PLATE MAPPING: USING DRAWINGS OF FOODS TO EXAMINE ASSOCIATIONS OF PLATEWARE WITH PERCEPTIONS, PREDICTIONS, AND RECALLS OF MEAL SIZE AND MEAL COMPOSITION

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PLATE MAPPING: USING DRAWINGS OF FOODS TO EXAMINE ASSOCIATIONS OF PLATEWARE WITH PERCEPTIONS, PREDICTIONS, AND RECALLS OF MEAL SIZE AND MEAL COMPOSITION

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People eat meals rather than nutrients or food groups. Meals are typically eaten off of plates in American households. Plate size may influence meal size, meal composition, and food type. To examine the effects of plate size on meals, a new method called plate mapping was developed to analyze how participants responded to varying plate sizes and shapes. Four unique studies were developed and analyzed that used plate mapping to examine how various plates affected participant's estimations of food portion size and meal size. Two quasi-experimental studies asked participants to accurately draw and label a dinner on either a 9" or 11" standard paper plate. One quasi-experimental study asked participants to complete the same study design using either a 9.5" or 10.5" plate divided into three compartments. To validate plate mapping, a quasi-experimental study was conducted that asked participants in a college cafeteria to draw their self-purchased lunch at either pre-consumption or post-consumption time points on either a 9" or 11" paper plate.

Three studies were done on the campus of a large college in the Northeastern United States (n=270, n=248, & n=98) and a fourth study recruited adults from a medium sized city in the Northeastern United States (n=281). The independent variable was plate size. Dependent variables were meal size, meal plate coverage, individual sizes of foods by food type and portion, and temporal condition of a meal (pre- or post-

consumption). Gender was a moderating variable.

Overall, the size of plate drawings was highly correlated with the size of actual foods when the size of the plate drawn on was equivalent to the size of the plate containing the food. This provides support for the validity of the method of plate mapping and suggests that researchers must be cognizant of plate size whenever conducting research involving plates. Participants reported larger meal sizes whenever larger plates were provided, suggesting that participants are sensitive to the size of the plate and predict or recall meals as larger in the presence of larger plates. Gender moderated meal size drawings, with women generally drawing meals that were more highly correlated and similarly sized to actual meals than men. The effects from differing plate sizes appears to be more powerful for males than females and may encourage larger food servings by men. These findings suggest plate mapping can be used to reflect meal conceptualizations and assess sensitivity to plate size. Further research examining plate sizes influence on meals is needed to increase understanding of how participant estimations of “proper” meal sizes are developed and maintained.

BIOGRAPHICAL SKETCH

David Sharp earned his Bachelor of Arts degree in Cultural Anthropology from The University of Santa Cruz in 2007. In 2009 he joined the doctoral program in Community Nutrition at Cornell University.

While pursuing his degree, Dr. Sharp created and organized Dr. Jeffery Sobal's Built Environment lab. During his years at Cornell, he also ran Dr. Anthony Ong's Resilience and Lifespan Development lab and served as a researcher for Dr. Brian Wansink's Food and Brand Lab.

Dr. Sharp has been the recipient of numerous honors and awards including a Student Scholarship from the Society of Nutrition Education and Behavior Foundation and a Barnes Alumni Fellowship from Cornell University. He was also selected as an NIH NIDDK Cornell Nutrition Training Grant Trainee.

Dr. Sharp has presented his research at the Society for Nutrition Education and Behavior and the Association for the Study of Food and Society conferences and has published his dissertation research in the journals *Appetite* and *Eating Behaviors*.

Dr Sharp's dissertation, Plate Mapping: Using drawn representations of food to explore the effects of plateware on prediction, recall, and perceptions of meal size, was supervised by Dr. Jeffery Sobal.

To my wonderful children in the hopes that they one day will be inspired to read it and understand.

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CHAPTER 1: INTRODUCTION

Obesity is a prevalent health problem in the United States and globally (WHO, 2000; Ogden, Carroll, Kit, & Flegal, 2013). Excess body weight has been connected to increases in morbidity and mortality and a reduction in the overall quality of life (Flegal, Kit, Orpana, & Graubard, 2013). One influence on obesity is the overconsumption of food (Rennie, Johnson, & Jebb, 2005; Young & Nestle, 2003). With the prevalence of super-sized food portions, max-pack food containers, and cheap, high-calorie snacks readily available in homes, grocery stores, and restaurants, the United States has become saturated with food calories. An excessive availability of food, when combined with the environmental cues to eat that come from radio, television, internet, and billboards, create a landscape where it is difficult for an individual to not be constantly in a state of looking at or thinking about food.

There is extensive research about environmental variables that may impact food consumption (Sobal & Wansink, 2007). Some of these environmental variables may influence us in ways that we are not aware of or fail to actively monitor (Rozin, Dow, Moscovitch, & Rajaram, 1998). These factors may drive food intake without individuals even knowing that they have been affected. One such factor includes the size of the vessel in which food is served (Kallbekken & Sælen, 2013). While the USDA offers guidelines about appropriate eating practices (U.S. Department of Agriculture & U.S. Department of Health and Human Services, 2010), it does not have similar guidelines for the plates and bowls that those portions are served in to. Even to experts, proper portion size can be hard to discern when seen on different sized vessels.

Larger serving vessels are associated with people taking larger food portions in several studies. For example, Wansink, van Ittersum, & Painter (2006) examined whether bowl size could influence portion size selection of ice cream by nutrition experts. In a 2x2 study design, 85 nutrition professionals were randomly given either a large or a small bowl and a large spoon or a small spoon. The participants who were given the larger bowl served themselves, on average, 31% more ice cream than participants provided with a smaller bowl. These findings have also been observed in children (Fisher & Kral, 2008). Similar results were found when van Kleef, Shimizu, & Wansink (2012) provided participants with two sizes of serving bowls filled with pasta but did not change the size of the vessel that participants used to eat from. Participants in the larger serving bowl condition self-served themselves 77% more pasta when compared to the portions served from the smaller serving bowl. DiSantis et al. (2013) found that children's self-served portion sizes increased when the sizes of both plates and bowls increased. Wansink, Payne, & Werle (2008) have shown that children's self-served portion sizes of cereal increased when the available bowl size increased. All of these studies illustrate that the size of the bowls and plates in which people eat from can influence the size of self-served portions.

Large pre-served portion sizes encouraged greater food consumption in several studies (Rolls, Morris, & Roe, 2002; Scheibehenne, Todd, & Wansink, 2010). A study that utilized inconspicuous self-refilling bowls found that participants given the self-refilling bowl consumed 73% more than those with a normal fixed amount bowl (Wansink, Painter, & North, 2005). Participants who consumed more reported that they had not perceived that they ate more than those with the non-refilling bowls. These participants who did not report knowing that they consumed more soup also did not indicate that they were more satiated. In combination with the findings of van Kleef, & Wansink (2012), these results suggest that participants who self-serve larger portions may not result in increased feelings of satiation even though participants consumed more food. This association between portion size and intake was found to operate when portion sizes were decreased as well. For example, Rolls, Roe, Halverson, & Meengs (2006) reported that decreasing portion size and energy density decreased energy intake without changing hunger and fullness ratings.

While prior research finds evidence for a relationship between portion size and energy intake, recent literature reviews report mixed findings about the relationship between vessel size and real or imagined portion size (Libotte et al 2014; Wadhera & Capabaldi-Phillips, 2014). Prior studies have generally shown a relationship between three dimensional vessels such as drinking glasses and bowls and portion sizes where even individuals considered “experts” in portion or serving sizes like bartenders (Wansink and van Ittersum, 2005) and nutrition faculty (Wansink et al., 2006) self-serve differently sized portions depending on the shape or size their vessel. Drinking glasses have been shown to promote size miss-estimating depending on whether the participants were given a tall, thin glass or a short, wide glass (Wansink & van Ittersum, 2005). A majority of the studies that do identify an effect of vessel size on portion size and consumption utilize bowls as the dishware in which food is served (Wansink & Cheney, 2005; Wansink, van Ittersum, & Painter, 2006; Wansink & van Ittersum, 2007; Van Ittersum & Wansink, 2012. These studies suggest that there may be an association between vessel size and consumption. Like larger bowls, larger plates increase the size of food that people can serve themselves, and having more food available on a plate increases the opportunity for a person to consume more food.

While bowls and glasses have generally been shown to influence portion size, there are mixed reports about the capacity for plates to influence portion size in a similar fashion (Libotte et al., 2014). Shah, Schroeder, Winn, & Adams-Huet (2011) performed a pilot study to observe if plate size influences consumption in normal and overweight or obese women. They utilized two different size plates (8.5” and 10.8”) and a crossover study design to study potential differences in total energy intake from a single food item. This pilot study found that plate size did not affect intake in normal weight and obese women. Similarly, Yip, Wiessing, Budgett, & Poppitt (2013) found that using a smaller plate did not decrease consumption in overweight women eating in a buffet setting. Additionally, Koh & Pliner (2009) found that plate size altered consumption when a secondary measurement, degree of acquaintance, was added to the equation. A recent meta-analysis of plate size studies concluded that the difference in food consumption between small and large plates was marginally statistically significant and the magnitude of effect was small (Robinson et al., 2014). They concluded that plate size’s effect on public health was still unknown and more research was required before recommendations could be made.

