Increasing portion sizes of fruits and vegetables in an elementary school lunch program can increase fruit and vegetable consumption

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Abstract

Children in the United States are not eating enough fruits and vegetables, but the school environment via the National School Lunch Program can be used as a conduit to increase consumption of these items. Our study focused on increasing portion sizes of fruit and vegetable side dishes because increasing portion size is one of the few methods that has been shown to increase consumption among children. This was accomplished using two similar menus, with a control and two experimental days for each type of menu. Children generally did not take a vegetable serving, 16% at best (for carrots). The proportion of students taking a fruit serving was highest at 54% for students taking oranges. For students taking fruits and vegetables, average consumption for all fruits and vegetables combined was increased by 17 grams during experimental days when comparing the combined control versus the combined experimental days. Children always ate significantly more fruit during the experimental days when compared to control days; this was not always true for vegetables. Our study implies that an increase in portion size can be used in a school setting to increase consumption of fruit. It can also be used to increase vegetable consumption, but vegetable consumption during our experimental days was not always significantly higher than the vegetable consumption on control days. Increasing portion size will likely only be worth the additional cost for nutrient vegetables or fruits as they contribute a more substantial amount of micronutrients.

Table of Contents

Table of Tables

List of Figures

CHAPTER 1: INTRODUCTION

Introduction: fruits, vegetables, benefits, implications

The United States (U.S.) Department of Agriculture's (USDA) food recommendation model, MyPlate, emphasizes the value of fruits and vegetables by illustrating a plate with half of it portioned for fruits and vegetables. However, fruit and vegetable consumption among U.S. children and adults is below recommended levels (Jones, Steer, Rogers, & Emmett, 2010; Lorson, Melgar-Quinonez, & Taylor, 2000; Foltz, et al., 2011; Guenther, Dodd, Reedy, & Krebs-Smith, 2006; Fox, Pac, Devaney, & Jankowski, 2004). Between 1999 and 2000, only 2/5 of people in the U.S. achieved USDA's daily recommendations for intake of fruits and vegetables (Guenther et al., 2006). Fruit and vegetable consumption was also low in the years 2003 and 2004 as shown by a study published by Kimmons, Gillespie, Seymour, Serdula, & Blanck (2009). Kimmons et al. (2009) showed that "only 0.9% of adolescents, 2.2% of adult men, and 3.5% of adult women" ate adequate amounts of fruits and vegetables per day according to MyPyramid guidelines. Only about 37% of children aged 4-8 consumed an adequate amount of fruits and approximately 8% had consumed sufficient vegetables to meet daily recommendations (Krebs-Smith, Guenther, Subar, Kirkpatrick, & Dodd, 2010). It will be important to improve these figures in children for the future as there are several health benefits associated with eating fruits and vegetables (Marmot et al., 2007; He, Nowson, Lucas, & MacGregor, 2007; He, Nowson, & MacGregor, 2006; Montonen et al., 2005; Rolls, Ello-

Martin, & Tohill, 2004a). It is also important because dietary habits developed in childhood persist and as such can affect lifelong health (Forestell & Mennella, 2007; Sullivan & Birch, 1994; Wardle et al., 2003a; Wardle, Herrera, Cooke, & Gibson, 2003b; Timperio et al., 2008).

CHAPTER 2: LITERATURE REVIEW

A review of the literature

2.1 Relationship between fruit and vegetable consumption and health

Consumption data for fruits and vegetables are disappointing as studies have shown that consuming a diet plentiful in fruits and vegetables is beneficial to health. These benefits include reductions in relative risk for coronary artery disease (Knekt et al., 1994; Gillman et al., 1995; Gaziano et al., 1995; Joshipura et al., 1999; Joshipura et al., 2001; Liu et al., 2000a; Liu et al., 2000b; Bazzano et al., 2002; He, Nowson, Lucas, & MacGregor, 2007), stroke (He, Nowson, & MacGregor, 2006), and cancer (Riboli & Norat 2003; Marmot et al., 2007). Inclusion of fruits and vegetables in the diet also show favorable effects on weight status (Ludwig et al., 1999; Howarth, Saltzman, & Roberts, 2001; Rolls et al., 2004a; Fisher, Liu, Birch & Rolls, 2007b). Since coronary artery disease, stroke and cancer are in the top four causes of death in America—the call for an increase in vegetable and fruit consumption is much overdue (Kochanek, Jiaquan, Murphy, Miniño, & Hsiang-Ching, 2011).

2.1.1 Obesity

According to the Centers for Disease Control (CDC) obesity can be defined in adults as a body mass index (BMI) of ≥ 30 (CDC, 2010) and as “BMI at or above the 95th percentile for children of the same age and sex” (CDC, 2011). Obesity is an unhealthy state associated with several maladies; its incidence rate in the United States is staggering, with no state having less than 20% prevalence in

2010 (CDC, 2012b). However, diet (including inclusion of fruits and vegetables) may be part of the solution (CDC, 2011). According to a U.S. Department of Health and Human Services report (2005), there many harmful effects associated with overweight/obesity in childhood including: “the risk of developing high cholesterol, hypertension, respiratory ailments, orthopedic problems, depression and type 2 diabetes as a youth.” This report also indicated that the number of overweight adolescents in the U.S. has increased 300% since 1980. Between1999-2002, an estimated 16% of school-aged children were overweight/obese. Moreover, between 2009 and 2010, an estimated 16.9% of children aged 2-19 years were obese (Ogden, Carroll, Kit, & Flegal, 2012). Interestingly, Lorson et al. (2009) showed that only 16.2% of children aged 6-11 years ate the recommended amounts of vegetables advised by MyPyramid guidelines.

Fruits and vegetables are high in fiber, water, and overall are more nutrient dense than energy dense; therefore increasing consumption of these foods would be expected to lead to an overall decrease in obesity (Ludwig et al., 1999; Howarth et al., 2001; Rolls, et al., 2004a; Fisher et al., 2007b). Though it is an obvious point, it needs to be noted that many other factors influence energy balance and the prevalence of overweight/obesity in addition to diet (Alexy, Sichert-Hellert, Kersting, & Schultze-Pawlitschko, 2004; Sugimori et al., 2004). The relationship between fruit and vegetable intakes and weight-related benefits may be due to water having zero calories and fiber’s action in suppressing hunger (Ludwig et al., 1999; Howarth et al., 2001). This early satiety leads to displacement of more calorically-dense foods (Rolls et al., 2004a; Fisher et al., 2007b) and tempering of glycemic load. These fruit and vegetable induced effects lead to altered hormonal concentrations in the body after consumption (decreased incidence of hyperinsulinemia and less insulin resistance) (Livesey, Taylor, Hulshof, & Howlett, 2008; Ebbeling, Leidig, Sinclair, Hangen, & Ludwig, 2003). In a study by Vernarelli, Mitchell, Hartman, & Rolls (2011), the researchers determined energy density of a diet during a 24 hour period and displayed data in terms of age of participants (2-3 years, 4-8 years) and food group category. The results showed that children aged 4-8 years who consumed the lowest energy-dense diets, had significantly lower calorie intakes overall, despite eating nearly double the weight of food in comparison to children who had the highest energy-dense diets. Furthermore, when energy density of the diet was low, fruit and vegetable consumption was likely to be high.

2.2 Eating patterns in youth carry on into adulthood

Eating patterns including the intake of fruits and vegetables stem from intake behaviors established in childhood (Nicklas et al., 1988; Coulhard, Harris & Emmett, 2010; Lake, Mathers, Rugg-Gunn & Adamson, 2006). To hope to achieve the recommended amounts of fruit and vegetable servings per day in adulthood, early consumption patterns need to be developed with many incidences of fruit and vegetable consumption per day (Currie et al., n.d.).

Children begin to learn eating behaviors as early as infancy as shown in the two studies to follow (Sullivan & Birch, 1994; Forestell & Mennella, 2007).

2.2.1 Longitudinal studies: infants

Eating behaviors are sustained over time; several longitudinal studies have been conducted involving children and, on occasion, parents. Sullivan and Birch (1994) tested whether infants aged 4 to 6 months could learn to eat either peas or green beans. These infants were exposed to either peas or green beans 10 times over a 26 day period. The consumption of these two vegetables was measured during each exposure. The results showed that children ate more of these items as time passed, greater than 22 g from first exposure to tenth for both types of vegetables. This could mean that they "learned" to like them, or at least developed an eating pattern for these vegetables.

Forestell and Mennella (2007) also studied eating patterns of infants (participants were 4-8 months) and found similar results to those of Sullivan and Birch (1994). Infants were exposed to green beans for eight consecutive days in which time researchers measured consumption. In just over a week, consumption of green beans, on average, was improved by nearly 30 g (56.8 g to 93.6 g).

2.2.2 Longitudinal studies: young children

There have been at least two studies testing whether children can be influenced to like and incorporate vegetables into their diets based on repeated exposure.

Wardle et al. (2003a) published a report in which children aged 2-6 were given taste tests to determine a least liked vegetable of six options. Once determined, the children and their parents were stratified into 3 groups: control, information and exposure groups. The control group received no treatment. The information group received a pamphlet of information about fruit and vegetable recommendations and strategies for boosting their intake. The exposure group had parents give their children tastes of the least liked vegetable along with encouragement and modeling. Data from these three groups showed that only the exposure group had increases in vegetable consumption. The number of children in the exposure group who voluntarily ate their test vegetable increased from 47% to 77%. Moreover, among children in the experimental group, mean intake values for the test vegetable increased from 4.1 g to 9.0 g—though this isn't a large amount, it is over a 100 percent improvement.

To examine whether children can be influenced to eat more of an unfamiliar vegetable without the assistance of a parent, Wardle and a different group of colleagues conducted another study (Wardle et al., 2003b) in a school environment. Students in three elementary schools were given red pepper during eight daily sessions (taste tests) where they could eat as much as they wanted. As time progressed, the exposure-based intervention increased both liking and consumption of red peppers. Thus, exposure to vegetables over several days in young children can enhance intake and liking of this vegetable.

2.2.3 Longitudinal studies: adolescents

In a longitudinal study published in 1994, middle school students were surveyed annually until they graduated from high school on several topics including smoking habits, physical activity and food preferences (Kelder, Perry, Klepp, & Lytle, 1994). The food preference section asked “[which] food they would usually eat when they had a choice” for 18 food pairs (Kelder et al., 1994). The results suggest that if children selected more healthy options as sixth-graders they were still likely to select more healthy options as twelfth-graders, providing evidence for endurance of food behavior. Though it may seem that children aren’t influenced by others’ consumption as they age (as sixth graders had similar preferences to their future twelfth grade selves) (Kelder et al., 1994), this may not actually be the case. When the focus included parental influence on eating habits, Arcan et al. (2007) followed 509 child/parent pairs over a five year period to investigate if there was an intake trend for fruit, vegetable and dairy items within the pair. The results confirmed that parental intake of fruits, vegetables, and dairy products predicted the consumption of these items five years later in their children. However, this was only true when their children were at the age of young adults, not when their children were still in high school. [However, dietary characteristics can wane from early childhood into the teenage years, so if children are not eating several helpings of vegetables and fruits daily early in life, they will most likely eat less as they grow older (Mannino, Lee, Mitchell, Smiciklas-Wright, & Birch, 2004; Nicklaus, Boggio, Chabanet, & Issanchou, 2004)]. It is important to note that modeling (parental intake) definitely factored into fruit and vegetable intake in this group of adolescents. Thus, children are influenced greatly by their parents, so parents *should* ingrain the benefits of fruits and vegetables early, but when consumption is as low as it is in the United States, it is obvious that this is not occurring in all families.

2.3 Fruit and vegetable intake among children

2.3.1 School--a useful environment for fruit and vegetable consumption improvement

Since the United States government, specifically the United States Department of Agriculture (USDA), offers several feeding programs in the school setting including the Fresh Fruit and Vegetable Program, Seamless Summer Option, National School Lunch Program (NSLP), and School Breakfast Program (USDA, 2012b), it is reasonable that these programs can be used as a starting point to improve fruit and vegetable consumption in childhood. In the 2010 fiscal year, over 31 million students across the United States ate lunches provided by the National School Lunch Program (USDA, 2011a). According to School Nutrition Dietary Assessment Study-IV, "56 percent of students attending schools that offer an NSLP lunch eat the school lunch" (USDA, 2011b). This provides many opportunities for children to eat fruit and vegetables each week.

Efforts to amplify fruit and vegetable intake have included changes in food service procedures, approaches and several environmental methods (Frieden, 2010; Glanz et al., 1995). If any of these methods were put into place more widely, the impact on consumption could be substantial. Robinson-O'Brien, Burgess-Champoux, Haines, Hannan, & Neumark-Sztainer (2010) reported that school-aged children in St. Paul, MN (n=103, mostly low income), ate approximately 15-30% of their total daily fruit and vegetable intake while at school. As mentioned earlier, children eat a significant portion of their daily food intake at school through the National School Lunch Program; therefore, it would be beneficial to understand the factors that influence fruit and vegetable consumption in school-aged youth in general.

