion size, energy density, and variety in obesity and weight management. In Handbook of Obesity Treatment, 2nd ed. (pp. 93–104). New York, NY: The Guilford Press.

Rolls BJ, Roe LS, & Meengs JS (2007). The Effect of Large Portion Sizes on Energy Intake Is Sustained for 11 Days. Obesity, 15(6), 1535–1543. 10.1038/oby.2007.182 [PubMed: 17557991]

Rolls BJ, Roe LS, & Meengs JS (2010). Portion size can be used strategically to increase vegetable consumption in adults. The American Journal of Clinical Nutrition, 91(4), 913–922. 10.3945/aicn.2009.28801 [PubMed: 20147467]

Sanchez CE, Roe LS, Keller KL, Smethers AD, Meehan CT, & Rolls BJ (2019). Does serving a larger proportion of vegetables and fruit influence children's intake over 5 days? Poster Presented at Obesity Week.

Savage JS, Peterson J, Marini M, Bordi PL, & Birch LL (2013). The Addition of a Plain or Herb-Flavored Reduced-Fat Dip Is Associated with Improved Preschoolers' Intake of Vegetables. Journal of the Academy of Nutrition and Dietetics, 113(8), 1090–1095. 10.1016/j.jand [PubMed: 23701754]

Smethers AD, Roe LS, Sanchez CE, Zuraikat FM, Keller KL, Kling SMR, & Rolls BJ (2019). Portion size has sustained effects over 5 days in preschool children: a randomized trial. The American Journal of Clinical Nutrition, 109(5), 1361–1372. 10.1093/ajcn/nqy383 [PubMed: 30976782]

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Spill MK, Birch LL, Roe LS, & Rolls BJ (2010). Eating vegetables first: the use of portion size to increase vegetable intake in preschool children. The American Journal of Clinical Nutrition, 91(5), 1237–1243. 10.3945/aicn.2009.29139 [PubMed: 20219955]

U.S. Department of Health and Human Services and U.S. Department of Agriculture. (2015). 2015 – 2020 Dietary Guidelines for Americans. 8th Edition. Retrieved September 16, 2020, from https://health.gov/our-work/food-and-nutrition/2015-2020-dietary-guidelines/.

U.S. Department of Health and Human Services, Centers for Disease Control and Prevention. (2016). SAS Program (ages 0 to < 20 years). Retrieved September 16, 2020, from https://www.cdc.gov/nccdphp/dnpao/growthcharts/resources/sas.htm

U.S. Department of Agriculture. (2011). ChooseMyPlate.Gov. All about the Vegetable Group. Retrieved September 16, 2020, from https://www.choosemyplate.gov/eathealthy/vegetables

U.S. Department of Agriculture, Agricultural Research Service, FoodData Central. (2019). FoodData Central. Retrieved September 16, 2020, from https://ndb.nal.usda.gov/ndb/

U.S. Department of Agriculture, Food and Nutrition Services. (2017). Nutrition Standards for CACFP Meals and Snacks | USDA-FNS. Retrieved September 16, 2020, from https://www.fns.usda.gov/cacfp/meals-and-snacks

Wardle J, Guthrie CA, Sanderson S, & Rapoport L (2001). Development of the Children's Eating Behaviour Questionnaire. Journal of Child Psychology and Psychiatry, 42(7), 963–970. 10.1111/1469-7610.00792 [PubMed: 11693591]

Warkentin S, Mais LA, Ranganath K, Jansen E, & Carnell S (2020). Controlling and less controlling feeding practices are differentially associated with child food intake and appetitive behaviors assessed in a school environment. Pediatric Obesity, Special Issue, e12714. 10.1111/ijpo.12714

Zlatevska N, Dubelaar C, & Holden SS (2014). Sizing up the Effect of Portion Size on Consumption: A Meta-Analytic Review: Journal of Marketing. 10.1509/jm.12.0303

Zuraikat FM, Smethers AD, & Rolls BJ (2019). Potential moderators of the portion size effect. Physiology & Behavior, 204, 191–198. 10.1016/i.phvsbeh.2019.02.043 [PubMed: 30831182]