Given the current research status regarding the effects on consumption volume, Figure 1.1 shows the factors previously connected to consumption volume as well as the hypothesized relationships that plate size has with gender and portion size (Yuhas, Bolland, & Bolland, 1989; Brunstrom, Rogers, Pothos, Calitri, & Tapper, 2008) when influencing consumption. The potential interactions between plate size and gender, especially on serving size and consumption volume, underline the importance of better understanding the effects of plate size on meals.

FIGURE 1.1: HYPOTHESIZED RELATIONSHIP BETWEEN PLATE SIZE, SERVING SIZE, AND CONSUMPTION VOLUME

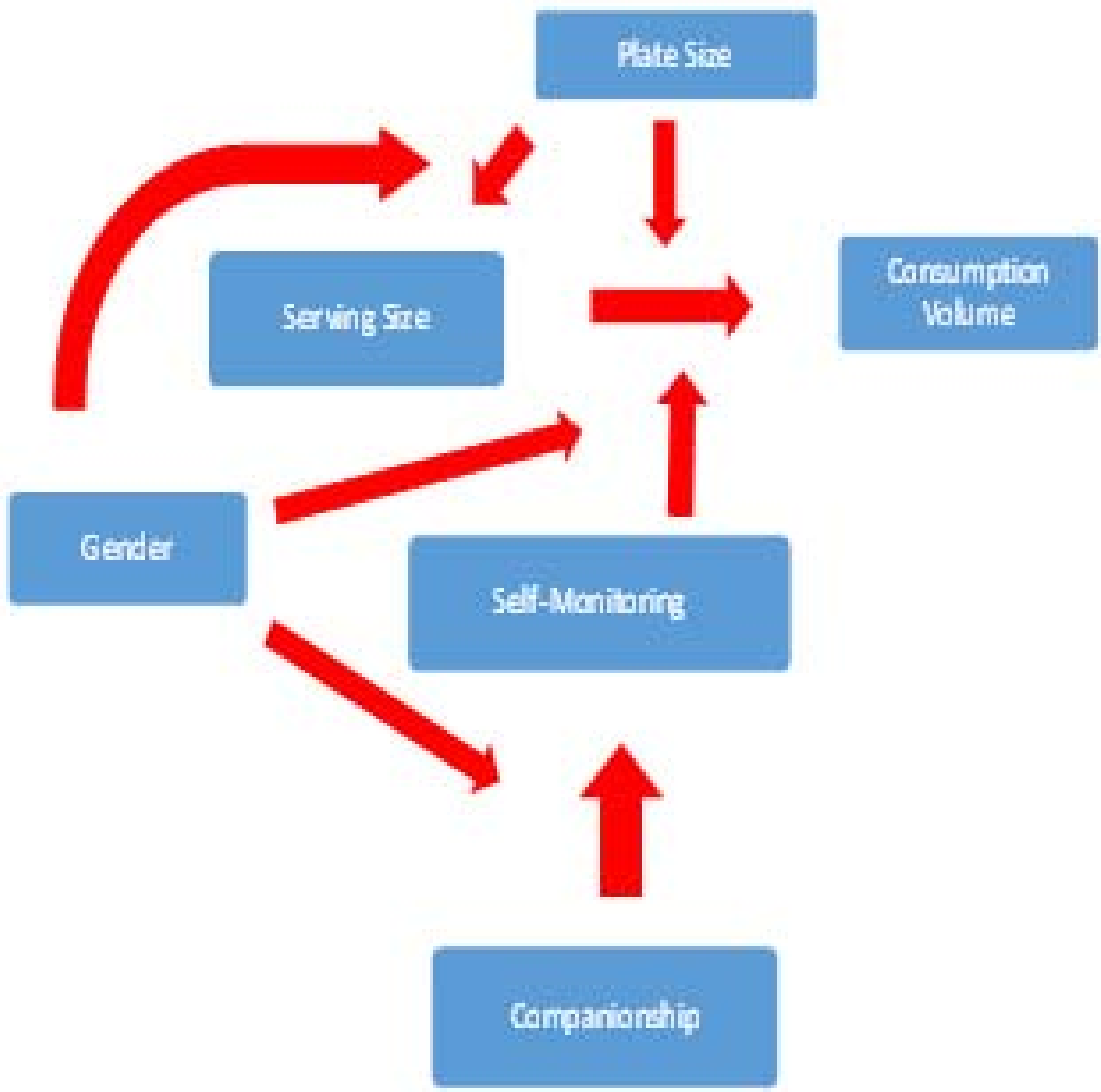


Plate Mapping

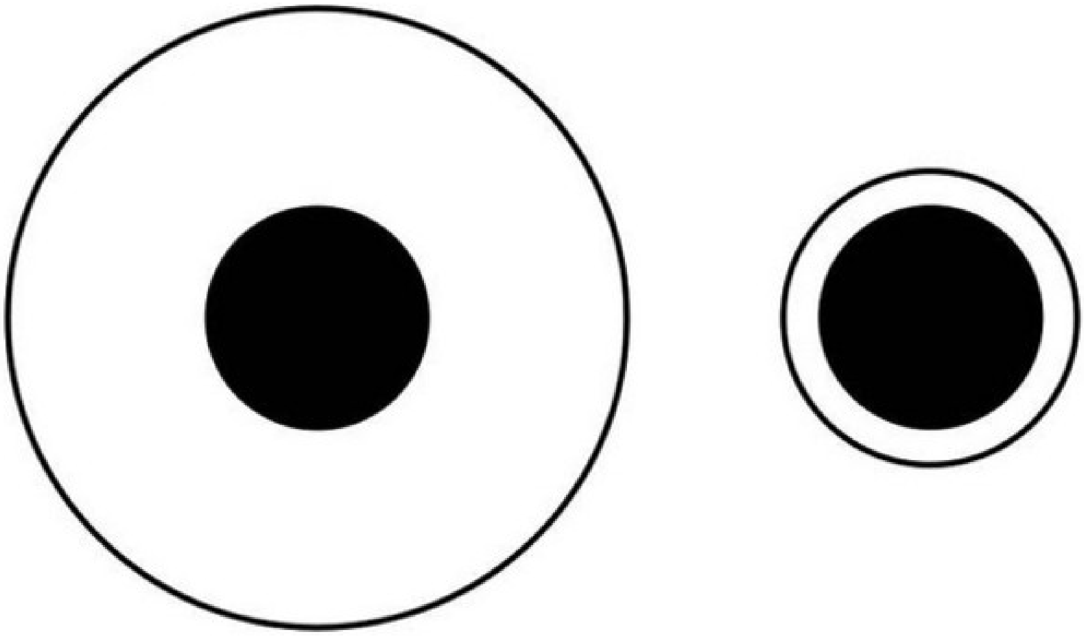
Plate mapping is a way to measure an individual's meal conceptualization (Sharp & Sobal, 2012; Sharp, Sobal, & Wansink, 2014). The plate mapping method was developed by the Built Environment and Nutrition Lab in the Division of Nutritional Sciences at Cornell University. Plate mapping measures meal conceptualization by asking participants to draw foods on a paper plate that correspond with their estimation of a meal that they have eaten, will eat, would like to eat, or are currently observing. The use of drawing is supported by studies that show that drawings of food on the horizontal plane can be used as a reasonable alternative to food models or actual food (Pratt, Croager, & Rosenberg, 2012). Steyn et al. (2006) found that two-dimensional drawings of food provided better estimates of actual energy and fat than three-dimensional models. These drawings may have been accurate because of individuals' perceptions of the size of an object anchoring on a single linear dimension, even if more than one dimension is available (Krider, Raghubir, and Krishna 2001).

Drawing on plates has previously been used by health educators in Canada as a training tool in conjunction with education to enhance the relationship between nutrition education and healthy eating in persons with diabetes (Camelon et al. 1998). Van Ittersum and Wansink (2012) also used plate drawings to examine the perceptual bias known as the Delboeuf illusion.

Over 150 years ago, Delbeouf (1865) reported a visual illusion where two identically sized circles would appear to be of different sized depending on their immediate surroundings. If a small ring surrounded it, the circle appeared larger then when compared to the same circle with a larger ring surrounded it. This illusion is based upon a phenomenon called contrast and assimilation (Coren and Girgus 1978; Nicolas 1995) and occurs to varying degrees depending on the size of the gap between the circle and the ring. When the gap is small, the brain assumes that they are the same circle (assimilation) and views it a single, large circle. When the gap is large, both items are viewed independently of each other and the relative size of the large ring emphasizes the relative smallness (contrast) of the circle, making it appear smaller. Figure 1.2 illustrates the Delboeuf illusion (row a.) and the operation between meal size and plate size in making a meal appear larger, smaller, or “appropriate” on a plate (row b.).