2.4 Determinants of fruit and vegetable consumption in children

Many studies have been conducted to identify determinants of fruit and vegetable intakes among children with several factors firmly established as consistently influencing intakes. In a literature review conducted by Rasmussen et al. (2006) ninety eight studies were reviewed and analyzed for predictors of fruit and vegetable consumption in children in different environments. The most influential predictors of fruit and vegetable intake were the child's age, sex, socio-economic status, taste, presence of fruits and vegetables in the home and their ease of access, and finally parental ingestion.

According to Rasmussen et al. (2006), findings regarding factors that influence fruit and vegetable intakes are mixed. When solely examining age/grade effects on fruit and vegetable intake, 10 of 22 papers showed negative associations (as students grew older, they ate less vegetables), 9 of 22 showed no effect and 3 of 22 papers found positive associations (as student grew older, they ate more vegetables). The authors believe that this may be due to different recall methods—the majority of the papers finding negative association (9 of 10) used a food frequency questionnaire while the authors of the no effect group (six out of nine papers) mainly used 24 hour recalls/food records.

Differences in intake attributed to sex seem to be influenced by national origin. In the U.S., only six of eighteen papers reported gender differences with all but one showing higher consumption of fruits and vegetables in girls than in boys. In contrast, nearly all the studies from Europe (fourteen of seventeen) reported differences in the intake of fruits and vegetables due to gender. These data from the European studies also pointed to girls consuming a higher amount of fruits and vegetables in comparison to boys. However, when considering all studies (including those from the United States, Europe and other countries) that explore gender effects on fruit and vegetable consumption, the majority (27 out of 49) point towards girls eating more fruits and vegetables when compared to boys.

In contrast to age and gender, Rasmussen et al. (2006) reported that taste and some environmental factors are more consistently found to affect fruit and vegetable consumption in children. The most consistent of these is taste. In eleven of eleven papers examined, positive associations were determined between taste for fruits and vegetables and their consumption. Socioeconomic characteristics also are fairly consistent predictors. As socioeconomic status decreases, so does fruit and vegetable intake. Rasmussen et al. (2006) stratified these socioeconomic results into three categories--parental education, parental occupation, and family income. Parental education was the most influential aspect of socioeconomic status (eleven of eleven papers) followed by parental occupation (nine of eleven) and then family income (seven of fourteen papers). In terms of accessibility and availability of fruit and vegetables in the home, three of three papers found a positive relationship between these two factors and intake. However, there seems to be some interference in this association by gender usually with girls being more directly influenced by both accessibility and the mere presence of fruits and vegetables in the home.

2.4.1 Strategies to increase fruit and vegetable consumption: approaches that do not rely on taste, gender, age, socioeconomic status, parents or the home environment

The next four sections address separate strategies for increasing fruit and vegetable intake in children and adults--most of which were conducted in a laboratory setting using a variety of foods. These methods include how fruits and vegetables are served to children including portion presented, hiding fruit and vegetables, and the chronological order of food presentation. Increasing portion size (Kral, Kabay, Roe, & Rolls 2010; Leahy, Birch, & Rolls, 2008b; Leahy, Birch,

& Rolls, 2008c; Mathias et al., 2011) (in children)) (Rolls, Roe, & Meengs 2010; Kral, Roe, & Rolls 2002; Chang, Hong, Suh, & Jung, 2010; Bell, Castellanos, Pelkman, Thorwart, & Rolls, 1998) (in adults)), decreasing entrée portion size (Savage, Fisher, Marini, & Birch, 2012 (in children) concealing vegetables (Leahy, Birch, Fisher, & Rolls, 2008a (in children)) (Blatt, Roe, & Rolls, 2011 (in adults)), and serving fruits and vegetables before the main meal (Spill, Birch, Roe, & Rolls, 2011; Spill, Birch, Roe, & Rolls, 2010 (children)) (Rolls, Roe, & Meengs, 2004c) have all been shown to increase fruit and/or vegetable intake.

2.5 Portion size background

Augmenting portion size has been shown to increase consumption in several age groups even in unappetizing foods. Increasing portion size has been shown to increase intake in children (Leahy et al., 2008a; Rolls, Engell, & Birch, 2000; Fisher, 2007; Fisher, Rolls & Birch, 2003; Fisher & Kral, 2008; Fisher et al., 2007b; Fisher, Arreola, Birch & Rolls, 2007a; McConahy, Smiciklas-Wright, Birch, Mitchell & Picciano, 2002; McConahy, Smiciklas-Wright, Mitchell, & Picciano, 2004; Fox, Devaney, Reidy, Razafindrakoto, & Ziegler, 2006). This same phenomena has been shown to affect adults in much the same way (Rolls, Morris, & Roe, 2002; Geier, Rozin, Doros, 2006; Kral 2006, Kral, Roe, & Rolls 2004a; Kral & Rolls, 2004b; Diliberti, Bordi, Conklin, Roe, & Rolls, 2004; Rolls, Roe, Kral, Meengs, & Wall, 2004b; Rolls, Roe, Meengs, & Wall, 2004d; Ello-Martin, Ledikwe, & Rolls, 2005; Rolls, Roe, & Meengs, 2006; Flood, Roe, & Rolls, 2006; Rolls, Roe, & Meengs, 2007; Wansink & Kim, 2005; Wansink, 1996;

Wansink, Painter, & North, 2005; Wansink & Cheney, 2005). The influence of portion size has been shown to even work with less appetizing items such as stale buttered popcorn (Wansink & Kim, 2005). Portion size's influence on intake in youth populations will be explored below.

2.5.1a Portion size effects in children: more than one meal and day

The amount of food offered to a child can play a role in consumption at the time of presentation--portion size seems to be correlated with calorie intake. McConahy et al. (2004) established the average portion sizes of the 10 most popular foods in the United States for children two to five years. Since these data relied on parent recall, they may not be totally accurate measurements of intake. However, results from that investigation indicated that 17% to 19% of variability in calories consumed could be attributed to serving size. Furthermore, in children four to six years, Mrdjenovic and Levitsky (2005) reported a convincing positive correlation ($r=0.77, p<0.001$) between portion size and intake. (The amounts served and the amounts consumed were based on food weights obtained from the children's daycare center (in grams) and estimations by parents converted into grams.) The weighing and estimation of consumption for the children of that study occurred for 5-7 consecutive days. The major problem with both studies was the reliance on recall of untrained parents, making the results less convincing than data based on weights. The parents in Mrdjenovic and Levitsky's study had to recall intake amounts from five to seven 24 hour blocks while parents who participated in either Survey of Food Intakes by Individuals 1994-

1996 or 1998 had to remember at least one 24 hour block of time (sometimes in duplicate) (McConahy et al., 2004).

If the studies had relied on weighing foods to estimate amounts eaten, results would have been more accurate. In a study conducted by Fisher et al. (2008) when mothers recorded food intake (24 hour recalls) for infants aged seven to eleven months and for toddlers aged 12 to 24 months, their records differed from food weights recorded by researchers. In fact, mothers overestimated energy consumption for infants by 13% and by 29% in toddlers. If McConahy et al. (2004) and Mrdjenovic and Levitsky (2005) had parents weigh foods, then perhaps intake would be more accurate.

2.5.2b Portion size manipulation in children: single meal

In an attempt to confirm whether children of different ages were affected uniquely by portion size, Fisher (2007) gave children of varying age groups a dinner in which an age-appropriate single (200 g for 2-3 years, 250 g for 5-6 years, or 450 g for 8-9 years) or double portion of an entrée of macaroni and cheese was offered. In this group of 75 white children (aged 2-3 years, 5-6 years, and 8-9 years) mean entrée consumption increased by 29% (from about 112 g for 2-3 years, 140 g for 5-6 years and 252 g for 8-9 year to about 145 g, 181 g and 325 g respectively) when served the double portion size compared to the single. The mean intake of the entire meal was greater by 13% (from about 276 kcal for 2-3 years, 480 kcal for 5-6 years and 637 kcal for 8-9 year to about 294 kcal, 562 kcal and 700 kcal respectively) when the children were fed the larger entrée. No differences were found between age groups for the effect of portion sizes on consumption in terms of percentages.

2.5.3 Portion size manipulation in children: single meal over many weeks

To determine whether portion size can enhance intake over an extended time, Rolls et al. (2000) conducted a study with a population of small children. The study fed 3-5 year olds macaroni and cheese lunch entrées and manipulated portion size of the entrée on three distinct occasions over three weeks. The sizes of the entrées, described as small, medium and large were based on the USDA recommended serving sizes for children age 3 and children age 5. Children aged three received 150 g (2/3 c), 263 g (1 1/6 c), and 376 g (1 2/3 c) of macaroni and cheese; five-year-olds received 225 g (1 c), 338 g (1 1/2 c), and 450 g (2 c). The “medium” serving sizes for children aged 3 and 5 were the amounts recommended by the USDA for their ages. Only older children were affected by portion size, eating about 46 g (~60%) more macaroni and cheese when large portions were served in comparison to a small serving. Younger children ate like amounts over all three experimental days (though slightly higher amounts were eaten on the medium portion size when compared to the small).

The Rolls et al. (2000) study differed from the previous single meal study (Fisher 2007) in terms of reporting consumption and the amounts consumed per grade group, though, consumption was not significantly different between portion size conditions for either study. This will be shown using participants aged 2-3 years from both studies and using the medium and large portions for the Rolls et al. (2000) study as those amounts served are most similar to the reference and large portions served in Fisher (2007). Rolls et al. (2000) served 263 g for the medium portion and 376 g for the large portion. Fisher (2007) served 200 grams for the reference condition and 400 grams for the large portion. Rolls et al. (2000) served 63 grams more for the medium portion than the reference portion served in the Fisher (2007) study; Rolls et al. (2000) served 24 grams less for her large portion in comparison to Fisher (2007) for her large portion condition. The consumption comparison will not be exact as Rolls et al. (2000) gave more accessible data than Fisher (2007). Rolls et al. (2000) gave specific mean amounts consumed for children aged 3 for each portion size type—small, medium, and large—44.8 g, 54.6 g and 39.6 g respectively. While Fisher (2007) gave a mean gram weight for consumption among 2-3 year olds in the large portion group, she did not report a mean gram weight for consumption for the reference portion. Thus, I had to calculate the consumption in grams based on the calories eaten for this age group and the calories per gram of macaroni and cheese in that study (1.4 kcals/g). Using this method of calculating, the 2-3 year olds in the Fisher (2007) study ate 95 grams of macaroni and cheese in the reference condition and 103 grams in the large portion condition. Comparing the percentage increases between the two studies, Rolls et al. (2000) had a decrease in consumption of -27% between the medium and large portion size conditions, and Fisher (2007) had a percentage increase of 8% between the reference and large condition. Thus, 2-3 year olds ate more during the Fisher (2007) study than the Rolls et al. (2000) study, but it took more effort to get this data as she did not give exact numbers as Rolls et al. (2000) did.

In the Fisher (2007) publication, she states that the difference in consumption due to portion size between age groups (only older children eating more when served more for the Rolls et al. (2000) study and all age groups increasing consumption in the Fisher (2007) study) when compared to the Rolls et al. (2000) could be due to several reasons including different meals being served. These include environment, and the number of additional foods offered during meal times, among other things. Fisher (2007) explains a statistical methodology aspect of her study that may also explain differences between her study and that of Rolls et al. (2000):

> "this study [Fisher, 2007] expressed children's intake of the large entrée portion relative to entrée intake in the reference condition to take into account the fact that the entrée serving size in each condition was different for each age group. This approach allowed each child to serve as his/her own control, where each child's intake in the large portion condition was directly compared with his/her intake in the reference condition" (p. 409-410).

There were similarities between the Fisher (2007) and Rolls et al. (2000) studies. Children aged 3 and 5 years were both included in the studies and had the same entrée served—macaroni and cheese. Each age group was served different portion sizes. Furthermore, in both studies, children aged 5 (and 6 for Fisher, 2007) years increased the amount consumed when comparing their small (“reference” for Fisher, 2007) portion intake to their large portion intake by ~48 g (Fisher, 2007) compared to 46 g (Rolls et al., 2000). Moreover, both of these studies compared the same entrée (macaroni and cheese) for a relatively short duration, three or less meal periods.

To examine if recurring exposure to a larger portion size of macaroni and cheese affected food intake among preschool children in a daycare setting, Fisher et al. (2003) conducted a 12 week study to investigate this question. The study used two groups of students with one lunch being manipulated each week. The macaroni and cheese was served with other foods that were normally served when macaroni and cheese was on the menu such as applesauce and milk. The menu was served four times with the customary amount of entrée, four times with a doubled amount of the entrée, and four times (divided into two intervals) when students self-selected portions of macaroni and cheese. If the student received the customary portion first (125 g for < 4 years, and 175 g for ≥ 4 years), then they would have received the double portion (250 g for < 4 years and 350 g for ≥ 4 years) third and vice versa (Table 1). (The study used two groups of children, therefore two different orders). Changes in consumption of macaroni and cheese ranged from approximately 125 gram increase for the younger children to a 150 gram increase for the older children respectively when comparing customary to large portion sizes. Overall, results showed significant increases in consumption for both older and younger children.