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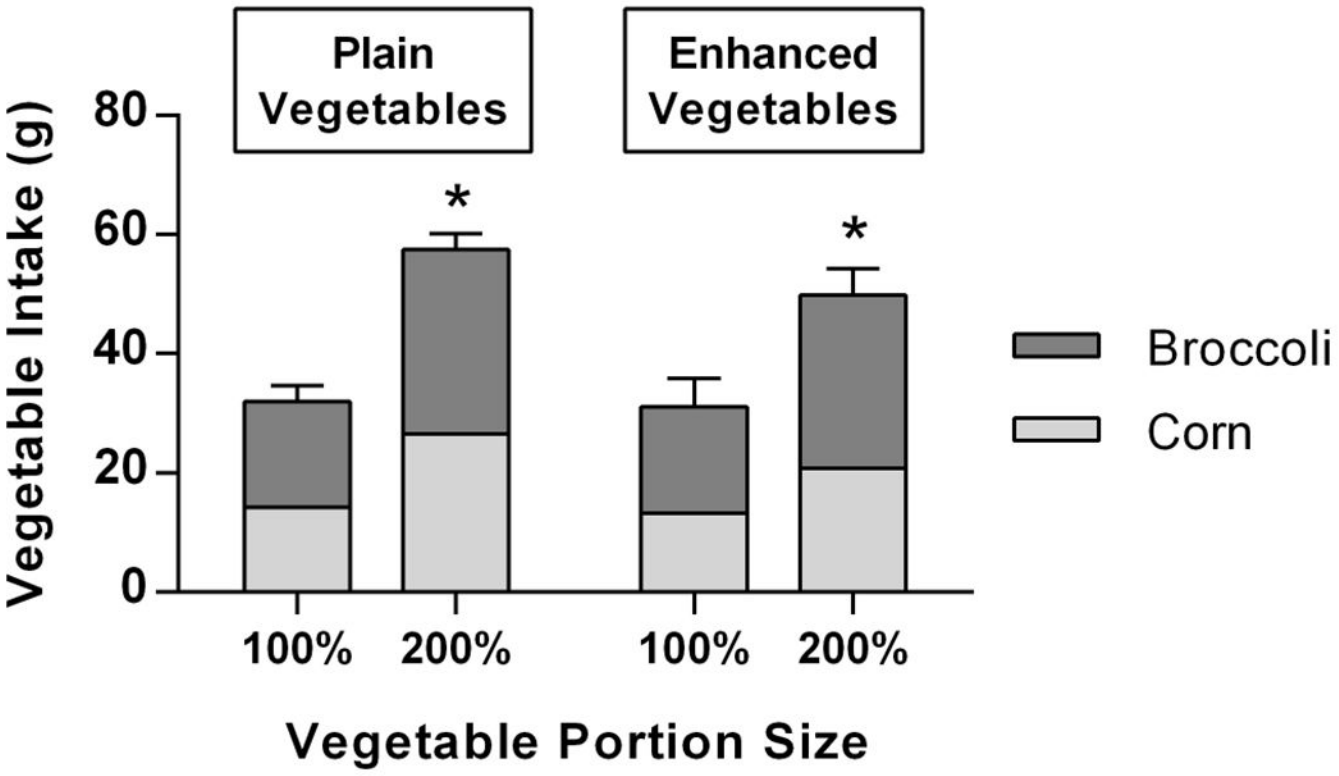

Figure 1.

Mean (±SEM) vegetable intake (g) consumed at lunch by 67 preschool children. Across four meals, vegetables were served at two levels of portion size (100% [30 g of each vegetable] or 200% [60 g of each vegetable]) and two levels of flavor enhancement (plain or enhanced by adding butter and salt). *Mean vegetable intake in the 200% portion size conditions was significantly greater than mean intake in the 100% portion size conditions ($p < 0.0001$). Enhancing the flavor of vegetables did not influence vegetable intake ($p = 0.13$) nor modify the effect of serving a larger portion on vegetable intake (interaction $p = 0.10$).