FIGURE 1.2: THE DELBOEUF ILLUSION, DINNERWARE SIZE, AND MEAL SIZE

a.



b.

Current research examining portion size has previously relied upon either real food or imitation food such as plastic food models or food images to collect data. Both of these options may guide the subject into thinking about specific foods or specific portions (Herman & Polivy, 2005; Levitsky, Obarzanek, Mrdjenovic, & Strupp, 2005). These external food cues provided by the researchers can anchor an individual's perceptions of portion size and may bias their food choice responses (Sobal & Bisogni, 2009; Wansink, Painter, & North, 2005). By incorporating the Delboeuf illusion into nutrition research and limiting external food cues, it should be possible to examine plate size's relationships to portion and meal size and add an under-investigated and important topic of how meals are shaped. Since there were no existing data sets available that looked at two dimensional visual representations of food portions and meal size, new research protocols were designed to add depth and better understand these influences on real and perceived food.

Four unique studies were used to collect primary data and examine the plate size's relationships with participants' ability to accurately estimate food portion and meal size, accuracy in predicting portion and meal size, accuracy in recalling food portion and meal size, and sensitivity to external influences on food portion and meal size. Participant sensitivity to the external effects of plate size on food portions and meal size is examined in college students in Chapter 2 and adults in Chapter 3. Real and perceived food portions and meal sizes are examined in Chapter 4 as both a proof of concept that participants can draw their foods immediately prior to and directly after consuming a meal and to measure the accuracy of those drawings. Chapter 5 manipulates the composition of the platescape and examines sensitivity to plate size using small and large divided plates. Finally, implications of the research and concluding summaries of the work are presented in Chapter 6.

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CHAPTER 2: USING PLATE MAPPING TO EXAMINE SENSITIVITY TO PLATE SIZE IN FOOD PORTIONS AND MEAL COMPOSITION AMONG COLLEGE STUDENTS*

*Sharp, D. & Sobal, J. (2012) Using plate mapping to examine sensitivity to plate size in food portions and meal composition among college students. *Appetite.* 59(3):639-645.

Introduction

Nutritionists promote and educate the public about calorie counts, serving sizes and food guidelines such as the MyPlate dietary tool (Post, Haven, & Maniscalco, 2012). Despite efforts to engage people in maintaining healthy diets, however, the prevalence of obesity has continued to rise (Ogden, Carroll, Kit, & Flegal, 2012) and a majority of Americans are not meeting federal dietary recommendations (Krebs-Smith, Guenther, Subar, Kirkpatrick, & Dodd, 2010). In addition, methods for assessing food intake, such as the 24-hour food recall and food frequency questionnaires, remain the usual technique for obtaining eating data in spite of their known limitations and time demands on participants (IOM, 2005). These disparities suggest an incongruity between data collection and recommendations about eating practices. Nutrition education focuses on food groups and nutrients, but eating practices primarily occur as individually constructed meals.

A ‘proper’ meal in Western cultures traditionally consists of one core food and two secondary foods, usually defined in Britain and America as a protein dish, a starch dish, and a vegetable dish (Douglas, 1972). This meal structure is embedded in our culture yet many nutrition assessment methods focus on individual food items or food groups. Nutrition interventions promote adding healthy foods that may be new or unusual for the participant without acknowledging the meal context in which each of these individual foods are embedded. Our study develops a method for eliciting an individual's personal conceptualization of a meal while being sensitive to influences from internal scripts and external environmental cues.

Previous studies have found that government recommended serving sizes often do not match estimated or actual portions consumed (Bolland, Ward, & Bolland, 1990; Bolland, Yuhas, & Bolland, 1988; Harnack, Steffen, Arnett, Gao, & Luepker, 2004) and that students made substantial errors in reporting food consumption (Rumpler, Kramer, Rhodes, Moshfegh, & Paul, 2008). Two thirds of the portions consumed in a study of college aged adults were substantially bigger than the recommended portion sizes (Burger, Kern, & Coleman, 2007). A self-served portions experiment revealed that only 45% of portions at breakfast and 32% of portions at lunch or dinner were either 25% bigger or 25% smaller that the recommended portion size, with a majority of those portions being bigger (Schwartz & Byrd-Bredbenner, 2006). People who serve themselves bigger portions or who are served bigger portions tend to consume more (Diliberti, Bordi, Conklin, Roe, & Rolls, 2004; Levitsky & Youn, 2004; Raynor & Wing, 2007; Rolls, Morris, & Roe, 2002; Rolls, Roe, Kral, Meengs, & Wall, 2004) and food choice is important when determining the preferences (Zampollo, Kniffin, Wansink, & Shimizu, 2012) and number of foods available at a meal (Levitsky, Iyer, & Pacanowski, 2012).

Current research about portion sizes and meal satiation generally relies upon external cues such as real foods, plastic food models, or images of foods to guide the subject into thinking about specific foods or specific portions (Herman & Polivy, 2005; Levitsky, Obarzanek, Mrdjenovic, & Strupp, 2005). These external food cues can anchor an individual's perceptions of portion size and limit their food choice responses to those based on available types and amounts of foods, instead of involving the person's cultural ideals, personal preferences, or individual experiences (Sobal & Bisogni, 2009; Wansink, Painter, & North, 2005). Size misestimating was evidenced in an experiment where participants who were influenced to be thirsty and primed with the knowledge that drinking a glass of water would achieve the goal of being satiated perceived the glass to be larger in size and thus contain more water than unprimed controls (Veltkamp, Aarts, & Custers, 2008). This link between goal motivation and size misestimating has been well established and is not unique to food and eating (Brendl, Markman, & Messner, 2003; Bruner & Goodman, 1947; Bruner & Postman, 1948).

Our study asked individuals to draw the types and sizes of foods of a meal in the absence of as many food cues as possible. We then observed whether portion size, meal composition, and overall meal size vary with the size of plate provided. We used a method we call Plate Mapping to study plate sensitivity and meal composition and examined gender differences.

Plate Mapping:

Plate mapping is a new method of eliciting what foods a person may eat for a meal by having them draw on a plate. This activity provides a projection of how the individual conceptualizes and represents a meal. Understanding the conceptualization of a meal requires knowledge of the cultural scripts for meals and environmental factors influencing meals. Time of day, plate and utensil size and type, eating partners, and foods available influence what we eat, how much we eat, and what priority we place on particular foods or food groups. This experiment manipulated the size of the plate to observe how it affects people's scripting of a dinner meal into large main food portions that are predominant on the plate and smaller side food portions that complement the main portion.

A review of current literature shows some justification for using food drawings, which rely on the horizontal plane to estimate size, as a reasonable proxy for actual food or food models. While not drawn by the adolescents being examined, Steyn, Senekal, Norris, Whati, Nackeown, and Nel (2006) found that two-dimensional plate drawings could provide a better estimate of actual energy, fat, and carbohydrates than three-dimensional ones did. These drawings may have been accurate on account of individuals' perceptions of the size of an object anchoring on a single linear dimension, even if more than one dimension is available (Krider, Raghubir, and Krishna 2001) and mathematical modeling shows that horizontal plane calculations are fairly accurate estimators of food area for moderately sized portions (Pratt, Croager, and Rosenburg 2011). Drawing on plates has also been used as a learning tool in conjunction with pictures, displays, and education as a means of enhancing the connection between nutrition education promoting healthy eating in persons with diabetes (Camelon et al. 1998) as well as to reinforce the perceptual bias known as the Delboeuf Illusion (Van Ittersum and Wansink 2011).

Plate Sensitivity:

Plate sensitivity is the concept that people select and serve themselves foods for a meal based on the eating cues provided by their plate such as size, shape, depth, and color. This concept addresses the research question "To what extent do participants draw food in proportion to their internal conception of an appropriately sized meal or in proportion to the size or form of plate?" We examine if individuals are sensitive to the size of the plate provided, specifically whether they draw a meal that corresponds to how food fits on the plate rather than the amount they want to eat or feel they should eat. Our first hypothesis, the plate sensitivity hypothesis, is that larger plates will influence participants to portray their meals as being bigger and smaller plates will influence participants to portray their meals as smaller. This hypothesis will be supported if the amount of food drawn is influenced by the amount of food the plate size can hold.

We are also interested in determining if there is a sensitivity to how much a plate needs to be filled in order for a participant to consider the drawings on their plates to be an appropriate depiction of their dinner. When drawing a meal, participants may be sensitive to the “food appropriateness” of their dinner and will consider plates that look too empty to appear insufficient and plates too full to appear excessive. Our second hypothesis is that people have established internalized standards for the size of a meal and that the percentage of a plate covered will be independent of the size of the plate provided. If this hypothesis is supported, the mean amount of food drawn should be independent of plate size and represent a participant’s idealized meal size rather than a meal that attempts to look appropriate on the provided plate.