Table 1: Chronology of serving different portion sized entrées over a four-week period in two groups of students* (Fisher et al., 2003)

Group Number	Serving Size: First Week	Serving Size: Second Week	Serving Size: Third Week	Serving Size: Fourth Week
Group 1	CCCC	SS	DDDD	SS
Group 2	DDDD	SS	CCCC	SS

*C: customary serving size, S: self-selected serving size, D: double serving size by weight compared to customary serving size

2.5.4 Portion size manipulation: diverse group of children over an entire day

Because many of the studies evaluating intake according to serving size manipulation have used populations of more often than not just white (or mostly white) children, additional investigation was necessary to evaluate intake changes due to portion size manipulation in a more diverse youth population. In a study among low-income African American and Hispanic children aged five enrolled in Head Start, Fisher et al. (2007a) increased portion size for three consecutive meals and one night snack in a laboratory setting. Children were served double portions of macaroni and cheese, apple juice, graham crackers, chicken nuggets and oat cereal on the experimental day and standard portions of all menu items on the control day (Table 2).

Table 2: Portion Size in Manipulated foods in both gram and kilocalories for Fisher et al., 2007

Portion size manipulated food	Reference portion size (g)	Large portion size (g)	Reference portion size (kcal)	Large portion size (kcal)
Macaroni and cheese	300	453	600	906
Apple juice	240	480	113	226
Graham crackers	40	80	185	370
Chicken nuggets	152	304	368	736
Oat cereal	40	80	160	320

Interestingly, in this study, only chicken and cereal were associated with *significant* increases in intake when the larger portion was served in comparison to the reference portion (37 g and 14 g respectively). The other three manipulated foods were not significantly affected by the increase in portion size (macaroni and cheese intake increased 9 g, apple juice 0 g and graham crackers

5 g). However, energy consumption from the foods whose serving was doubled increased by about 180 kcals (22%) overall. This study confirmed that larger portion size can boost intake over an entire day in a diverse sample of children.

Another group of researchers (Fisher et al., 2007b) manipulated portion size with another diverse group of children aged 5 to 6 years in a laboratory setting. Portion size and energy density of a macaroni and cheese entrée were modified. Firstly, the portion size of the entrée was increased by 100% by weight, and second, the energy density (using butter) of the entrée was increased by 40%. Children were given each type of possible combination once (e.g. reference portion size at 40% higher energy density, double portion size at standard energy density etc.). When increasing serving size of an entrée of macaroni and cheese while leaving sides and the beverage at fixed levels, 33% more entrée (by weight, 158 g compared to 210 g, 52 g increase) was consumed.

Across studies involving children of diverse ethnic and racial backgrounds (including black, white and Hispanic children) aged 2-9 years, doubling serving sizes of entrées increased consumption in dinner meals (Fisher 2007; Fisher et al., 2007b), in all meals covered in one day (Fisher et al., 2007a), and in lunches over several weeks (Rolls et al., 2000; Fisher et al., 2003). In all of these studies, when researchers doubled a macaroni and cheese entrée, they were able to increase consumption. When the results of those studies were statistically significant, the increase in consumption was in the range of 29% to 60% in the doubled portion conditions in comparison to the reference portion conditions. It seems however, that somewhere between 29% and 33% is a more likely expected increase in entrée intake of macaroni and cheese when a range of children from 2-9 are the target population. The studies are compared below (Table 3) on macaroni and cheese consumption in children ages 4 to 6 years when portion sizes were doubled. Within children aged 4 to 6 years, it appears that doubling the portion size of macaroni and cheese can produce mean increases in consumption from 9 grams to 52 grams (Table 3).

Table 3: Comparison of average increase in consumption (g) upon doubling portion size of macaroni and cheese in 5-6 year-old children

Study by author(s)	Increase in amount consumed
Fisher, J.O. (2007)	48 *
Rolls, B. J., Engell, D., & Birch, L. L. (2000)	46 * (4-5 years)
Fisher, J. O., Rolls, B. J., & Birch, L. L. (2003)	Gram data not available
Fisher, J. O., Arreloa, A., Birch, L. L., & Rolls, B. J. (2007a)	9
Fisher, J. O., Liu, Y., Birch, L. L., & Rolls, B. J. (2007b)	52 *

* Indicates a significant increase in consumption when the portion was doubled ($p < 0.05$)

2.5.5 Portion size manipulations with fruits and vegetables

Portion size manipulations can also influence consumption in more than just entrees; consumption of fruit and vegetable side dishes can also be affected. Kral et al. (2010) investigated whether fruit and vegetable intake could be augmented in children aged 5-6 (~77% African American) by doubling the portion given in fruit and vegetable side dishes only while in a laboratory setting. The fruit served in this study was *unsweetened* applesauce (122 g at reference, 244 g at doubled size). The vegetables were broccoli and carrots (both of these were served at 75 g for the reference and 150 g for doubled portion). All three (applesauce, broccoli, and carrots) were served *unadorned* without toppings, seasonings, etc. The only food that was consumed in greater quantities during the doubled portion size in comparison to the reference portion size was the applesauce. This increase was about 36 g or 43%. Doubling the amounts of the broccoli and carrots did not significantly increase consumption of these vegetables except when comparing children who said they preferred the broccoli or carrots (respectively) over the other menu items in comparison to children who preferred these items least. The increase in consumption for broccoli was about 27 g among children who preferred it most over other foods. The increase in intake of carrots in children who ranked it most preferable was 43 g; it was 46 g among children who ranked carrots as the second preferred item.

In contrast to Kral et al. (2010), Mathias et al. (2011) also doubled the portion sizes (in a laboratory setting) of fruit and vegetable side dishes, but this time with increased consumption of both the fruit and vegetable. The children involved in this study were 4-6 years of age with a relatively diverse racial/ethnic background. The fruit in this study was canned peaches in *light syrup* and the vegetable was broccoli (*with butter*) served with a side of salad dressing. When the fruit and vegetable side dishes were doubled, peach consumption increased by about 70% (~42 g) while broccoli consumption increased by approximately 37% (~12 g). There are several possible reasons for the difference in fruit and vegetable intakes between Kral et al. (2010) and Mathias et al. (2011). For example, Mathias et al. (2011) used sweetened fruit and gave dressing with the buttered broccoli, any of which could have enhanced palatability. Kral et al. (2010) served fruits and vegetables without any extra ingredients.

Doubling portion sizes in fruit and vegetable side dishes as well as macaroni and cheese affected consumption among children in the studies mentioned above. However, children who participated in the studies related to fruit and vegetable portion size doubling were four to six years, whereas the children in the macaroni and cheese portion size studies had more variability in age. Increases in consumption for macaroni and cheese were between 9 and 52 grams due to doubling. Doubling fruit side dishes resulted in a range of 36 g (applesauce) to 42 g (peaches), while increases in broccoli (vegetable) consumption ranged from negligible to 12 g.

2.5.6 Increasing vegetable intake by incorporating pureed vegetables into sauce

A less obvious way to increase children's vegetable consumption (and lower calorie content of an entrée) in children is to hide vegetables within pasta sauce. Leahy et al. (2008a) used this "hiding method" and portion size manipulation as means for increased vegetable intake. Although Leahy et al. (2008a) used a couple methods to try and improve vegetable consumption, this discussion will begin with manipulation of energy density ("hiding method"). Children in this study were mostly white (63%), about 3 to 5.5 years of age (n=61) and enrolled in a daycare facility. They were fed a pasta entrée with differing amounts of calories and vegetables. The decrease in energy density was accomplished by tripling the amount of pureed broccoli and cauliflower (approximately) in a tomato-based sauce, using a low-fat version of cheese and using less cheese. (The higher energy density version of the pasta had 5.9 g of pureed broccoli and 4.2 g of pureed cauliflower while the lower energy density version had 17.6 g and 12.5 g, respectively). When the high vegetable content (lower energy density) versions of the entrée were served, the mean vegetable intake improved by 194% or approximately 10 g when compared to the mean vegetable intake from the higher energy density (low vegetable content) pastas.

Portion size was also manipulated in the Leahy et al. (2008a) study to investigate whether decreasing portion size would affect intake. The preschool-aged children in this study were fed four entrée types: high calorie and large portion (400 g), high calorie and moderate portion (300 g), low calorie and large portion (400 g) and low calorie moderate portion (300 g). Unlike the studies mentioned above (Kral et al., 2010; Leahy et al., 2008b; Leahy et al., 2008c; Mathias et al., 2011), when portion sizes were manipulated in the opposite direction (decreased), intake did not follow suit. When children were served less, they did not eat significantly less.

2.5.7 Portion size summary

The section above on portion size presented the effects of doubling servings of food ranging from macaroni and cheese to broccoli in children 2-9 years—but the effects of portion size on consumption were not always similar across studies. For studies incorporating macaroni and cheese as part of the portion size manipulation, Table 3 has a good summary for studies with ages 5-6 years, but results were broader than this. For example, not all studies had significant results for all ages. Fisher et al. (2003) and Fisher (2007) did not show significant results by age group, and Fisher (2007) was the only study above with children over the age of 6 years. In terms of effect size, Fisher et al. (2003) showed a range of consumption of -44% to 109% when comparing the doubled portion of macaroni and cheese to the single portion of macaroni and cheese. Among all studies, the effect of doubling of portion size on intake ranged from -44% to 109% (Fisher et al., 2003) for macaroni and cheese, 43% (Kral et al., 2010) to 70% (Mathias et al., 2011) for fruits and 0 (Kral et al., 2010) to 37% (Mathias et al., 2011) for vegetables.

2.6 School-based interventions

2.6.1 Multi-component design

Baranowski et al. (2000) used a randomized control intervention design with eight schools receiving treatment and the other eight none in order to test whether fruit and vegetable consumption could be influenced using a multifaceted, education-based approach in the school setting. Measurements of food intake (via 7-day food records) were taken at baseline (n=1732), year one (n=1864) and year two (n=1946). During year one, children received the intervention geared toward fourth graders, and in year two children received the intervention for fifth graders. The grade-appropriate interventions lasted six weeks per year and involved five different methods to improve fruit and vegetable consumption among children while at school. These methods included: role-playing, taste-testing, fruit and vegetable preparation, goal-setting in regards to fruit and vegetable consumption and finally, teaching students skills to surmount unattained preliminary goals. The subjects were fourth and fifth graders enrolled in one of 16 elementary schools. Each of the two grades had different goals; the fourth grade students had education that was meant to improve vegetable consumption, whereas the fifth grade students had lessons intended to increase fruit and juice consumption, though vegetables were also highlighted. In both the control and experimental groups increases in intakes of both fruits and vegetables were observed, albeit only in the lowest consumption quintile category. Since ‘a portion’ of a fruit or vegetable was the serving a student usually put on his or her plate, it is difficult to compare the results of this study to others. Nevertheless, the control group had increases of 0.47 servings of fruit, juice and vegetables while the experimental group had increases of about 0.82 servings (p = .038). Whether or not one intervention component played more of a role than another is unknown.

Reynolds et al. (2000) also used a multi-faceted approach to improve fruit and vegetable consumption in elementary school children, but the method included the participation of parents and cafeteria staff. Students were recruited in third grade and were followed over a three year time period. Researchers measured fruit and vegetable consumption (via 24-hour recalls) at baseline and at years one and two post intervention. (Fruit and vegetable portions were determined using the National Cancer Institute, 5 a day guidelines, 1991). Like the Baranowski study, students participated in taste tests, were trained to be self-aware in terms of fruits and vegetables eaten, and learned strategies for overcoming barriers to fruit and vegetable consumption. The students in this study also learned fruit and vegetable intake patterns by watching parents' consumption of fruit and vegetables—modeling—among other methods. In total, twenty-eight elementary schools participated in the study, 14 were assigned to the intervention group and 14 were in the 'usual care' group (total n=1698).

Since children were not expected to prepare/buy/find food on their own while at school, Reynolds et al. (2000) included the cafeteria employees in the intervention. Each cafeteria was given a monthly star rating based on whether they had completed participation activities such as offering 10 fruit and vegetable servings per week. Information on whether most school cafeterias obtained a five star rating (best rating) on most occasions was not reported. However, based on the results published, a combination of education and increased accessibility played a role in improved fruit and vegetable intake. Based on 24-hour recalls, fruit and vegetable servings were higher at year one and year two post intervention compared to baseline values (3.96, 3.20, 2.61 respectively) in the experimental group compared to the control group during the same time points (2.28, 2.21, 2.51 respectively). These results would equate to a 51% increase for year one and 23% increase in year two when comparing the experimental groups' servings in year one and two compared to their baseline figures. Since the average increase in fruit and vegetable intake waned slightly from the first to the second year, it is possible that the abatement could continue and the two groups (control and intervention) would have similar consumption patterns over a longer period.