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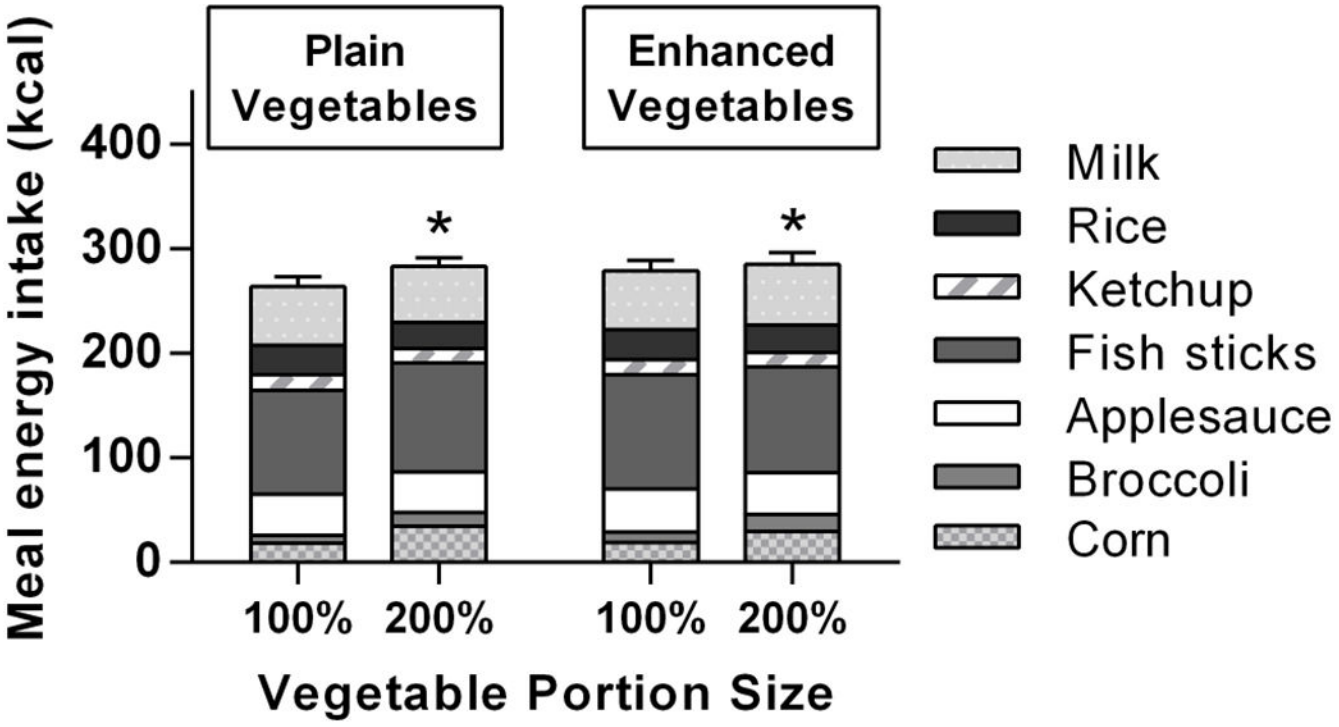

Figure 2.

Mean (±SEM) energy intake (kcal) consumed at lunch by 67 preschool children. Across four meals, vegetables were served at two levels of portion size (100% [30 g of each vegetable] or 200% [60 g of each vegetable]) and two levels of flavor enhancement (plain or enhanced by adding butter and salt). * Mean energy intake in the 200% portion size conditions was significantly greater than mean energy intake in the 100% portion size conditions ($p = 0.02$). Enhancing the flavor of vegetables did not influence meal energy intake ($p = 0.10$).