Plate Composition:

Plate composition deals with judgments about main courses and side courses in meals. Main courses dominate the meal while being complemented or accented by secondary or supporting foods both in flavor and appearance. Based on this idea, we propose two hypotheses. The meal composition hypothesis proposes that main portions and side portions are considered differently when constructing a meal and that larger plates will cue people to draw proportionally bigger main dishes than side dishes. The food type composition hypothesis proposes that different food groups will be disproportionally influenced by plate size, with fixed-size foods such as meats being influenced less than malleable foods such as vegetables and grains.

Gender:

Gender is an important influence upon many aspects of food choices and eating (O'Doherty Jensen & Holm, 1999), and may be important as a moderating factor in plate sensitivity and meal composition. Men may be less mindful about food portions, less concerned about overeating, and more likely to be plate sensitive while women may be more mindful and experienced with portion sizes and less plate sensitive. Similarly, men are more likely to prefer protein foods and women more likely to prefer fruits and vegetables (Rolls, Fedoroff, & Guthrie, 1991; Wardle et al., 2004), which would lead to gender differences in how men and women construct the composition of foods on their plates into the arrangement of a platescape (Sobal & Wansink, 2007).

Methods

The study was approved by the University Institutional Review Board. A paper plate and a questionnaire were administered in a quasi-experimental design in two separate courses taken in the same department of a large Northeast U.S. university in the Spring of 2011. Both classes convened at 1:00 pm. The data for the 11" plates was collected on a Tuesday and the 9" plate data was collected on a Wednesday. The questionnaire provided brief instructions and informed consent plus asked basic demographic questions about the student's gender and age. The instructions for completing the plate drawing activity asked students to "please accurately draw and label the foods in a meal that you would enjoy eating for dinner tonight. Please be as realistic as possible with your drawings of the foods" (Appendix A). No images of food or examples of drawing styles were provided for the students nor were there food related pictures or themes present in either of the two classrooms. This intentional restriction of food and drawing related cues was done to reduce biasing the participants' food choices or risk introducing a cognitive bias (Tversky and Kahneman, 1974) to meal or portion sizes with any that may have been shown during a demonstration.

Each of the two classes received one size of plates of identical material, design, and color, but one plate was 9" in diameter and the other plate was 11" in diameter. Plates of only one size were used in each class to avoid potential biases if students noticed that plate sizes differed within the class. An announcement was made by the professors teaching the courses at the beginning of class that researchers would be describing the research and distributing the questionnaires in the final five minutes of class and encouraged the students to participate. Students were given class time to fill out the questionnaires and allowed to stay after class as needed. Completion of the task was not compensated with course credit or any other means. Completed plates/questionnaires were collected as students exited the room.

While the researchers were not able to count the total number of students attending class that day, only three plates distributed between the two classes were returned unused or placed in one of the trash receptacles. The estimated minimum response rate was 43% (334 respondents out of 763 registered students) although since not all registered students attend each class, the response rate of attending students was higher based on researcher observation and collection of unused plates. Of the 334 returned questionnaires, a total of 270 were analyzed after excluding 56 respondents who did not accurately follow instructions, 3 who were minors under the age of 18, and 5 who did not provide an age.

Completed plates were coded to construct indicators for the concepts in the hypotheses. Drawn foods were coded into food groups (cereal, dessert, fruit, legume, meat, vegetable, and other). Drawn foods that included multiple food groups were placed into the food group that provided the most calories (a hamburger was coded in the food group meat) or into the food group that took up the most space when calories were uncertain (a salad with lettuce, tomatoes, feta cheese, and shrimp was coded in the food group vegetable). Foods were rated by size to avoid presumptions about which foods were main courses or side dishes and were then sorted into largest to smallest portions for each individual based on their circumference. For each drawn food, the horizontal dimensions of circumference and area were used as an indicator of the size of drawn foods based on mathematical modeling showing that horizontal area is an acceptable estimate of overall food volume (Pratt, Croager, & Rosenberg, 2011). Dependent outcome variables for this analysis were plate coverage (percent of plate covered), food size coverage (circumference and area), food item size (largest to smallest for the five largest foods), and food item type (food groups). The independent predictor variable for this analysis was plate size.

Results

The 270 plates analyzed here included 38% (n=102) from the class drawing on 9" plates and 62% (n=168) from the class drawing on 11" plates. The classes differed in gender and age. The 9" class was 68% (n=77) female and the 11" class was 75% (n=134) female ($p < .05$). The mean age in the 9" class was 21 ± 2 years while the mean age in the 11" class was 19.5 ± 2 years ($p < .01$). Table 2.1 presents the composite data of our results. Food groups that were underrepresented in our study (fruits, legumes, roots, desserts, and other) and food courses that showed no statistically significant variation (4th and 5th largest foods) were reported in Table 2.1 but not further discussed.

Our first plate sensitivity hypothesis was that larger plates would invoke larger food drawings. Table 2.1 shows that the mean total food area on the 11” plate was 26% bigger than the mean total food area on the 9” plate ($p< .001$). This increase meant that larger plates had about 6.6 in^2 more of food, which approximates the cross-sectional area of a deck of playing cards. There was no significant gender moderation of the main plate sensitivity effect.

Our second hypothesis was that participants would draw their meals without regard to the size of the provided plate. This hypothesis was not supported by the results. When comparing the overall percentage of plate space covered, we found a difference between the amount of food drawn and the amount of plate covered (Table 2.1). Our sample had a mean coverage of 62% for the 9” plates while the 11” plates only covered 50% ($p< .01$). The large plates, while having significantly more food drawn on them, appeared 12% less filled than the smaller plates. There was no significant gender moderation of plate coverage.

Our third hypothesis was that main portions and side portions are considered differently when constructing a meal and that larger plates will cue people to draw proportionally bigger main dishes than side dishes. This hypothesis was supported as the size of the biggest drawn food item averaged 42% bigger for the 11" plate than the 9" plate ($p < .001$) even though the foods covered a similar overall percentage, around 30%, of their respective plates (Table 2.1). The second biggest foods were 18% bigger in 11" plates ($p < .01$) while third foods were 16% bigger in 11" plates ($p < .05$). There were no significant interactions of gender with course and plate size, indicating that main and side dish meal composition were not modified or moderated by gender.

Our fourth hypothesis stated that not all food types are equally influenced by plate size and that some food types would be affected differently by a larger plate size. Meat and cereal portions did not differ significantly by plate size, but vegetable portions were 62% bigger on 11" plates ($p < .001$).

Gender was significant as a moderating variable in the food type hypothesis. Figure 2.1 compares the difference in the mean food item size, categorized by food group, across both plate size and gender. The three biggest foods on each plate were considered. The main gender moderation effect was that females drew their vegetable portion 79% bigger on 11" plates than on 9" plates ($p < .01$) and while there was no significant difference in vegetable portion size between men and women on 9" plates, women drew 52% bigger vegetable dishes than men on 11" plates ($p < .01$). While males in this study drew 44% bigger cereal portions on 11" plates, it was not statistically significant ($p < .1$), possibly because of the small sample of male respondents.