A randomized school based trial using a different multi-component approach compared to Baranowski et al. (2000) and Reynolds et al. (2000) to increase fruit and vegetable consumption was launched in 1995 with participation of a diverse group of elementary schools. The study was conducted by Perry et al. (1998) with cafeteria staff and parents contributing to the study as well as other adults aside from researchers. Like the previous two studies described (Baranowski et al., 2000; Reynolds et al., 2000), Perry et al. (1998) focused on students in the fourth to fifth grade age group (the students were in the fourth grade in spring 1995 and were fifth graders in the fall of 1996). This study included 20 elementary schools, 10 of which were considered the intervention group and the other ten were in the delayed program condition. [The authors do not give a definition for the delayed program condition, so it is difficult to discern whether or not this would be considered a control group]. Similar to the aforementioned studies, Perry et al. (2008) included a classroom component—behavioral curricula; food service changes were also made in the cafeteria as in other studies. Industry (Beckman Produce Inc.) made contributions (produce) and participated in the study by also giving 30 minute presentations to the intervention group. The most comprehensive component of the Perry et al. (1998) study was cafeteria involvement. Not only were the cafeteria employees tasked with making fruit and vegetables look more appealing, but they also needed to set up promotional characters (from classroom lessons) at the point-of-sale, buy and present a larger variety of fruits and vegetables, and provide an additional fruit when baked desserts were offered. Interestingly, gender had an effect on consumption of vegetables. Only girls had a significant increase in vegetable intake (alone) at lunch, 0.26 servings per 1000 kcal compared to the same girls' baseline values. However, overall both girls and boys in the intervention group (based on direct observation) increased their combined fruit and vegetable intake by 0.47 servings per 1000 kcal compared to their baseline values.

2.6.2 Simple intervention--pricing

Two interventions to improve fruit and vegetable intake in children used a pricing/availability approach—one in Danish schools and one in American schools. (Only the Danish study will be discussed below as it pertains to elementary school children; the American study used high school students as participants).The Danish study conducted by Eriksen, Haraldsdottir, Pederson, & Flyger (2003) offered parents of children in three primary schools a subscription to a program that gave their elementary school children either a fruit or vegetable once per day at 25 cents per day (n=240). Parents of children in four control schools were not offered any subscription (n=205). Children in both the intervention and control schools increased their daily consumption of fruit—40% (1.3 to 1.7 mean pieces per day, p=0.019) in the intervention school and 30% (1.4 to 1.7 mean pieces per day, p=0.008) in the control school. However, no change in vegetable intake was observed in either group.

2.7 Behavioral Economics

"Behavioral Economics is the combination of psychology and economics that investigates what happens in markets in which some of the agents display human limitations and complications" (Mullainathan & Thaler, 2000). In the school setting an example of behavioral economics would be nudging (Cornell Center for Behavioral Economics in Child Nutrition Programs, 2012). A nudge is when an environment is changed by a person or body to promote "positive" decision making in others by "affecting the choices that are available to the decision maker" (E. Mykerezi, Ph.D., personal communication, September 6, 2012). An example of a nudge would be only offering fruits as dessert options in a lunch line. There are several kinds of nudges that have been discussed for increasing fruit and vegetable consumption in the school setting, some have even been tested. Types of nudging include lowering prices on fruits and vegetables (French et al., 1997), having fruits and vegetables available before other foods (Just & Wansink, 2009), having cafeteria staff urge students to take fruits and vegetables, and finally placing fruit and vegetable characters where students buy food (Perry et al., 1998).

Behavioral Economics: A real-world example

In a 16 week study (Hanks, Just, Smith & Wansink, 2012) using a two line cafeteria set up, researchers changed one lunch line into a "healthy lunch line" offering healthier options such as pre-made submarine sandwiches, fruits, vegetables and yogurt parfaits. The other line had less healthy options, such as make as-you-like submarine sandwiches in which students had more unhealthy options to choose from. The intervention was relatively successful; sales of what the researchers considered "healthy foods" were boosted by 18%. However, the weight of consumed "unhealthy" foods only declined by 28% (182.5 g to 131.5 g, a difference of 51 g) while the amount of healthy food consumed remained the same (282.4 g). Though the students were persuaded to buy healthier foods, they were not swayed into actually eating them.

CHAPTER 3: OBJECTIVE AND HYPOTHESES FOR OUR STUDY

OBJECTIVE:

The main objective of our study was to investigate whether increasing portion sizes of fruit and vegetable side dishes could increase consumption of these items in elementary school children who participate in the National School Lunch Program.

HYPOTHESES

1) Increasing the portion size of a vegetable or fruit side dish by 50% will increase their individual consumption by students.

2) The increased consumption due to our portion size manipulation will be higher for fruit than for vegetables.

CHAPTER 4: MATERIALS & METHODS

4.1 Subjects

With Institutional Review Board approval from the University of Minnesota, children grades K through 5 participated in our study from January 2011 through April 2011. Only children who bought lunch or received free lunch from the school were enlisted in the study (n=643-758 depending on the day). These students came from diverse racial/ethnic backgrounds (30% white and 70% minority—20 % black, 39 % Hispanic, 8 % Asian, 1 % American Indian) with the majority coming from an impoverished socioeconomic background as evidenced by the majority of students receiving free (53%) or reduced priced lunches (10%). None of the participants received monetary or any other kind of compensation as a result of their involvement in our study.

4.2 Experimental schedule—December 2010 through April 2011

4.2.1 Pilot day: mid December 2010

Before any official data were taken, a pilot day occurred in mid-December 2010 in which researchers conducted a mock control day. During the pilot session, everything was served at the standard portion sizes for each food item. As inefficiencies and problems were found, modifications were made to the original approach and procedures emerged leading to the methodologies used in this study.

4.2.2 Control days:

After the pilot day, two control days occurred to establish baseline consumption for the two different menus (green bean and pea). (Figure 1 illustrates the timeline for our study). Control days for both the pea and green bean menus occurred prior to experimental days for each type of menu. On one of the days, the green bean menu was served with standard portion sizes (as per normal for the school). On the other day, the pea menu was served with standard portion sizes. Tables 4 and 5 show the green bean and pea menus for our study. (Different menus were served on days when green beans were on the menu than on days when peas were on the menu (Tables 4 and 5). However, each menu type (green bean or pea) was served for the same amount of days—one control day and two experimental days (see Figure 1).

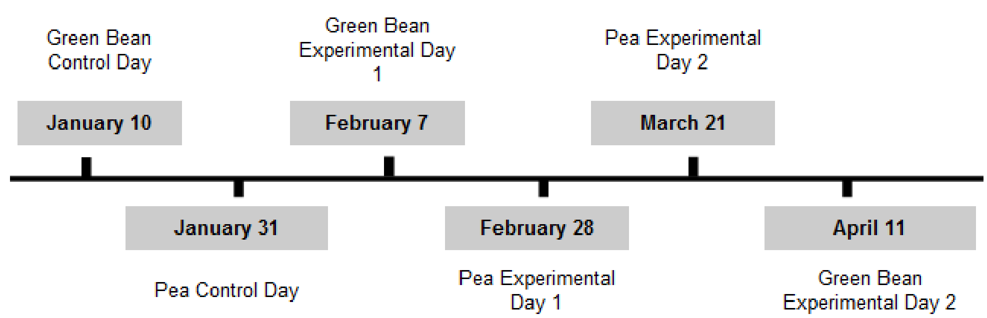

Figure 1: Research Progression Timeline

Table 4: Menu choices for control and experimental days when green beans were served

Milk (choose 1)	*Entrée (choose1)*	*Hot Side (choose 1)*	*Vegetable/Fruit (unlimited)*
Skim strawberry milk (8oz)	Chicken tenders	Buttery Noodles	Oranges
Skim chocolate milk (8oz)	BBQ beef sandwich		Carrots
Skim white milk (8oz)	Peanut butter and jelly sandwich		Green beans
2% white milk (8oz)			Applesauce

Table 5: Menu choices for control and experimental days when peas were served

Milk (choose 1)	*Entrée (choose1)*	*Hot Side (choose 1)*	*Vegetable/Fruit (unlimited)*
Skim strawberry milk (8oz)	**Popcorn Chicken**	**Whipped Potatoes**	**Oranges**
Skim chocolate milk (8oz)	**BBQ beef sandwich**		**Carrots**
Skim white milk (8oz)	**Peanut butter and jelly sandwich**		**Peas**
2% white milk (8oz)			**Applesauce**

4.2.3 Experimental days:

During experimental days, portion sizes of oranges, carrots and applesauce were increased by 50% in comparison to control days. For each type of menu (pea or green bean) we conducted two experimental days. Only the carrot, orange, and applesauce portion sizes were manipulated; all other food items including the green beans or peas (depending on the menu) were held constant (Tables 4 and 5). No verbal or written nudging from the kitchen or research staff was employed at any time during the control or experimental days.

4.3 Products: fruit and vegetable portion sizes and descriptions

The produce was purchased by the school district through their normal suppliers; the brands and types of vegetables and fruits are shown in Table 6. The portion sizes for each type of fruit and vegetable on control days (days when portions were not manipulated) were those typically served by the school (measured by volume). The portions served at the school were decided by nutrition staff at the school using guidelines established by the USDA. To establish the pre-weight (serving size) for each type of fruit and vegetable we weighed 10 servings of each type of fruit and vegetable individually and computed the average (Tables 7 and 8). Carrot data also included the number of carrots in the cups—the number was the same for all cups on any particular day, 5 for control days and 8 for experimental days for each menu type. From the number of carrots and the average weight of a serving, the average weight per carrot was also determined. Average serving sizes (in grams) were calculated each of the six days (Tables 7 and 8).

Table 6: Fruits and vegetables served during the study: conditions, brand names and company addresses

Type of fruit or vegetable	Condition in which it was bought	Condition in which it was served	Brand	Address
Peas	frozen	thawed	Libby's®	Marion, NY
Green beans	frozen	steamed	Bybee®	Pasco, WA
Baby carrots	fresh	fresh	Grimmway®	Bakersfield, CA
Oranges	fresh	fresh/quartered	Sunkist®	Sherman Oaks, CA
Applesauce	canned/unsweetened	canned/unsweetened	Nugget®	Atlanta, GA

Table 7: Average (based on ten samples) weight of a serving for each type of fruit and vegetable served on the green bean menu days for both control and experimental days

Type of Fruit or Vegetable	Control Day: Green Beans (g)	Experimental Day1: Green Beans (g)	Experimental Day2: Green Beans (g)
Applesauce	115	174	180
Carrots*	56	93	70
Oranges**	67	110	117
Green Beans	51	51	69

* Carrot weights were not increased 1.5 times (in grams) as the portion size increase was based on number of carrots—5 on control and 8 on experimental days.

** The average weight of the oranges does not include the peel weight, only flesh.

Table 8: Average (based on ten samples) weight of a serving for each type of fruit and vegetable served on the pea menu days for both control and experimental days

Type of Fruit or Vegetable	Control Day: Peas (g)	Experimental Day1: Peas (g)	Experimental Day2: Peas (g)
Applesauce	118	169	188
Carrots*	58	75	50
Oranges**	80	112	105
Peas	53	66	60

* Carrot weights were not increased 1.5 times (in grams) as the portion size increase was based on number of carrots—5 on control and 8 on experimental days.

** The average weight of the oranges does not include the peel weight, only flesh.

On all days, fresh orange quarters, fresh baby carrots, and canned applesauce were served. On experimental days, portions were increased by half by volume (½ cup to ¾ cup) for applesauce, but the other manipulated portions were increased by count—orange and carrot portions were increased by number of pieces. The amount of oranges served increased from four quarters on control days to six quarters on experimental days. The number of carrots increased from five on control days to eight on experimental days.

The vegetables and fruits were presented to students in individual containers on separate sheet pans for each type of fruit and vegetable (Figure 2). Portions of applesauce were placed in plastic Jcups (Dart®, Mason, MI) either in the 5 oz size (control days) or an 8 oz Styrofoam squat cup (Dart®, Mason, MI) (experimental days). Oranges, green beans, and carrots were placed in paper squat cups (Dart®, Mason, MI). Oranges and carrots were placed in the 5 oz size for control days and the 8 oz size for experimental days; green beans were placed in the 5 oz size for both control and experimental days. Peas were served in 5 oz plastic squat cups (Dart®, Mason, MI) for both control and experimental days.

Figure 2: Tray line food presentation

4.4 Experimental procedure

4.4.1 Subject identification

Index (3x5) cards (Figure 3) were used to identify individual children's plate waste. The 3x5 cards were made for each child enrolled at the school with exception of preschoolers and special education students. The original 3x5 cards included the child's name and pin number. The pin numbers were five digits long and were those used by the students in the lunch line normally; each student had their own unique pin number that followed them year to year within that elementary school. The cards were prepared by researchers prior to arrival at the school. (The cards were organized by teacher—all students' cards for a particular teacher were put into an envelope labeled with the corresponding teacher's name, then envelopes were grouped together by the lunch session—1^{st}-6^{th}).