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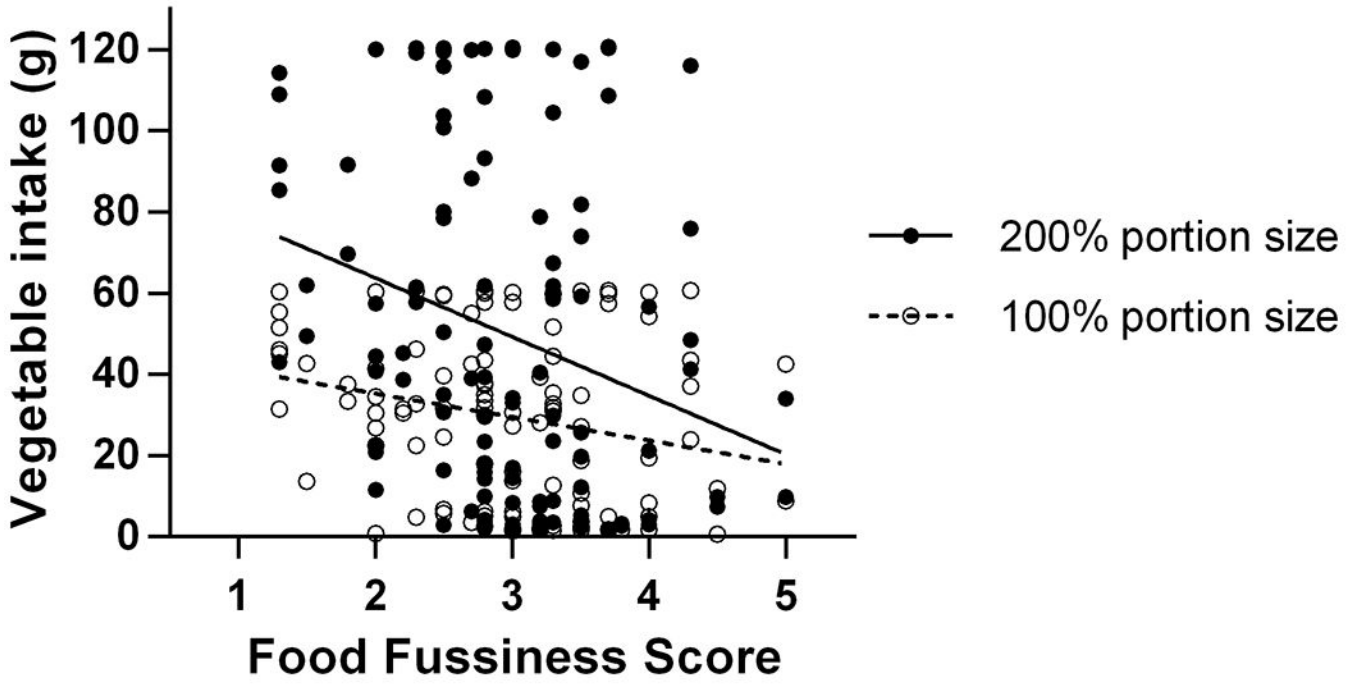

Figure 3.

Influence of parental scores for Food Fussiness on the relation between portion size and vegetable intake in 67 preschool children. Across four meals, vegetables were served at two levels of portion size (100% [30 g of each vegetable] or 200% [60 g of each vegetable]) and two levels of flavor enhancement (plain or enhanced by adding butter and salt). Results from analysis of covariance showed that the slope of the regression line for the 200% portions was significantly steeper than the slope for the 100% portions (adjusted $p = 0.03$). Thus, children who were rated higher in food fussiness had smaller increases in vegetable intake when the portion was doubled. The Food Fussiness scale is from the Children's Eating Behaviour Questionnaire (Wardle et al., 2001).

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Table 1

Amounts served at meals in the baseline (100%) portion conditions

Item	Amount served (g)	Energy content (kcal)		Energy density (kcal/g)	
	Plain or enhanced vegetables	Plain vegetables	Enhanced vegetables[1]	Plain vegetables	Enhanced vegetables[1]
Broccoli[2]	30 [3]	13	17	0.42	0.58
Corn[4]	30 [3]	38	43	1.26	1.42
Fish sticks[5]	45	117	117	2.60	2.60
Rice[6]	45	65	65	1.45	1.45
Applesauce[7]	62	53	53	0.86	0.86
Ketchup[8]	20	24	24	1.18	1.18
Milk, 1% fat[9]	184	77	77	0.42	0.42
Total meal[10]	416	386	396	0.93	0.95

[1]The enhanced vegetables had 6.6% light butter and 0.5% salt added by weight. The light butter was Country Crock Brand (Upfield, Inc., New Century, Kansas, USA) containing 28% fat by weight.

[2]Fresh broccoli florets (Wegmans Food Markets, Inc., Rochester, New York, USA)

[3]The amount of each vegetable served in the 200% portion conditions was 60 g

[4]Bountiful Harvest frozen whole kernel cut corn (Seneca Foods Corp., Janesville, Wisconsin, USA)

[5]Hidden Bay frozen fish sticks (Reinhart Foodservice LLC, Chicago, Illinois, USA)

[6]Uncle Ben's Whole Grain Rice (Mars, Inc., McLean, Virginia, USA)

[7]Mott's Applesauce Original (Mott's LLP, Plano, Texas, USA)

[8]Heinz Tomato Ketchup (Kraft-Heinz, Inc. Pittsburgh, Pennsylvania, USA)

[9]Giant Food Stores Milk (Foodhold U.S.A. LLC, Landover, Maryland, USA)

[10]Corresponding values for the total meal in the 200% portion conditions (with plain and enhanced vegetables, respectively) were: 476 g served; 437 and 457 kcal served; 0.92 and 0.96 kcal/g served