FIGURE 2.1: MEAN SIZE OF FOOD ITEM BY PLATE SIZE AND GENDER

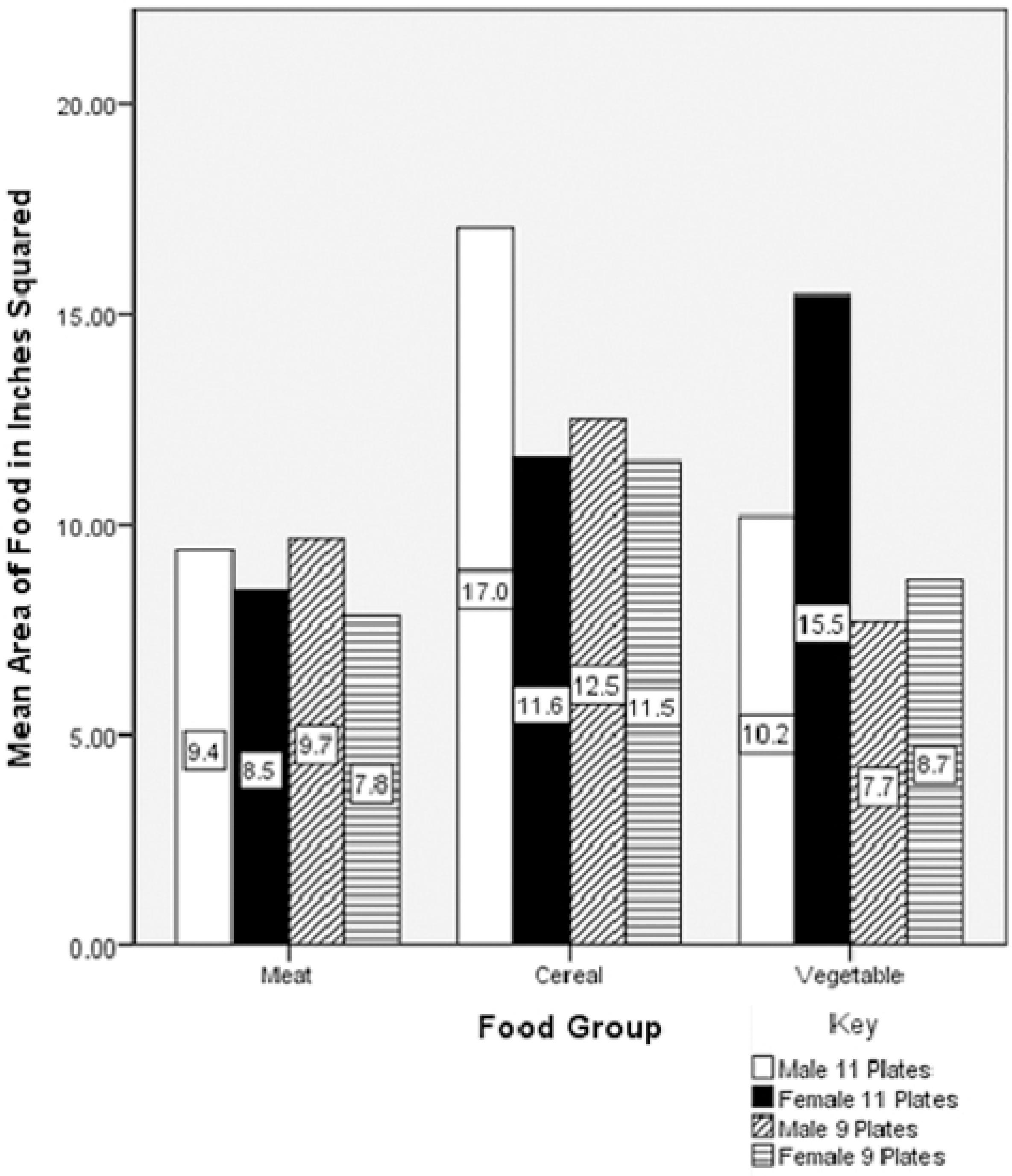

TABLE 2.1: DEMOGRAPHIC, PLATE SENSITIVITY, FOOD PORTION, AND FOOD TYPE RESULTS FROM 11" AND 9" PLATE RESPONDENTS

	Total Sample % or Mean ± SD	n	11" Plates % or Mean ± SD	n	9" Plates % or Mean ± SD	n
Male (%)	22%	59	20%*	34	24%*	25
Female (%)	78%	211	80%*	134	76%*	77
Age (Mean)	20 ± 2	270	19.5 ± 2***	168	20.9 ± 1.7***	102
Drawing Coverage						
Total Food Area (Square Inches)	29.2 ± 13	270	31.8 ± 13.8***	168	25.2 ± 10.5***	102
Plate Coverage (%)	54.4 ± 24	270	50 ± 21.7***	168	61.8 ± 25.8***	102
Drawn Foods Type (Square Inches)						
Meat	8.25 ± 4.6	176	8.4 ± 5	110	8.1 ± 3.9	66
Cereal	11.4 ± 9.1	229	11.8 ± 9.4	151	10.8 ± 8.3	78
Vegetable	11.1 ± 9.1	251	13 ± 10.4***	158	8.2 ± 4.7***	93
Root	7 ± 3.6	53	7.6 ± 4.3	25	6.6 ± 3	28
Fruit	7.1 ± 5.1	48	7.3 ± 5.6	32	6.7 ± 4	16
Legume	9.7 ± 5	20	9.6 ± 5	12	9.8 ± 5.4	8
Dessert	4.5 ± 2.3	29	4.7 ± 2.3	15	4.2 ± 2.4	14
Other	4.8 ± 2.9	14	5.4 ± 3.2	5	4.4 ± 2.8	9
Drawn Food Item Size (Square Inches)						
Largest	15.9 ± 9.8	270	17.9 ± 10.6***	168	12.6 ± 7.1***	102
Second	8.5 ± 4.1	233	9 ± 4.4**	144	7.6 ± 3.5**	89
Third	6.1 ± 3	198	6.4 ± 3.2*	121	5.5 ± 2.6*	77
Fourth	4.2 ± 2.2	95	4.25 ± 2.1	61	4.2 ± 2.3	34
Fifth	3.5 ± 2.3	20	3.5 ± 2.3	12	3.4 ± 2.4	8

* p = .05
** p = .01
*** p = .001

Discussion

Overall, data from this study showed that plate size can shape conceptualizations of appropriate meal and portion sizes that exist before foods are actually selected for dinner. We also found that the influence of plate size can be assessed with the new technique of plate mapping in the absence of normative external cues about foods. Participants with larger plates drew significantly bigger meals than their small plate counterparts. Also, gender appeared to play a role in influencing meal composition.

Our first hypothesis, that participants would be sensitive to the size of the plate and draw bigger amounts of food on larger plates to reflect the available space, was supported by data about the average plate coverage. We found that the difference in overall mean food coverage between 9" and 11" plates was 6.6 in^2. A piece of lean beef this size would provide about 275 additional kilocalories while similarly sized cooked mixed vegetables would supply about 35 additional kilocalories. This overall plate coverage pattern may be useful for managing food consumption. The Delboeuf illusion may explain these plate coverage findings. Delboeuf showed that an item surrounded by similar items larger than it will appear much smaller than an item surrounded by similar items that are smaller than it (Jaeger & Lorden, 1980). For example, a big steak that appears to be an imposing food item on a small plate will appear more manageable on a large plate. This illusion of food appearing smaller on a large plate provides an explanation to justify why larger plates entice consumers to mindlessly eat more food while not feeling more full than if they had eaten an identical meal on a smaller plate

(Wansink, et al., 2005). The plate and foods together create a visual platescape (Sobal & Wansink, 2007) that can influence consumption.

The second hypothesis was that individuals would not be influenced by a larger plate and would be able to draw a meal of similar size as participants with smaller plates rather than simply "filling the plate". The results of our study do not support this hypothesis as the average meal size was significantly different for each plate size.

Our third hypothesis stated that the overall area of the biggest food on the plate would be influenced differently than the rest of the foods on the plate. This hypothesis was supported as the total area of the biggest food was about 6.6 in^2 larger on 11" plates than 9" plates, while second and third foods were respectively only 1.2 and .8 in^2 bigger. There were no significant plate size differences in size of fourth or smaller foods. The majority of difference in food sizes between the 11" and 9" plates occurred on what was already the biggest food item. This difference was about 70% of the change in total food area.

While drawings on smaller plates suggest that individuals drew smaller overall meals, overall size of a meal should not be confused with the composition of a meal. What is interesting is how these foods appeared as a meal when seen in the context of their plate. Relative to their respective plate, the biggest foods on both 11" and 9" plates covered about the same percentage and appeared to be the same size despite being calorically different from each other. When comparing the second and third biggest foods, these foods covered a smaller percentage of the 11" plate compared to the 9" plate; however, they covered a greater area. This difference suggests that the second and third foods on 11" plates would provide a greater total amount of calories while still appearing to be a moderate or light serving size in the context of its full platescape. The importance of the biggest item on the plate may provide an avenue for interventions as choice of the biggest food may drive the overall meal composition and caloric intake of a meal.

The fourth hypothesis posited that some food groups would be disproportionally bigger for larger plates. While meat and cereal dishes were similar in size across plate sizes, vegetables showed considerable variation between plate sizes and gender moderated this relationship with female participants drawing significantly bigger amounts of vegetables when provided additional plate size area. In the present study we found that women portrayed their meals to include significantly more vegetables when the plate size allowed it while meat and cereal portions remained fairly constant.

Given the healthfulness of vegetable consumption, simply decreasing plate sizes in order to limit caloric intake or prevent obesity is not entirely supported by our findings. This examination of food group size creates a conundrum in plate size recommendations because decreasing plate size for women appears to disproportionately diminish vegetable consumption more than any other food group.

These findings suggest the importance of analyzing not just the size of the whole meal but also its composition. Recommending a reduction in plate size to assist in weight loss (Story, Neumark-Sztainer, & French, 2002; Wansink & van Ittersum, 2007) may reduce overall food consumption but may also decrease the overall healthfulness and diversity of meals for some individuals by disproportionally reducing vegetable consumption with respect to the other food groups.

Since meat portions did not differ significantly across plate sizes, a smaller plate led to smaller non-meat portions in order to appear full. This finding suggests that portion control plays a different role than meal composition for both small and large plates (Franco, 2007; Pedersen, Kang, & Kline, 2007). With 68% of our sample drawing a meal that contained a meat product, the overall structure of these drawn meals reinforces the cultural importance of meat (Douglas, 1972; Mann, 2000; Swatland, 2010) and changing meal structure offers health professionals an additional dietary change strategy. By targeting educational interventions about appropriate meat portions, environmental cues from plate size, and the interactions between plate size and meal composition, nutrition professionals may be able to improve dietary outcomes without changing established tastes.

Dietary advice may have the capacity to lead to large social impacts, and our results suggest that care must be taken when selecting strategies involving plates that are designed to encourage individuals to eat a healthier, more varied, or lower calorie diet in order to improve short- and long-term health goals. Reduced portion size can lead to reduced food intake (Freedman & Brochado, 2010) and external food cues can anchor perceptions of portion size and influence responses (Fedoroff, Polivy, & Herman, 1997; Jansen & van den Hout, 1991; Koh & Pliner, 2009), but these recommendations should be offered in a way that achieves the primary goal and minimizes unintended consequences. One unintended consequence could be found in the current images presented in the USDA MyPlate graphic used for dietary guidance by the USDA in the United States (Center for Nutrition Policy and Promotion, 2011).