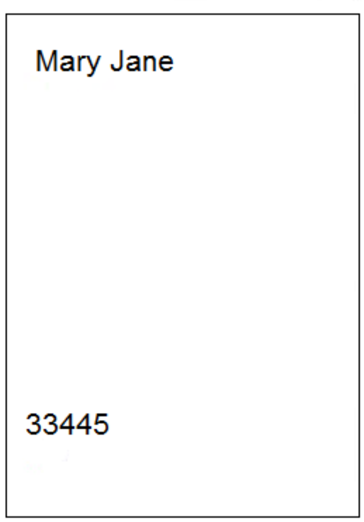

Figure 3: Example of a student index card prior to going through the lunch line

4.4.2 Lunch process

Students arrived at the cafeteria at the beginning of one of 6 twenty-minute lunch periods (organized by grade) beginning at 10:50 am with the last group arriving at 12:40pm. Upon arrival, students sat with their classes[1], then waited for and received[2] their cards. On all days students were given their 3x5 cards by either a researcher or a fellow class mate from their teacher's envelope. If a new student joined a class after the 3x5 cards were made, a new card would be made for them by one of the researchers and marked so as to ensure they received a pre-made card at the next session. When each class arrived for their lunch period, a researcher would ask for 3-4 students within that class to volunteer to pass cards out to their fellow classmates. Kindergarteners were able to assist when names were read aloud.

Once all of the students received a card, they proceeded to the lunch line (with their cards in tow) [3] where they picked up a milk, keyed in their pin number, had a researcher place an ordinal number over their name on their card (Figure 4) to

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[1] Some students moved during the lunch period to sit with their friends in other classes. There were a few days when certain students sat alone (punishment) or left the lunch area for reading time (these were the same group of about 20 students).
[2] Not all students waited for their cards, some immediately got up and went into line, in which case researchers tried to give them their cards in line, otherwise students received their cards upon their return to their table.
[3] If the student didn't have their card when they went through the tray line, the researcher would place the ordinal number sticker on their sleeve. Once the student returned to his or her seat, the researcher would instruct the student to put the ordinal sticker over his or her name.

track place in line, then went through the tray line. The tray line was arranged fruits and vegetable first, followed by the hot side item, then by hot entrées and finally by the alternative third entrée, peanut butter and jelly sandwiches (Figure 2). Children were able to self-serve the fruit and vegetables, but staff dished up the hot entrée and side. Students had to choose one entrée, one milk, and at least one side. These sides could be fruits, vegetables or the hot side of the day (buttery noodles or whipped potatoes for our menus). After the students had filled their trays, they proceeded outside the tray line area to tables stocked with ranch dressing, ketchup and extra fruits and vegetables. This is where students could pick up extra fruits and vegetables (excluding whipped potatoes) ad libitum. Once students finished filling their trays they sat down with their classmates at their teacher's designated table and ate lunch.

As the children ate, researchers went around each table and made a seating diagram. The diagram included the teacher's name at the top, the position of each child at the table (the closer to the tray line, the closer to the bottom of the diagram), and each position without a person seated (marked as an X). The position of the child was recorded by their individual ordinal number for a particular day (this allows for consumption of fruits and vegetables to be related to seating position). If the children did not have an ordinal number (meaning they had brought a lunch from home), then a "C" was recorded for "cold lunch". On occasion, parents/teachers would sit at the tables and their positions were recorded with an "A" for adult (Figure 5).

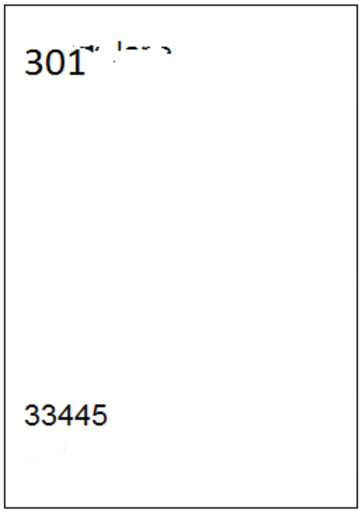

Figure 4: Example of student index card after going through the lunch line

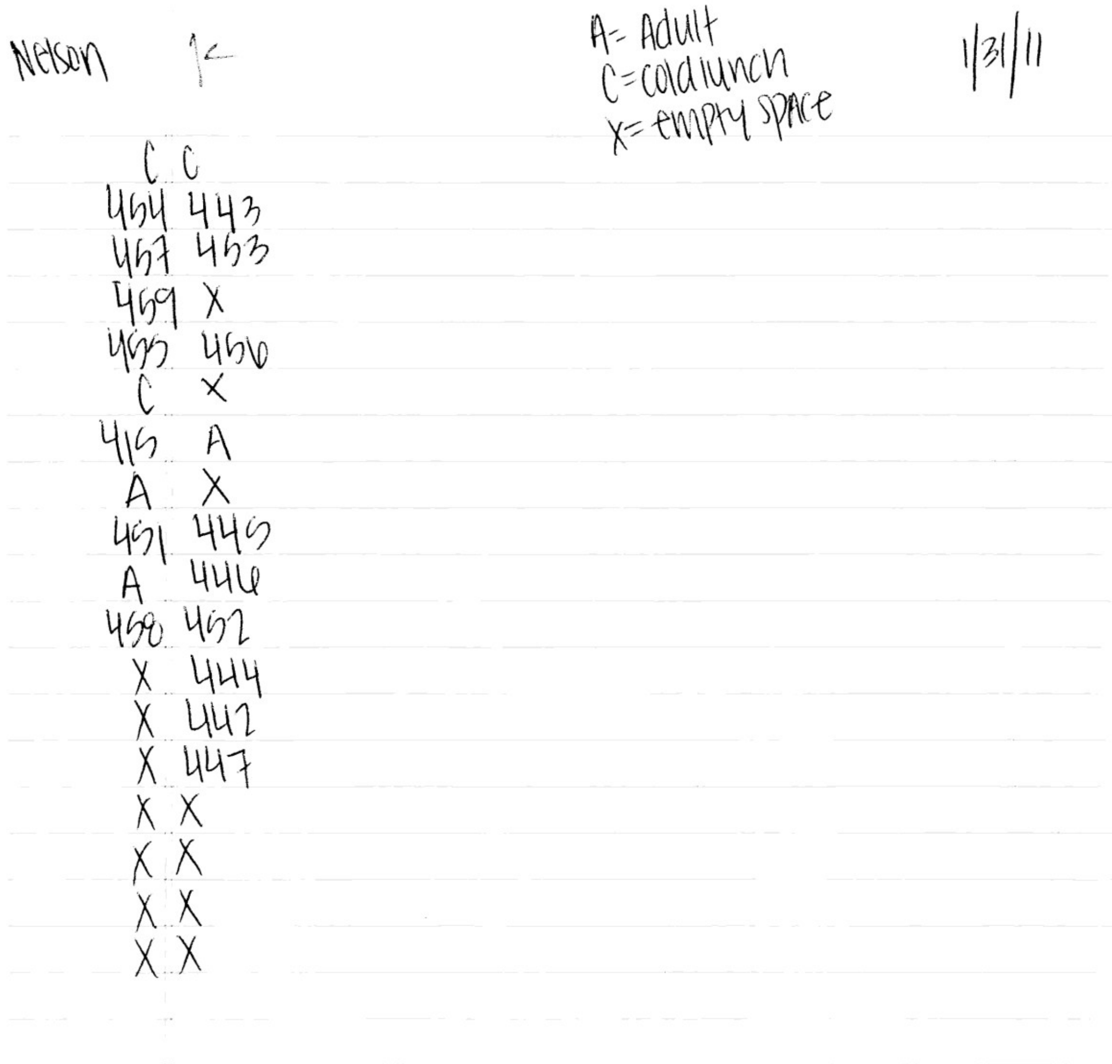

Figure 5: Example of Seating Position Documentation

The diagram shows the teacher's name at the top; the position of each child at the table (the closer to the tray line, the closer to the bottom of the diagram), and each position without a person seated (marked as an X). The position of the child was recorded by their individual ordinal number for a particular day (this allows for consumption of fruits and vegetables to be related to seating position). If the children did not have an ordinal number (meaning they had brought a lunch from home), then a "C" was recorded for "cold lunch". On occasion, parents/teachers would sit at the tables and their positions were recorded with an "A" for adult

4.4.3 Waste collection

After approximately 20 minutes the students were excused table by table by a lunch monitor to dispose of trash and continue onto a 10 minute recess. To dispose of trash, students had to wait in one of two lines at the trash bins where researchers were posted to collect fruit and vegetable waste. The students were instructed to give the researchers their 3x5 identification cards and their leftover fruits and vegetables (excluding whipped potatoes) and throw all other waste into the trash, recycling, or compost bins provided. The researchers placed each student's fruit and vegetable waste on top of each student's individual card on a hotel-sized sheet pan to be taken to another part of the kitchen for weighing (Figure 6).

Figure 6: Example of Plate Waste with Index Card Identifiers

4.4.4 Plate waste measurements: weighing procedures for uneaten fruits and vegetables

Fruit and vegetable waste was saved on sheet pans until at least one was full of samples, then the sheet pan(s) containing several children's waste from the trash line was brought back to the weighing area of the kitchen. At the weighing station, four digital scales (Escali, model Primo #P115M, Escali, Burnsville, MN) were tared (for the types of containers used to hold the fruits and vegetables on that day). Each weight was recorded to the nearest gram using the student's ordinal number as reference for ease in rapid entry.

4.5 Data analysis

4.5.1 Plate waste

Plate waste was determined by weighing each sample cup of fruit or vegetable that a student had left over after finishing lunch. If a plate waste cup appeared empty, we recorded plate waste as zero. If a student had taken more than one cup of any type of fruit or vegetable the plate waste for each cup was recorded individually.

4.5.1a Determining plate waste: special considerations

When measuring the weight of ten sample cups of carrots for average carrot serving size, the researchers recorded not only the individual weights of the portions, but they also calculated the average weight per carrot. [The weight of the individual carrot was calculated because although the number of carrots was either 5 or 8 depending on the day (control or experimental, respectively) the size of the carrots was not always consistent. The carrots were always “baby carrots” per the manufacturer, but sometimes the carrots varied in thickness across days.] This was done because students on occasion would drench their carrots in ranch dressing. If the carrots were weighed with the dressing, the measure would be inaccurate. Due to the sheer number of samples per day, it would be too time consuming to rinse and dry the ranch-laden carrots. Therefore, if a sample of carrots were drenched in ranch, the researcher would record the number of carrots left to calculate the plate waste. For example: if the average weight of a carrot on a particular day was 10 g, and there were three carrots left over in a ranch-laden cup, the researcher would record the plate waste as three carrots and replace it later with 30 g (3X10 g).

4.5.2 Amount consumed

Amount consumed for each student was determined by subtracting plate waste of a particular fruit or vegetable from its average serving weight. For example, if the average weight of a serving of applesauce was 100 g and the plate waste for a particular sample of applesauce was 30 g, then 100 g – 30 g = 70 g consumed. If a student had more than one plate waste value for a particular fruit or vegetable we subtracted each plate waste value from the average serving weight then added all of that student's amounts consumed for that fruit or vegetable. For example, if a student had two plate waste values for applesauce at 30g, we would estimate consumption as such: [(100 g - 30 g) + (100 g - 30 g)] =140 g.

4.5.2a Special considerations: orange plate waste/amount consumed

Oranges were a challenge for calculating amount consumed as they were served with peels still attached. In order to circumvent this hurdle, researchers would write "gone" next to the plate waste values for oranges when all of the flesh was gone, but the peel remained. From these "gone" data, we calculated an average weight for the peel based on an average of all of the orange plate waste when the flesh of the entire orange portion was eaten.

When determining the amount consumed for oranges, the average weight of the peel and the average of ten orange samples had to be known before any calculations could take place. If a student had a plate waste value of less than the average peel weight we assumed the student had eaten their entire orange portion and recorded a consumption value of the average weight of portion of oranges for that day. However, if a student had a plate waste value greater than the average peel weight, then that plate waste value would be subtracted from the average serving weight of a portion of oranges to determine the amount consumed.

If on a particular day, the values for the average portion of oranges and average peel weight were 66 g and 23 g respectively, we would use these values to estimate consumption. If a child's plate waste for oranges was 26 g, then we would calculate amount consumed as 66 g – 26 g = 40 g. In mathematical terms: If plate waste ≤ average peel weight, then amount eaten = average weight of a portion of oranges- average peel weight (to account for them not eating the peel). If plate waste > average peel weight, then amount eaten = average weight of a portion of oranges – plate waste.