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Table 2

Characteristics of the 67 preschool children participating in the study

Characteristic	Boys (N=26)		Girls (N=41)		Significance of difference[1] (P-value)
	Mean ± SD	Range	Mean ± SD	Range	
Age (y)	4.3 ± 0.6	3.2 – 5.6	4.1 ± 0.7	3.2 – 5.5	0.33
Weight (kg)	17.5 ± 2.4	12.2 – 24.1	16.5 ± 1.9	13.0 – 22.8	0.20
Height (cm)	104.9 ± 5.7	90.1 – 115.0	102.6 ± 6.5	91.9 – 121.3	0.49
Sex-specific BMI-for-age percentile[2]	51.9 ± 29.3	8.3 – 99.8	55.0 ± 25.9	1.7 – 97.0	0.49
BMI z-score[2]	0.1 ± 1.0	−1.4 – 2.9	0.1 ± 0.8	−2.1 – 1.9	0.28
Food fussiness score[3] by parent Food fussiness	3.1 ± 0.6	1.8 – 4.3	2.9 ± 0.8	1.3 – 5.0	0.15
Food fussiness score[3] by teacher	3.0 ± 0.7	1.8 – 4.5	2.8 ± 0.7	1.8 – 4.5	0.70
Pressure to eat score[4] by parent	2.6 ± 0.9	1.0 – 4.0	2.6 ± 1.0	1.2 – 4.8	0.84

[1] Differences between means of boys and girls were assessed by t-tests

[2] BMI measures were calculated from sex, height, weight, and age (U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, 2016).

[3] Score from the Children's Eating Behaviour Questionnaire (Wardle et al., 2001) completed by 66 parents

[4] Score from the Child Feeding Questionnaire (Birch et al., 2001) completed by 66 parents

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Table 3

Food and energy intakes[1] of 67 preschool children at the experimental meals

Outcome	Plain vegetables		Enhanced vegetables		Significance (P-value)[2]	
	100% portion size	200% portion size	100% portion size	200% portion size	portion size	Flavor enhancement
Food intake (g)						
Broccoli	18 ± 2	31 ± 3	18 ± 2	29 ± 3	<0.0001	0.69
Corn	14 ± 2	27 ± 3	13 ± 1	21 ± 2	<0.0001	0.036
Other foods[3]	116 ± 5	115 ± 5	122 ± 4	115 ± 5	0.10	0.22
Milk	135 ± 7	129 ± 9	134 ± 8	140 ± 8	0.92	0.32
Total meal	283 ± 10	302 ± 12	287 ± 10	305 ± 12	0.007	0.55
Energy intake (kcal)						
Broccoli	8 ± 1	13 ± 2	10 ± 1	16 ± 2	<0.0001	0.0002
Corn	18 ± 2	35 ± 3	19 ± 2	30 ± 3	<0.0001	0.25
Other foods[3]	181 ± 7	182 ± 7	193 ± 6	181 ± 7	0.10	0.18
Milk	56 ± 3	54 ± 4	56 ± 3	59 ± 4	0.92	0.32
Total meal	262 ± 10	282 ± 10	277 ± 8	284 ± 11	0.018	0.10
Energy density (kcal/g)						
Food only	1.41 ± 0.03	1.35 ± 0.03	1.48 ± 0.03	1.40 ± 0.03	<0.0001	0.0013
Total meal	0.97 ± 0.03	0.97 ± 0.03	1.01 ± 0.03	0.97 ± 0.03	0.17	0.23

[1] All values are means ± SEM

[2] Linear mixed models with repeated measures were used to test the effects of serving a larger portion size and enhancing the flavor of vegetables on all outcomes

[3] Includes fish sticks, rice, applesauce, and ketchup

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Table 4

Liking ratings and rankings of meal components[1]

	Liking rating (% of children)			Liking ranking (% of children)						
	Yummy	**Just okay**	**Yucky**	**1 (most liked)**	**2**	**3**	**4**	**5**	**6**	**7 (least liked)**
Broccoli, plain	60	22	18	3	10	2	23	13	20	29
Broccoli, enhanced	56	20	24	3	2	8	15	30	37	5
Corn, plain	68	14	18	3	7	13	20	26	11	20
Corn, enhanced	67	19	14	6	5	25	21	8	15	20
Fish sticks	81	11	8	37	27	15	5	5	3	8
Rice	70	10	20	8	13	33	8	12	10	16
Applesauce	88	9	3	39	37	5	8	6	3	2

[1]Milk and ketchup were also served at the meal, but were not included in the liking rating and ranking assessments

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