The principle goal of the MyPlate image is to be a mealtime symbol to remind Americans to eat healthfully. Intended to represent the recommendations from the *Dietary Guidelines for Americans* (2010) rather than provide recommendations for a specific meal, the MyPlate image is a simple and useful visual graphic for encouraging a balanced diet. One issue that has largely been overlooked, however, is that with respect to the intended use of the graphic, the MyPlate name suggests a single meal rather than a pattern of daily intake and the image represents a plate that is almost completely full. Because of this, we used the same method of analysis for measuring our participant generated data to analyze what a MyPlate plate of food would actually look like.

In order to estimate the size of the MyPlate plate image, we measured 20 forks and found the average fork to be about 7.25” long. When scaling the MyPlate image based on a 7.25” fork, the MyPlate plate appears to represent a plate that is 10” in diameter and that food covers about 70% of the surface. The area of the MyPlate plate, assuming no plate lip, is 78.5 in^2. Based on these numbers, the MyPlate image appears to have protein covering 11.5 in^2 (15% of the plate), vegetables covering 16 in^2 (20%), grains covering 14.7 in^2 (19%), and fruit covering 12.6 in^2 (16%). The area of food represented on the plate totals about 55 in^2, which is 72% more food than the average food area drawn by students in this study on 11” plates and more than twice the area of food drawn on 9” plates. In our study, college students drew their dinners with the plates on average 55% to 63% covered and were influenced by the size of their plate.

In the MyPlate image, the USDA may have provided a powerful external cue for people to not just eat healthful combinations and relative portions of food groups, but also to serve themselves more than they previously may have been in order to achieve the sizes of food groups portrayed in MyPlate. Is it a benefit to achieve a healthier balance of food groups if it includes higher caloric consumption? If the nutritional guidelines promote an image of a highly loaded plate, there should be a concern that attempts of individuals to make a meal look "like the guidelines" may result in adding underrepresented food groups to a plate to match the overall plate graphic rather than removing some overrepresented food groups to match suggested serving sizes and food group proportions.

Applications:

For nutrition interventions, the plate mapping technique can be used to ascertain which portions of a meal are most important to an individual. Asking a participant to draw what they would like to eat for dinner may offer keen insight into their views about the various food groups. Plate mapping warrants future development and evaluation as a new nutritional assessment method.

Plate mapping procedures can be incorporated into food recall, dietary management, and food intervention studies and may provide a rapid, inexpensive method for collecting additional data. Plate mapping may also enhance the connection between dietary theory and practice for participants by offering them personalized visual representations of meal routines (Camelon et al., 1998).

The composition of a meal, as the MyPlate dietary guidance suggests, may be a useful avenue for nutrition researchers to pursue rather than only influencing an individual to select specific portions of foods or a smaller plate to eat from. Reducing large plates may not be an appropriate intervention for weight loss if the biggest food item drawn is a salad, vegetable, or fruit, but could be appropriate if that item is a cereal, starch, or a high-fat meat product. Alternatively for underweight individuals seeking to gain weight, increasing the size of a plate may not substantially increase caloric intake on its own.

Limitations:

There are several limitations in this study. Our first limitation is that Plate Mapping is a new method of measuring meal and portion size and the results should be interpreted in that context. The quasi-experimental design did not use random assignment or include a baseline assessment, which reduces the overall strength of these findings (Shadish, Cook, & Campbell, 2001). The college student sample may limit the generalizability of these findings to other populations. The low number of male participants in the sampled classes limits statistical power for gender comparisons. A measurement limitation is the extent that a drawn meal validly represents an actual meal. While an actual meal can be observed to see if participants finish all of the food that they serve themselves or if they take second portions, a drawn plate relies both on participants being accurate in their drawn portions and that the drawing accurately reflects a meal that will be completely consumed.

There are also some potential alternative explanations that challenge the importance of plate size for caloric intake. Steenhuis and Vermeer (2009) claim that the effects of plate size may only occur when the participant does not consider the food as a meal but is instead a snack like ice cream or popcorn. Others suggest that energy intake is only statistically significantly associated with container size when people self-serve from a bowl rather than a plate (Rolls, Roe, Halverson, & Meengs, 2007; van

Kleef, Shimizu, & Wansink, 2011). These other hypotheses need to be examined in future research.

Future Studies:

This study used plate mapping as a method to avoid the influences of external environmental, social, and economic factors that may influence reporting about meal choices. Replicating this study with other samples that allow between-group age and within-group gender equivalence would assist in confirming the findings. Other factors influence eating, such as second helpings, group eating settings, food sharing, and variations in silverware, serving utensils, and total available food; and measuring the role of these other factors on meal perception would provide additional insight into their effect as alternative predictors or moderating factors. Studies examining the correspondence between drawn meals and actual meals are also needed to strengthen the potential applicability of this study in nutrition interventions, food policies, and clinical care.

Conclusion:

Aggregate observational data suggests that the average size of dinner plates has been increasing (Klara, 2004) and points to a historical parallel between the increases of portion size and body weight (Young & Nestle, 2003). Mathematical modeling of plate sizes and portion sizes indicate that increasing or decreasing plate size has the potential to lead to substantial changes in caloric intake (Pratt, Croager, & Rosenberg, 2011). We observed that plate size alone was enough to influence the estimated amount, proportions, and types of foods that participants drew as a selection for a dinner. Eating behaviors and food choice may be structured activities, but easily integrated environmental changes such as changing plate size could be a method for better understanding meal preferences and encouraging more appropriate eating habits (Camelon et al., 1998).

Many external and internal factors influence what individuals eat. This study suggests that people can portray dinner size and composition by drawing a meal, that plate maps differ between larger and smaller plates, and that plate maps may also differ between genders. Drawings on larger plates appeared emptier while actually portraying a greater area of food than drawings on smaller plates. This visual illusion may prompt an individual to consume more food. The results of this study suggest that conceptualizations of dinner can be influenced by plate size even if actual food is not smelled, seen, or touched.

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CHAPTER 3: REPRESENTATIONS OF DINNER MEALS VARY BY THE SIZE OF THE PLATE: USING PLATE MAPPING TO EXAMINE SIZE AND MEAL COMPOSITION AMONG ADULT MEN AND WOMEN

Introduction

People in Western societies usually consume foods grouped on tableware, often plates. Plate size may influence how much and which types of food a person serves themselves or is served, which may affect portion size and food type (Wansink, van Ittersum, & Painter (2006). Changing plate size may be a potential public health strategy to alter food intake. This study examined whether community dwelling adults portrayed how much and what types of foods they planned to eat differently on bigger or smaller plates.

Most studies of the effects of tableware on food selection manipulate plate, bowl, glass, or serving utensil size as individuals serve themselves foods (Wansink & van Ittersum, 2005; Raynor & Wing 2007; Wansink & van Ittersum 2010; Fisher, Birch, Zhang, Grusak, & Hughes, 2013). An alternative research technique, labeled "plate-mapping" (Sharp & Sobal, 2012), has individuals draw a meal on differently-sized plates.

In an initial study using plate mapping (Sharp and Sobal, 2012), researchers asked college students to draw a meal on either a 9" or 11" diameter paper plate. The findings revealed that students exhibited plate sensitivity because they drew about 26% more food on the larger plate than students given the smaller plate. The larger plates had about 50% more available space to draw upon, which made the food drawings on the larger plates appear smaller when observed within the context of the plate. Gender of the students moderated the relationship between plate size and meal composition in that initial study as indicated by the size of food types, with women drawing 36% bigger vegetable portions than men on larger plates.

Previous studies of plate size and food intake report mixed results (Libotte et al 2014; Robinson et al., 2014; Wadhera & Capabaldi-Phillips, 2014). Some report no difference in energy intake between those using larger and smaller plates (Rolls, Roe, Halverson, & Meengs 2007). However, while Koh and Pliner (2009) did not find a main effect of plate size on amount of food served and consumed, there was an interaction between plate size and food sharing, where those who shared foods and used small plates served and consumed less food than those not sharing and using small plates. These prior studies of plate size and food intake were conducted primarily in laboratory settings and may not reflect actual behavior in households.

The present study used plate mapping to examine plate sensitivity and meal composition in the homes of a community-dwelling population whose behaviors may be shaped by their family roles and other experiences. Using a plate mapping protocol in an adult community sample is important for both proof of concept of plate size sensitivity and generalizability of findings into households; because the college environment does not necessarily represent practices that will be continued past graduation from academic institutions (Cooper, McCord, & Socha, 2011). Adults' cooking skills, financial constraints, time availability, and interactions with other family members are all part of the external environment involved in food selection (Sobal & Bisogni, 2009). This more complex environment for food selection may affect typical meal composition and serving size of different types of food.