4.5.3 Statistical analysis

Most quantitative statistical data analysis was conducted using SAS version 9.2 (SAS Institute Inc, Cary, NC). Data were broken up into two different data sets: green bean menu data and pea menu data. This was done because the menu when green beans were served and the menu when peas were served were different and could not be compared together. To investigate whether or not the amounts consumed were different between test and control days we employed a mixed analysis of variance model (proc mixed) for each type of fruit and vegetable separately for each menu type. In this model, the dependent variable was the amount of an individual fruit or vegetable consumed by students taking that specific item with the explanatory variables being grade, pin (nested in grade) and the condition (control or test day). The pin in this model was used to identify individual children. The second to last line in the SAS coding (appendix) compared differences between least squares means for a specific fruit or vegetable among the grades and between the control and experimental conditions. In general, proc mixed also provided F statistics that compared each type of fruit and vegetable's consumption for control versus the combined experimental portions for each menu type. The "pdiff" function provided a t test between the experimental days (together) and the control day for each menu type for the specific fruit and vegetable used in the model statement. (The t test output gave the least squares means for the experimental days (for both days combined) minus the least squares mean for the control observations and gave the p value for evaluation of significance. Please see the coding in appendix for the model used for applesauce.

Since the proc mixed procedure in SAS compared the *combination* of both experimental days for a particular menu type with its respective control day, we used the proc univariate procedure to obtain the means for consumption of specific food items on *individual* days. The proc univariate procedure provided the number of students who had plate waste for each type of fruit or vegetable on a *particular day* and the standard error surrounding that mean plate waste data. [This information was not provided using the proc mixed procedure]. The procedure allowed for determination of confidence intervals for the mean, standard deviation and variance for a particular variable (fruit or vegetable) on a specific day. This procedure was necessary as it enabled us to verify the number of students who took a fruit or vegetable on a particular day. The proc univariate coding in the appendix was used for summarizing data for applesauce consumption on day 3 (“var applesauce”).

To compare the ratios of students who took individual fruits and vegetables out of students who participated in school lunch on control and a particular experimental day (within the same menu type), z scores for binomial proportions were computed manually. The ratio for each fruit and vegetable (whose portion was augmented) taken on the control and experimental day 1 were compared to one another and analyzed for statistical significance. The same was true for the ratio of a particular augmented fruit or vegetable taken for the control and experimental day 2. To be clear, any test of significance between a control and a particular experimental day was always within the same menu type, either green bean or pea. P values were computed using http://graphpad.com/ quickcalcs/PValue1.cfm.

CHAPTER 5: RESULTS

Increasing portion size by 50% can increase intakes of fruits and vegetables in those choosing fruits and vegetables

Mean values for all grades

Green bean menu days

When portion sizes were increased by 50% during the green bean menu sessions, consumption increased for every product whose portion was augmented (Table 9 and Table 10). There was a 40 gram increase in consumption of applesauce on experimental day 1 and there was a 55 gram increase in applesauce consumption when compared to the control day for experimental day 2 (Table 9). For orange consumption, there was a 23 gram increase in intake of oranges on experimental day 1 when compared to the control day and 15 gram increase in orange consumption during experimental day 2 when compared to control day values (Table 9). In regard to carrot consumption, there was an 11 gram increase in consumption between the control day and experimental day 1. There was a 15 gram increase in consumption between the control day and experimental day 2 (Table 9). There were no significant differences between test and control days for green beans (Table 10).

Pea menu days

The consumption of applesauce and oranges were affected by the 50% increase in portion size (Table 11 and Table 12); the portion size for peas was not augmented, and consumption remained unchanged. There was a 33 gram increase in consumption of applesauce on experimental day 1 and there was a 43 gram increase in applesauce consumption when compared to the control day for experimental day 2 (Table 11). For orange consumption, there was a 7 gram increase in intake of oranges on experimental day 1 when compared to the control day and 2 gram increase in orange consumption during experimental day 2 when compared to control day values (Table 11). There were no significant differences between test and control days for peas (Table 12).

For carrots, it was more difficult to discern how much of an impact our increased portion size had on consumption because on the second experimental day on the pea menu, we actually served less carrots by weight (Table 8). When experimental day 2 was excluded for carrot consumption data for the pea menu, LS means for carrot consumption between control and experimental day 1 were nearly equal at 25 g (p=0.9904). Thus, there were no significant differences between test and control days for carrot consumption (Table 12).

Table 9: Fruit and vegetable consumption for students taking fruit and vegetable servings and number of participants for each day of the green bean menu: means (g), standard errors (se) (g), and number of students taking a particular product on control and both experimental days

	Control			Experimental day 1			Experimental day 2		
Fruit/Vegetable	Means for amount consumed	se	Number of students taking individual product / number eating school lunch	Means for amount consumed	se	Number of students taking individual product out of number eating school lunch	Means for amount consumed	se	Number of students taking individual product out of number eating school lunch
applesauce	77	3	315/680	117	4	237/663	132	4	248/684
carrots	20	2	80/680	31	4	77/663	35	3	94/684
oranges	22	1	238/680	45	2	346/663	37	2	343/684
green beans	22	3	36/680	18	4	41/663	30	5	27/684

Table 10: Fruit and vegetable consumption during green bean menu days: amount consumed per student taking a specific fruit or vegetable—experimental days (combined), the difference between control and combined experimental days, and results of significance testing

	Experimental days (combined)		**Difference experimental$_{1+2}$ -control for amounts consumed**				
Fruit/Vegetable	LS means (g) for amounts consumed	se	Difference in Least Squares Means (g)	se	LS Means percentage change	P value*	F value
applesauce	119	3	44	5	59%	<.0001	83.8
carrots	33	3	17	7	106%	.02	6.0
oranges	38	2	20	3	111%	<.0001	33.9
green beans	24	4	8	8	50%	0.36	0.88

*P value and F statistic were both generated from the proc mixed procedure within SAS

Table 11: Fruit and vegetable consumption for students taking fruit and vegetable servings and number of participants for each day of the pea menu: means (g), standard errors (se) (g), and number of students taking a particular product on control and both experimental days

	Control			Experimental day 1			Experimental day 2		
Fruit/Vegetable	Means for amount consumed	se	Number of students taking individual product / number eating school lunch	Means for amount consumed	se	Number of students taking individual product out of number eating school lunch	Means for amount consumed	se	Number of students taking individual product out of number eating school lunch
applesauce	90	3	245/631	123	4	226/643	133	5	255/654
carrots	25	3	64/631	25	3	71/643	24	2	104/654
oranges	36	2	342/631	43	2	337/643	38	2	320/654
peas	16	4	41/631	26	5	31/643	26	4	39/654

Table 12: Fruit and vegetable consumption during the pea menu days: amount consumed per student taking a specific fruit or vegetable—experimental days (combined), the difference between control and combined experimental days, and results of significance testing

	Experimental days (combined)		**Difference experimental$_{1+2}$ -control for amounts consumed**				
Fruit/Vegetable	LS means for amounts consumed	se	Difference in Least Squares Means	se	LS Means percentage change	P value	F value
applesauce	125	3	39	6	45%	<.0001	52.0
carrots	24	2	-1	5	-4%	0.74	0.12
oranges	38	1	4	2	12%	0.01	2.80
peas	16	4	-4	8	-20%	0.61	0.27

*P value and F statistic were both generated from the proc mixed procedure within SAS

Kindergarteners

Consumption data for applesauce and carrots among kindergarteners was extracted for the sole purpose of enabling us to compare our results to similar studies. The ls means for applesauce consumption increased 46 grams between the control day and the experimental days (combined) during the pea menu; consumption increased 60 grams during the green bean menu (Table 13 and Table 14). The ls means for carrot consumption increased 15 grams during the green bean menu when comparing the control day and the experimental days (combined). The ls means for carrot consumption decreased 25 grams between the control and experimental days (combined) for the pea menu (Table 13 and Table 14).

Table 13: Kindergarten consumption of applesauce and carrots during the green bean menu: ls means for the control day (g), experimental days (combined) (g), and the difference in ls means for consumption (g) with significance testing.

Product	Ls means for control day	Ls means for experimental days (combined)	Difference between control and experimental days	Percentage difference	P value*
applesauce	65	125	60	92	0.0004
carrots	3	18	15	500	0.13

*P value was generated from the proc mixed procedure within SAS

Table 14: Kindergarten consumption of applesauce and carrots during the pea menu: ls means for the control day (g), experimental days (combined) (g), and the difference in ls means for consumption (g) with significance testing.

Product	Ls means for control day	Ls means for experimental days (combined)	Difference between control and experimental days	Percentage difference	P value*
applesauce	85	131	46	54	0.02
carrots	33	8	-25	-75	0.14

*P value was generated from the proc mixed procedure within SAS

Percentage of amounts eaten of increased portions for all grades

Green bean menu days

The consumption of all augmented products increased percentagewise between the control and experimental days (combined). The percentage increases between the control and experimental days were as follows: 71% for applesauce, 64% for carrots, and 43% for oranges (Table 15). Students who chose the augmented products ate 44 grams more of applesauce when served 62 grams more, 16 grams more carrots when served 25 grams more, and 20 grams more orange when served 46 grams more (Table 15).

Pea menu days

The consumption of applesauce and oranges increased percentagewise between the control and experimental days (combined), but not the consumption of carrots. The percentage increases between the control and experimental days were as follow, 63% for applesauce and 14% for oranges (Table 16). Students ate 11% less carrots during the experimental days when compared to the control day. Students who chose the augmented products ate 68 grams more of applesauce when served 60 grams more, 4 grams more of oranges when served 28 grams more, and 2 grams *less* carrots when served 17 grams more, (Table 16).

Table 15: Impact of the portion size increase on consumption for those students taking fruits and vegetable when the green bean menu was served

Type of fruit or vegetable	Average increase served on experimental days (g)	Average change in consumption^ (g)	Average percentage increase in consumption due to increase in portion size
applesauce	62	44	71
carrots	25	16	64
oranges	46	20	43

^ averages from LS means

Table 16: Impact of the portion size increase on consumption for those students taking fruits and vegetable when the pea menu was served

Type of fruit or vegetable	Average increase served on experimental days (g)	Average change in consumption^ (g)	Average percentage increase in consumption due to increase in portion size
Applesauce	60	39	63
Carrots	17	-2	-11
Oranges	28	4	14

^ averages from LS means

Increasing portion size by 50% can increase intakes of fruits and vegetables for students participating in school lunch as a whole

Green bean menu days

The consumption of augmented fruits and vegetable per student eating school lunch rose between 1 and 13 grams during the green bean menu when comparing the control day to the experimental days. For applesauce the amount consumed per child eating school lunch increased 7 grams from control to experimental day 1 and 12 grams from control to experimental day 2 (Table 17). For carrots, consumption increased 1 gram between the control and experimental day 1 and 3 grams between the control and experimental day 2 (Table 17). For orange consumption, students ate about 13 more grams on experimental day 1 when compared to the control day and 10 grams more when comparing the control day to experimental day 2.

Pea menu days

The consumption of applesauce and carrots increased for the experimental days when compared to the control day, but orange consumption was only increased on experimental day 1 during the pea menu per student eating school lunch. Applesauce consumption per student eating school lunch increased 8 grams when comparing experimental day 1 to the control day and 16 grams when comparing the control day to experimental day 2 (Table 18). Carrot consumption only increased 1 gram between the control day and experimental day 1, the same was true for the control day and experimental day 2 (Table 18). For orange consumption, there was a 3 gram increase in consumption between the control day and experimental day 1. There was no change in pea consumption between the control day and experimental day 2 (Table 18).

Table 17: Average consumption (g) per student eating school lunch for each fruit and vegetable on green bean menu days

Type of fruit or vegetable	Sum of consumption per item/ number of students eating school lunch on control day	Sum of consumption per item/ number of students eating school lunch on experimental day 1	Sum of consumption per item/ number of students eating school lunch on experimental day 2
applesauce	23284/680 = 34	27081/663 = 41	31380/684 = 46
carrots	1627/680 = 2	2360/663 = 3	3202/684 = 5
oranges	5029/680 = 7	13437/663 = 20	11410/684 = 17
green beans	776/680 = 1	758/663 = 1	822/684 = 1

Table 18: Average consumption (g) per student eating school lunch for each fruit and vegetable on pea menu days

Type of fruit or vegetable	Sum of consumption per item/ number of students eating school lunch on control day	Sum of consumption per item/ number of students eating school lunch on experimental day 1	Sum of consumption per item/ number of students eating school lunch on experimental day 2
applesauce	20914/631 = 33	26699/643 = 41	32142/654 = 49
carrots	1589/631 = 2	1747/643 = 3	2309/654 = 3
oranges	10696/631 = 17	13051/643 = 20	11415/654 = 17
peas	645/631 = 1	803/643 = 1	996/654 = 1

Increasing portion size by 50% does affect the number of servings taken, but in varying ways

There did not seem to be any particular pattern for proportions of students taking fruits and vegetables when comparing control and experimental days for the two menu types.

Carrots

The proportion of students who took carrots was not significantly different between control and either experimental day during the green bean menu (Table 19 and Table 20). For the pea menu, students who ate school lunch took a higher proportion of carrot servings on experimental day two than on the control day; there was no difference between the control day and experimental day 1 (Table 21 and Table 22). [It needs to be reiterated that we served less carrots by weight on experimental day 2 than on the control day for the pea menu].

Oranges

The proportion of students who took oranges was significantly higher on both experimental days than on the control day during the green bean menu (Table 19 and Table 20). This was not true during the pea menu. The proportion of children who took oranges during experimental day 1 and experimental day 2 did not significantly differ from the proportion of students on the control day (Table 21 and Table 22).

Applesauce

For the green bean menu, the proportion of students who took applesauce actually decreased on both experimental days in comparison to the control day (Table 19 and Table 20). For the pea menu, the proportion of students who took applesauce was not significantly different between the two experimental days and the control day (Table 21 and Table 22).

Table 19: Proportion of all students eating school lunch that took the specific fruit or vegetable for the green bean menu

Type of fruit or vegetable	% of students taking fruit/veg on control day (n=680)	% of students taking fruit/veg on experimental day 1 (n=663)	% of students taking fruit/veg on experimental day 2 (n=684)
applesauce	46	36	36
carrots	12	12	14
oranges	35	52	50

Table 20: Comparison of proportion of students taking fruits and vegetables between control and experimental days on the green bean menu

Type of fruit or vegetable	Z score for control v experiment day 1	P value for z score of control v experiment day 1	Z score for control v experiment day 2	P value for z score of control v experiment day 2
applesauce	3.9	<.0001	3.8	.0002
carrots	0.1	0.93	-1.1	0.27
oranges	-6.3	<.0001	-5.6	<.0001

Table 21: Proportion of all students eating school lunch that took the specific fruit or vegetable for the pea menu

Type of fruit or vegetable	% of students taking fruit/veg on control day (n=631)	% of students taking fruit/veg on experimental day 1 (n=643)	% of students taking fruit/veg on experimental day 2 (n=654)
applesauce	39	35	39
carrots	10	11	16
oranges	54	52	49

Table 22: Comparison of proportion of students taking fruits and vegetables between control and experimental days on the pea menu

Type of fruit or vegetable	Z score for control v experiment day 1	P value for z score of control v experiment day 1	Z score for control v experiment day 2	P value for z score of control v experiment day 2
applesauce	1.4	0.17	-0.1	0.95
carrots	-0.5	0.60	-3.1	0.0022
oranges	0.6	0.52	1.9	0.06

CHAPTER 6: DISCUSSION

6.1 Comparison of consumption between our study and that of Kral et al. (2010): comparing 5-6 Year olds from both Studies

Both our study and that of Kral et al. (2010) resulted in increases in applesauce consumption when portion sizes of fruit and vegetable side dishes were augmented among kindergarten aged children. Kral et al. (2010) was able to increase the amount of applesauce eaten by ~36 g (~46%) for children aged 5-6 years. This occurred when serving 122 g during the control phase and 244 g during the experimental phase. Our results show an increase in ls means of applesauce consumption of about 46 to 60 grams (54% to 92%) among kindergarteners (Table 13 and Table 14). We served ~115 g and ~180 g between our control and experimental days between both menus (Tables 7 and 8). Thus, for kindergarten-aged children, our results showed an average increase in ls means for consumption of 73% between control and experimental days for both menus, larger than those of Kral et al. (2010).

There are likely several factors as to why our kindergarteners ate more applesauce when served more when compared to the kindergarten aged children of Kral et al. (2010) including choice, preexisting relationships, and portion sizes. One possible explanation as to why our children had higher intakes of applesauce when served more is we didn't make their choices—students had options. This is important because when people are offered more choices they are likely to eat more in general (Rolls et al., 1981). Also, our students knew the people they were eating with, whereas in the Kral et al. (2010) study, participants were recruited from the community. (Salvy, Howard, Read, & Mele, 2009). Lastly, our group of 5-6 year olds was served about 56% more applesauce while the group in the Kral et al. (2010) study was served 100% more during the experimental condition.

Like Kral et al. (2010), we were not able to *significantly* increase the consumption of carrots among kindergarteners (Table 13 and Table 14). For our study, there was no difference between the control and experimental days for carrot consumption. These results are comparable to those of Kral et al. (2010) who reported no significant increase in carrot consumption between conditions.

6.2 Possible confounding factors with control and experimental days

Because control days occurred before experimental days, it is possible that growth in this pediatric population influenced consumption, increasing it over time. When examining the data for green beans and peas, whose portion size was not increased from control to experimental days, there seemed to be an upward trend in consumption as time progressed (Tables 9 and 11). The increase looked to be about 8-10 grams of increased consumption of peas and green beans from the control to experimental conditions. The values for consumption of green beans were 22 g on the control day and 18 g on experimental day 1 and 30 on experimental day 2. For the peas, the values for consumption were 16 g on the control day and 26 g on both experimental day 1 and experimental day 2. Thus, this 8-10 gram increase from control to the experimental days could have been due to time. When comparing applesauce consumption between the control and experimental conditions, there was about a 41 gram average increase between both menu types (Table 9 and Table 11). Based on the average increase in consumption of applesauce and that of peas and green beans, it is possible that up to 24% of increased consumption could have been due to timing alone. One should take this suggestion with a grain of salt however, considering the proportion of students taking peas on any one day was about 6% (Table 11) and about 5% for green beans (Table 9).Thus, the data for peas and green beans were likely not a good representation of our students.

Our ls means for consumption may have been affected by the lunch period children ate in. Since children ate in six lunch periods beginning at 10:50 in the morning with the last session arriving at 12:40, hunger may have definitely played a role in consumption (Table 23). Grade and time of lunch period were confounded. Moreover, since fourth graders ate in two lunch periods, and we did not differentiate between the two sets of fourth graders, we cannot say more firmly how much of an effect timing had on consumption based on this group. However, if one compares consumption of third graders (who ate last) with the other grades, one will notice that they tend to have higher consumption than most grades (Figure 7 and Table 24). This gives some credence to the hypothesis that if a child ate later, then he/she was more likely to eat more.

Table 23: Lunch periods and the grades who attended each

Lunch Period and time	Grade(s)
1 (10:50 – 11:10)	1 & 2
2 (11:10 – 11:30)	4
3 (11:30 – 11:50)	5
4 (11:55 – 12:20)*	k
5 (12:20 – 12:40)	4
6 (12:40 – 1:00)	3

*Kindergarteners were allowed more time to eat as they needed more assistance

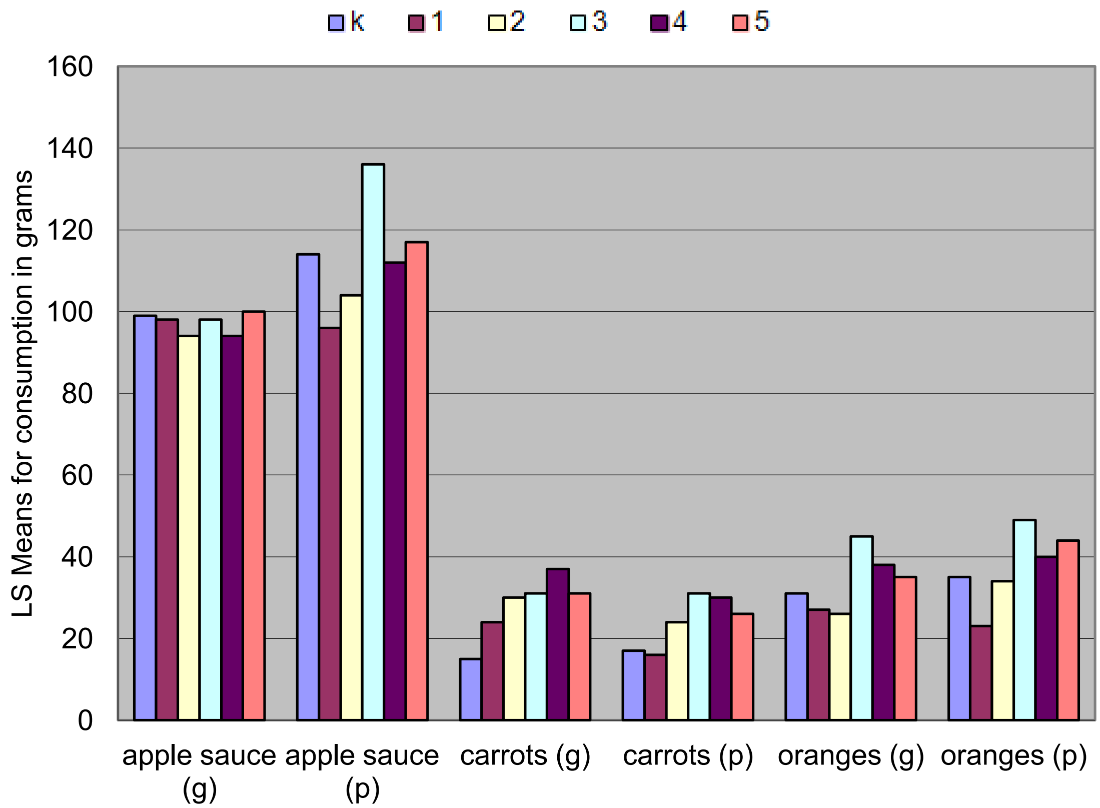

Figure 7: Least squares mean consumption of augmented fruits and vegetables between menu types, green bean (g) or pea (p) and grades (see legend)

Table 24: Consumption in grams per student taking each fruit or vegetable (collapsed over all control and experimental days) for selected fruits and vegetable served on the green bean and peas menus for each grade

	Type of fruit or vegetable and menu type					
grade	applesauce		carrots		oranges	
	green bean	peas	green bean	peas	green bean	peas
k	99	114	15	17	31	35
1	98	96	24	16	27	23
2	94	104	30	24	26	34
3	98	136	31	31	45	49
4	94	112	37	30	38	40
5	100	117	31	26	35	44

The five extra minutes allotted to kindergarteners to eat seemed to have increased the amount they were able to consume. Consider the amounts consumed by kindergarteners in regards to other grades (Table 24); the youngest students in our study only had one consumption data point that was the smallest compared to the other grades. Moreover, kindergarteners ate more applesauce and oranges than first and second graders for both menu types (Table 24). When solely considering the ages of our students, one would not logically think this age group would have eaten more than some other grades. However, when a lunch period is only twenty minutes long for most students and needs to include the time it takes to wait in line, input one's pin, assemble one's tray, then find a seat, it cuts into the time one has to eat. On average, elementary school children need about 10 minutes from the time they sit down until they bring their tray to the garbage to consume school lunch (Conklin, Lambert, & Anderson, 2002). However, an average of 39% of elementary school-aged children will need more than 10 minutes (Sanchez, Hoover, Sanchez & Miller, 1999). (At the STEM school, most children received 20 minutes to eat lunch, but since we did not measure the time it takes from the end of the line waiting to punch in a pin number to sitting at the table, we are unsure of how much time our students had to sit and eat). If a child happens to be the last person in line for their lunch period, they will have less time to eat than the first child in line. Therefore, this child may decide to eat more of the main dish as it may be less time consuming to eat. Children in a study out of the Netherlands reported eating more fruit on the weekends because they had more time to eat than during the school week (Wind, Bobelijn, De Bourdeaudhuij, Klepp, & Brug, 2005). If students in the Netherlands eat more fruit when allotted more time on the weekends, it may also relate to eating fewer vegetables at school. In our study, if a child chose something like baby carrots as their vegetable side dish, it more than likely would have taken more time to chew a portion of carrots than a portion of popcorn chicken. In general, this is likely true for most age groups, but may be especially relevant for a population like ours who frequently are missing a few teeth. Thus, kindergarteners likely ate more than expected due to the five extra minutes they were allotted in comparison to the other grades.

6.3 Many children chose not to put a fruit or vegetable on their tray

The proportion of students who took a fruit or vegetable during our school lunch period doesn't seem to be as high as results from other studies. In a study conducted in the United Kingdom (UK) investigating fruit and vegetable intake among children receiving school lunch, 36% of children chose fruits and 81% chose vegetables when receiving school lunch (Golley, Pearce, & Nelson, 2010). In our study, the best we achieved for students taking a vegetable was 16% (for carrots) and 54% for fruit (for oranges) (Tables 19 and 21). However, the amount of students who chose fruits and vegetables in the Golley, Pearce, & Nelson (2010) is not equally comparable to our study as the data from the UK study were grouped across all vegetables and across all fruits, whereas our data were for a single fruit or vegetable. Furthermore, the amount of students who took fruits or vegetables in our study was "very low" in comparison to the same school using a different method of increasing vegetable intake (M. Reicks, Ph.D., personal communication, September 17, 2012). In a study completed within the STEM school during the same year as our study (2011), Reicks, Redden, Mann, Mykerezi & Vickers (2012) had up to 37% of students taking carrots during their intervention. There is at least one explanation as to why our numbers were lower than others. We did not have any sort of education, whereas the other study within the STEM school (Reicks et al., 2012) used pictures in a lunch tray to exhibit vegetables in them. In the UK study (Golley et al., 2010) education was not given, but they still had a higher percentage of students taking vegetables, but the reason is unknown.