We propose four hypotheses about plate sizes and plate mapping. 1) The *plate sensitivity* hypothesis posits that people are "mindless" about portion size and fill plates to capacity, drawing bigger overall meal sizes on larger plates than smaller plates. 2) The *meal norms* hypothesis posits that people draw meals to conform to normative micro-level built environment conceptions (Sobal & Wansink, 2007) about how full a plate should be; filling plates to levels that seem appropriate to the plate size, with the same percentage of area covered by food on larger and smaller plates. 3) The *meal composition* hypothesis posits that plate size influences servings of different kinds of foods, with the *type of food* sub-hypothesis proposing that bigger vegetable dishes will be drawn on larger plates and the *food course* sub-hypothesis proposing that bigger main courses will be drawn on larger plates than smaller plates. 4) The *gender moderation* hypothesis posits that there are gender differences in size and type of food selection (Rolls, Federoff, & Guthrie, 1991; Wardle, Haase, Steptoe, Nillapun, Jonwutiwes, & Bellisle, 2004; Emanuel, McCully, Gallagher, & Updegraff, 2012), with men more sensitive to plate size than are women, and men drawing larger main courses on plates than women draw on plates.

Materials and Methods

Data for this study was collected as a component of a larger study in the homes of adult volunteers with children recruited by local U.S.D.A. Cooperative Extension Service workers and internet and radio advertisements in one medium sized city in the Northeastern U.S. As part of this larger study, participants were asked to do plate mapping by drawing what they planned to eat for dinner that night on either a 9" or 11" paper plate. Interviewers provided the plates and orally administered instructions for this study. The instructions were to “Accurately draw and label the foods that you expect to be eating for dinner tonight. Be as realistic as possible with the sizes of the foods that you are drawing.” Investigators did not provide examples of how to complete this task, nor were any food-related cues provided to assist participants in determining meal or portion size. A random number generator was used to determine which differently sized but otherwise identical paper plate, either 9” in diameter or 11” in diameter, was provided to each participant. People in homes with multiple participants were each given the same sized plates to avoid potential plate size recognition bias. Participants were interviewed in separate rooms to avoid discussions between them about the study protocol or dinner plans. Both partners in these couples were included as individual units of analysis in the data based on analyses showing that stratification revealed no significant differences between married/cohabiting and unmarried individuals with respect to the major study outcomes. This study was approved by the Cornell University Institutional Review Board.

Of the 309 participants recruited, 281 (91%) took part in the plate mapping task. A total of 164 were cohabitating adults or married couples. Reasons for nonparticipation included participants not completing a usable plate drawing (19), interviewer omission errors (5), or the participants were initially enrolled over the telephone (4).

Participants self-labelled all of the foods they drew to provide accurate information about type of food. Drawn foods were first coded by food type (meat, grain, vegetable, root vegetable or tuber, fruit, legume, dessert, other) and then were organized by size based on their overall drawn area (most to least plate area covered). Foods were coded by area (Largest, second largest, etc.) rather than by course (appetizer, main courses, side course, salad, dessert, etc.) for two reasons. First, participants were not instructed to label their foods by course because this could have influenced participants to draw a meal guided by Western cultural ideals about main courses and side courses (Douglas, 1972) rather than their actual anticipated meal. Second, investigators did not want to presume which foods constituted main courses or side courses. The horizontal dimension of area was used as an indicator of overall size of each drawn food and these sizes were then coded starting with the biggest food on each plate. The appropriateness of using horizontal measurement of area as an indication of overall food volume was based on mathematical modeling of food sizes (Pratt, Croager, & Rosenberg, 2011) as well as prior research suggesting that individuals focus on the serving diameter rather than the serving height of food (Krider, Raghubir, and Krishna 2001). Four coders performed the initial coding, and then two of the coders verified the initial coding for area, food type, and food size.

The independent variable was plate size. Dependent outcome variables were overall plate coverage (as total area and as percent of plate covered by food), individual food size coverage by area, food item size (largest course to smallest course for the five biggest foods), and food item type. Gender was examined as a moderating variable. Age was assessed as a demographic variable to characterize the sample.

Results

Among the 281 participants, 50% (n=139) drew on 11” plates and 50% (n=142) on 9” plates. Table 3.1 summarizes all study variables. Most participants were female and middle aged. Men and women comprised about the same percentage of the 11” plate group and the 9” plate group. Most people (84%) drew three foods as comprising a complete dinner. Root vegetables, fruits, legumes, desserts, and other were infrequently drawn and showed little variation as were the sizes of fourth and fifth biggest foods, so these were reported in Table 3.1 but were not analyzed further. No participants in this study requested a second plate to supplement the drawn size of their dinner.

Our first hypothesis (plate sensitivity) was that larger plates would influence participants to draw bigger dinners than the drawings on smaller plates. This hypothesis was supported, with individuals drawing about 8 in^2 more area of food on 11” plates ($p< .001$) (Table 3.1). Participants drew their meals to be an average of 25% bigger when provided the larger of the two plates.

Our second hypothesis (meal norms) was that the participants would be influenced by normative conceptions about the percentage of the plate that should be covered by food. This hypothesis was not supported by the data for men and women combined. Overall meal sizes were bigger with larger plates, but percent of plate coverage was statistically different by plate size with 9” plates appearing on average 76% full and 11” plates appearing 60% full (Table 3.1). While more food was drawn on larger plates, the larger plates did not produce greater size of meals to the extent that both plates appeared to be equally filled with food.

Our third hypothesis (meal composition) was that meal courses and food types would be differentially influenced by plate size. The hypothesis was supported. Drawings of individual courses covered a larger percentage of space on the 9” plates when compared to the 11” plates, with the largest food covering 6% more of the smaller plate ($p < .001$), the second largest food covering 6% more ($p < .005$), and the third largest food covering about 4% more ($p < .001$) (Table 3.1). While the smaller 9” plates were drawn to appear more full, the 11” plate food drawings were still bigger with main courses drawn to be on average 4.9 in^2 or 34% bigger, the second course drawn to be 2 in^2 or 21% bigger, and third courses drawn to be 1.4 in^2 or 20% bigger. More than half of the overall size differences between plates was due to a greater size of the biggest food. When food types were compared between plate sizes (Table 3.1), three food types were drawn significantly bigger when given a larger plate: meat courses were 4.2 in^2 bigger ($p < .001$), grain courses were 2.6 in^2 bigger ($p < .01$) and vegetable courses were 2.7 in^2 bigger ($p < .001$).

Our fourth hypothesis (gender moderation) was that gender would moderate the influences of plate sensitivity and plate composition, with men responding to larger plates by drawing bigger portions than women drew. The hypothesis was partially supported. Men with larger plates drew meals that averaged about 11.9 in^2 bigger ($p=.001$) and while men’s smaller plates were about 6% more full, this was not statistically significant ($p < .13$). Women with larger plates drew significantly bigger overall meals, with a 4.2 in^2 difference in meal size ($p < .012$) while the composition of the smaller plates appeared to be 19% more “full” ($p < .001$) when the women’s drawn meal was examined in the context of the size of the plate (Figure 3.1). Comparing genders within the same plate size, men’s drawn dinners were 8.5in^2 bigger than dinners of women when given a large 11” plate ($p < .001$) but there was no significant difference in size between genders for a small 9” plate ($p < .39$). For the plate consistency hypothesis, men covered 13% more of their 11” plates with food than women did ($p <.001$), but men did not cover more of the smaller 9” plates than women did (p< .34). Analyses of food type by plate size and gender revealed significantly bigger men's drawings of meat size, vegetable size, and grain size than women's drawings with 11" plates, but no significant gender differences for 9" plates (Figure 3.2).