6.4 Cost of intervention and its worth

The increased monetary costs for fruits and vegetables during our experimental days in comparison to the average increase in consumption are investigated below. For our study period, depending on the time of year and type of produce, a single, standard size portion of a fruit or vegetable ranged from $0.15 to $0.25 per serving. During our experimental days, the cost rose to about $0.23 to $0.38 per serving of fruit or vegetable. This is about an 8 to 13 cent rise in cost, or on average, about an 11 cent rise in cost for increased portion sizes. When comparing all the averages of every fruit and vegetable combined for students taking fruits and vegetables for the control days (combined) and the experimental days (combined) with both menu types combined, there was an average of a 17 g increase in fruit and vegetable consumption between the control and experimental days. This means for every student eating fruits and vegetables, we spent an average of 11 cents for a 17 g increase in consumption of fruits and vegetables.

To investigate whether our intervention would be more or less expensive in a school setting in comparison to home, we calculated the cost per gram of our products in comparison to similar products one could order from a delivery grocer (Coborns Delivers). From prices gathered on May 4, 2013 from corbornsdelivers.com, we found that on average, it would cost $0.003 per gram of an average fruit or vegetable similar to the ones served in our study. It cost us an average of $0.006 per gram of fruit or vegetable in our study, thus a school based intervention seems to be doubly more expensive than buying the similar products in the home setting. However, for students on free lunch, it definitely costs parents more to buy a serving of fruit or vegetable than having their child eat these items at school.

The increased cost of our study was not worth it for fruit consumption in terms of the extra weight consumed during our intervention for children eating school lunch. The recommendations for fruit and vegetable consumption for one meal equate to 100-125 grams for children aged 4-11 years (New South Wales Department of Health, 2013). However, for children aged 4 to 7 years, the minimum recommended fruit and vegetable intake is about 300 grams per day with two-thirds of that amount coming from vegetables. For children 8 to11 years, the minimum recommended amounts of fruits and vegetables increases to 375 grams with ¾ coming from vegetables (New South Wales Department of Health, 2013)). Using the recommendations above, the amount of fruit that should be eaten during one meal should be about 30 to 31 grams (100*.3=30; 125*.25=31.25). Among students eating school lunch, the average fruit intake during control days over both menu types was already 45 grams—15 grams above the minimum requirement for fruit intake at one meal (Table 17 and Table 18). Thus, when intake increased to an average of 63 grams over during the combined experimental days, it was not necessary. (However, if children were not eating fruit at home, then perhaps this 18 gram increase in fruit intake was beneficial for getting closer to meeting this dietary recommendation). Our intervention increased fruit intake by about 18 grams. This means we paid about one half a cent for each additional gram of fruit eaten. Our intervention was not worth it for fruit consumption because our children ate an average of 45 grams of fruits during the control days, which was already exceeding the recommendation for fruit consumption for children aged 4-11.

The cost of our intervention for the increase in vegetable consumption among children eating school lunch was not worth it. For average consumption of vegetables among all children eating school lunch, values were very low at 3 g for the control days for both menu types and 4.5 grams for the averaged experimental days over both menus. On average, we increased the amount of vegetables eaten among the students eating school lunch by an average of 1.5 g. This means for a 1.5 gram increase in consumption, we paid about 11 cents—much more than we paid for the gram increase in fruit consumption.

Since students ate more orange quarters and applesauce than other produce items offered during our study, the nutritionals of these two items (in particular, vitamin C and potassium) will be examined to investigate whether the size of the increase in intake was worth the cost. [Vitamin C and potassium were chosen as oranges are best known for these two nutrients]. For all students consuming school lunch, we had an increase in applesauce consumption of 9 grams during the green bean menu and an increase of 12 grams during the pea menu—an average of 11 grams (Table 17 and Table 18) . This amounts to a cost of about 7 cents per child eating school lunch. For all students consuming school lunch, orange intake increased about 11 grams during the green bean menu and 1 gram during the pea menu—an average of 6 grams (Table 17 and Table 18). This would equate to about a 4 cents per child eating school lunch. The average increase of 11 grams of applesauce equates to an increase of 0.11 mg of vitamin C and a 4.44 mg increase in potassium (U.S. Department of Agriculture, n.d.b). In terms of overall nutrition, this would be less than 1% of the RDA for vitamin C and less than 1% of the AI for potassium for children aged 4 to 8 years (Drake, 2011). The 6 gram average increase in orange consumption during our experimental days meant we were able to increase vitamin C consumption by 3.2 mg and potassium intake by 10.8 mg (U.S. Department of Agriculture, n.d.a). This equates to 12.8% of the RDA for vitamin C and less than 1% of the AI for potassium for children aged 4-8 years (Drake, 2011). Since the RDA and AI increases for vitamin C and potassium due to the increases in applesauce consumption were less than 1% of what is necessary for children aged 4-8, the cost of increasing the proportion of applesauce was not worth the size of the increase of consumption for this product. Similarly, the increase in orange consumption increased the amount of potassium the students ate by less than 1% of the AI necessary for children aged 4-8 years. A 12.8% increase in the RDA of vitamin C was worth the cost because it only cost us 4 cents and was a substantial increase. Since males and non-Hispanics whites are likely to be vitamin C deficient in the United States and they were part of our data set, the 12.8% value for the RDA of vitamin C obtained from the increase in orange consumption was likely worth the cost in a micronutrient sense as it would bring children closer to the recommendation for vitamin C for children aged 4-8 years (CDC, 2012a). Thus, it may only be worth the money to pay for increases in nutrient rich fruits and vegetables; in this case, the nutrient poor applesauce was not worth the cost, but the nutrient rich oranges were.

The intake of oranges during control days had a greater nutritional value than the intake of applesauce during control days. For the average student eating school lunch during averaged control days, intake of oranges was about 12 grams. This value of 12 grams of orange equates to 6.4 mg of vitamin C and 21.6 mg of potassium (U.S. Department of Agriculture, n.d.a)—25.6% of the RDA for vitamin C and less than 1% of the AI for potassium for children aged 4-8 years (Drake, 2011). Since applesauce itself isn't really known for any nutrient in particular, other than sugar, vitamin C and potassium will also be evaluated for applesauce. For the average student eating school lunch during averaged control days, intake for applesauce was about 34 grams. This equates to 0.34 mg of vitamin C and 25.16 mg of potassium (U.S. Department of Agriculture, n.d.b)—just over 1% of the RDA for vitamin C and less than 1% of the AI for potassium for children aged 4 to 8 years (Drake, 2011). This is to say that the value of serving oranges was greater than the value of serving applesauce when solely focusing on potassium and vitamin C.

6.5 Strengths and weaknesses of our study

There are several strengths associated with our study. One of our biggest strengths is the number of students we were able to include. Our school had a population of about 800. Our population was also very diverse with the majority of our students coming from low-income homes. Having low income students was important as fruits and vegetable at school may be one of the few places they are able to get them. Moreover, another strength of our study was that we were able to track individual students. We also included a variety of fruits and vegetables in our study of different types of preparations (fresh, canned, cooked, etc.); most studies in our literature review did not have more than one or two preparations.

There are a few weaknesses associated with our study as well. The first weakness is that we were unable to differentiate trends in eating patterns due to grade because it was completely confounded by lunch session. Another weakness was we did not rate hunger. If measurements of hunger had been taken, then we could have determined how much of the variability in consumption was actually due to portion size and how much was due to hunger (a major player in consumption). However, hunger levels probably had a minor role in our study as the same groups of students ate during the same time period during both control and experimental days. With that said, hunger would have still be relevant between days as children may have skipped breakfast on one day, but not another. Another weakness was we did not request any information regarding fruit and vegetable consumption within the home. If we were able to have this type of data and tie it to individual students, we would have been able to determine if students who were choosing fruit and vegetables at school were also choosing them at home. Perhaps we would have also been able to examine whether students were eating adequate amounts of fruits and vegetables at home.

6.6 Further areas of research

Further research into portion size manipulation could use the general methods of our study but add more components (like surveys) to examine how much of the variability in consumption is due to portion size in comparison to several other things. For example, if one wanted to test how much aesthetics affected consumption of fruit or vegetables, they could ask students to rate the look of each fruit and vegetable. Using a survey and our methods, the researchers could record the results of the rating in comparison to the consumption data to determine if aesthetics were related to fruit and vegetable consumption. Researchers could also ask students to taste test all fruits and vegetables prior to experimental days like Kral et al. (2010) to interpret how much preference affects consumption in relation to portion size in a school setting. If elementary school children react similarly to infants, then taste testing would likely increase the amount consumed with increased exposure (Sullivan & Birch, 1994; Forestell & Mennella, 2007).

Other questions can be investigated adding on to our methodology as well. For example, researchers can ask whether or not children are able to perceive the increased portion sizes. If they are able to point out the portion size manipulation—how does this affect their willingness to take/eat it? (In our study, portion size did not seem to affect the proportions of students taking fruits and vegetables). Is the extra portion size seen as a bargain or scary? No matter what the question, all will be important in expanding our knowledge base of what affects children's consumption of fruits and vegetables in the school setting.

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APPENDIX

Procedures

Initial Weights

- Before tray line begins, please take 10 samples of each item available on the line.
- Weigh each group of 10 samples and calculate the average weight of each item—this will give you the individual average initial weights.

ID Cards

- On each slip of paper please print the name and PIN number of each student by teacher. * note * This should be done prior to arriving at the site.
- When a teacher's name is placed at the end of a table at the beginning of a lunch period please place all of the students ID cards corresponding to that teacher at the end of the table.
- Except for kindergarten, please ask 3-4 volunteers from the class to pass out the ID cards to classmates before they are allowed to go into the lunch line.
- For kindergarten, please call children's names and pass individual ID cards to the responding child.
- Instruct the children to take their ID slips into the line when them when their table is allowed to get in line.
- Once in line, please place an ordinal number sticker over the child's name on the ID card. If the child has forgotten his/her ID card, please put the sticker on the child's shoulder.
- Go around the tables and ensure all children have ordinal numbers over their names, if they haven't done so, please do it for them.
- If a child at the table does not have an ID number, obtain the child's name and go to the cash register to obtain the child's pin number. Make a new card for the child and place the pin number over his/her name. Mark the card to ensure we have a card for the student at the beginning of the next session.

Ordering by position in line

- Please stand in front of the line before the children are allowed to move from their tables.
- As each child lines up, please place a sticker on the ID slip corresponding to their place in line, for example, if the child is second in line, please place the sticker with the number 2 on their ID slip.

- If a child does not have his/her card put the ordinal sticker on the child's shoulder to be put on the card when they go to their table.

Item Choice

- Please stand at the end of the tray line and observe the items on each tray as the children pass by.
- Make sure that the foods are correct on your data sheet. If you see a child with a pear on his/her tray and you do not have it on your sheet, please add it.
- You will receive a clip board with some sheets of paper that have the ordinal number on the left and columns with food for the day on the top.
- Mark the items that you see on each tray. For example, if child number 16 has a pear, a peanut butter and jelly sandwich, a milk, and peas, you would put a check in the box for pear, the box for pb & j sandwich, the box for milk and finally the box for peas corresponding to child 16.

Peer Influence on eating

- As the children return to their tables, note their positions by writing down each child's number on the table diagram corresponding to their position around the table—MAKE SURE THE TEACHER'S NAME ON YOUR DIAGRAM MATCHES THE TEACHER'S NAME AT THE END OF THE TABLE.
- If there are spaces between the children, mark the empty seats with an X.

Weighing

- Tare your scale before beginning any data collection—make sure that when there is nothing on the scale, the scale reads zero. If the scale reads anything else, you will need to re-tare it.
- Place something of a known weight on the scale and make sure the read out is accurate.
- Tare 2 scales for each type of container being used for the day.
- As each table is dismissed they will go to the trash line to dispose of any uneaten food/packaging—collect all fruit and vegetable plate waste (including containers) and instruct the students to throw the rest away.
- As quickly and as ACCURATELY as possible, put each item onto its respective scale (correspond the container which holds the plate waste to its tared scale)
- Weigh each item on each individual ID card.
- Record each of the remaining amounts on the table documents by *ordinal* number.

SAS Coding

The following is an example of proc mixed coding used in SAS:

```
proc mixed data = gb;

title applesauce on green bean days PIN model;

class pin grade day condition;

model applesauce = grade pin(grade) condition;

LSMEANS  grade condition ;

LSMEANS  grade condition / pdiff

run;
```

The following is an example of proc univariate coding used in SAS

```
proc univariate data=d3;

title proc univariate applesauce day3;

var applesauce;

run;
```