FIGURE 3.1: FOOD COURSE SIZE BY PLATE SIZE AND GENDER

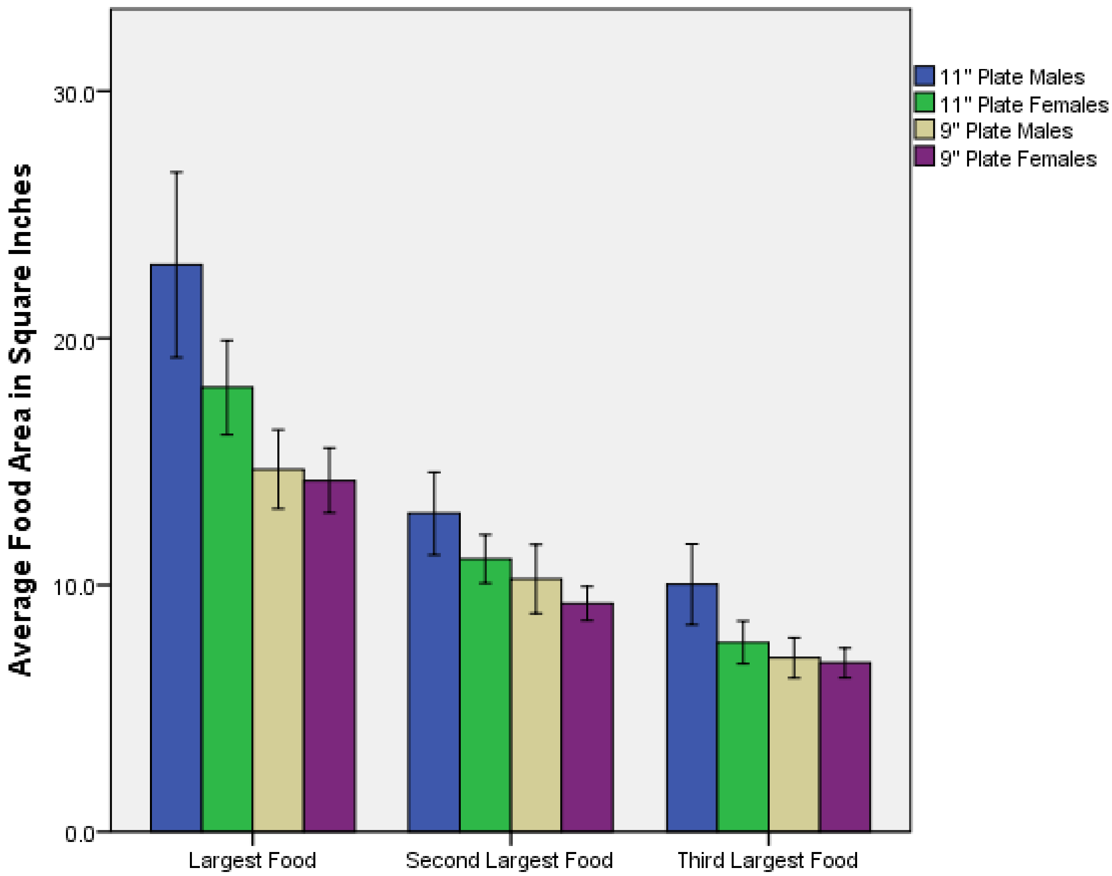

FIGURE 3.2: FOOD TYPE SIZE BY PLATE SIZE AND GENDER

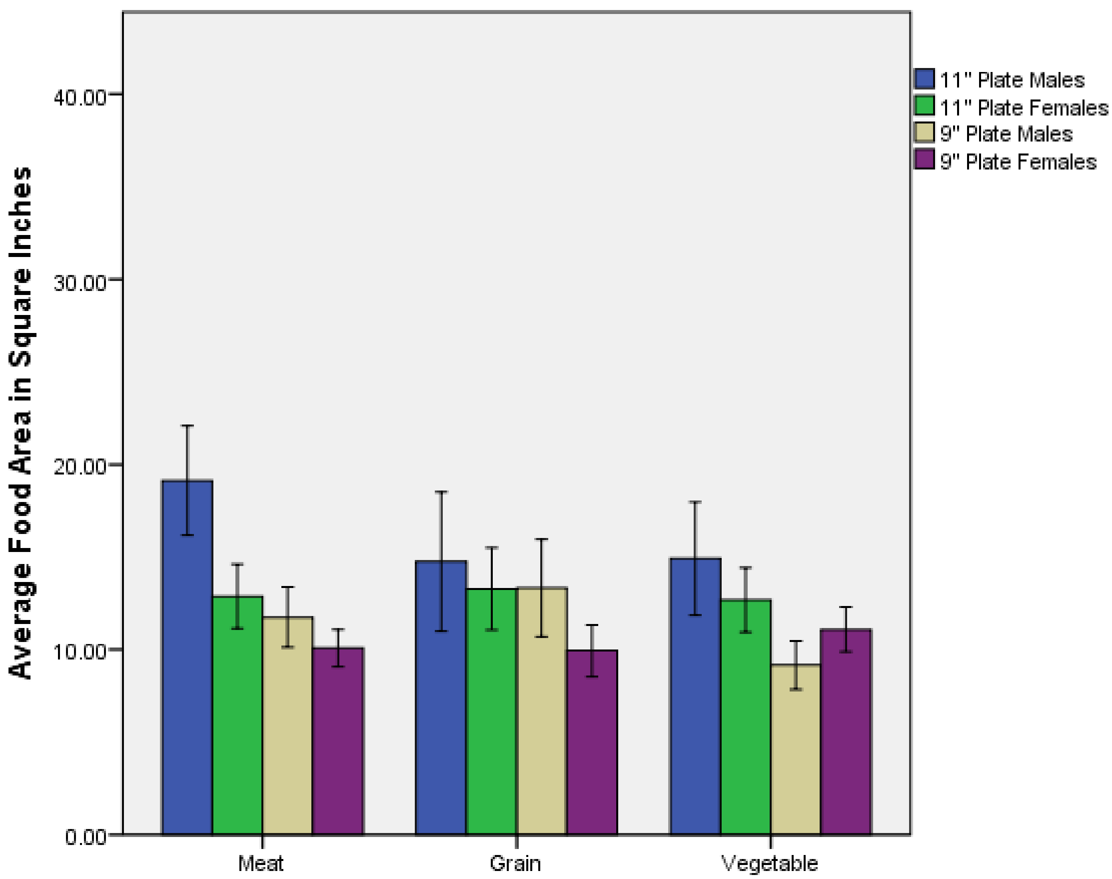

TABLE 3.1: DEMOGRAPHICS, PLATE DRAWING COVERAGE, FOOD TYPES, AND FOOD ITEMS BY PLATE SIZE

	Total Sample	**n**	**11" Plates**	**n**	**9" Plates**	**n**
Demographics						
Male	31%	86	34%	47	27%	39
Female	69%	195	66%	92	73%	103
Age (years)	38.6± 9.6	281	38.3	139	39.1	142
Drawing Coverage						
Total Food Area (in^2)	34.6± 13.4	281	38.5±15.9***	139	30.9 ± 9.1***	142
Plate Coverage	68% ± 25%	281	60% ± 25%***	139	76% ± 22%***	142
Drawn Foods Type						
Meat (in^2)	12.5 ± 7	243	14.6 ± 8.3***	119	10.4 ± 4.7***	124
Grain (in^2)	11.8 ± 7.4	192	13.1 ± 8.7**	91	10.5 ± 5.8**	101
Vegetable (in^2)	11.2 ± 7.1	289	12.6 ± 8.4***	119	9.9 ± 5.3***	147
Roots (in^2)	9.6 ± 6.2	84	10.5 ± 7.6	44	8.6 ± 4	40
Fruit (in^2)	7.4 ± 5.1	24	9.2 ± 7.4	8	6.5 ± 3.4	16
Legume (in^2)	8 ± 2.2	8	7.7 ± 2.2	4	8.3 ± 2.5	4
Dessert (in^2)	2.3 ± 2.1	3	2.3 ± 2.1	3		0
Other (in^2)	15 ± 13.9	9	24 ± 17.9	2	12.4 ± 12.9	7
Drawn Foods Item Size						
Biggest (in^2)	17 ± 8.7	281	19.2± 10.3***	139	14.3 ± 6***	142
Second (In^2)	10.7 ± 4.3	273	11.5± 4.8***	134	9.5 ± 3.7***	139
Third (in^2)	7.7 ± 3.6	254	8.2± 4.3***	124	6.9 ± 2.6***	130
Fourth (in^2)	5.2 ± 2.2	44	5.6± 2.4	19	5 ± 2.2	25
Fifth (in^2)	2 ± .01	5	4.2 ± 1.2	2	3.5 ± 2.6	3

Differences between 9” and 11” plates using chi-square and t-tests
* $p < .05$, ** $p < .01$, *** $p < .001$

(in^2) equals inches squared

TABLE 3.2: PLATE DRAWING COVERAGE, FOOD TYPES, AND FOOD ITEMS BY PLATE SIZE AND GENDER

	11" Males	**n**	**11" Females**	**n**	**9" Males**	**n**	**9" Females**	**n**
Drawing Coverage								
Total Food Area (in^2)	44.1± 17.7***	47	35.6± 14.9**	92	32.2±8.3***	39	30.4± 9.4**	103
Plate Coverage	69% ± 28%	47	56% ± 22%	92	79% ± 20%	39	75% ± 23%	103
Drawn Foods Type								
Meat (in^2)	19.1 ± 8.4***	38	12.9 ± 7.6***	83	11.8 ± 4.9**	35	10.1 ± 4.5**	89
Grain(in^2)	14.8 ± 10.2*	33	13.3 ± 7.9*	58	13.3± 5.9*	26	10.0 ± 5.7*	75
Vegetable (in^2)	14.9 ± 9.3*	47	12.7 ± 7.9	96	9.2± 3.7*	39	11.1 ± 5.8	108
Root (in^2)	11.8 ± 11.2	16	9.7 ± 4.6	28	9.5 ± 5.2	14	8.1 ± 3.1	26
Fruit (in^2)	4.4 ± 1.9	2	9.8 ± 7.8	7	7.4 ± .8	2	6.4 ± 3.6	14
Legume (in^2)	9.5 ± .43	2	5.8 ± .9	2		0	8.3 ± 2.5	4
Dessert (in^2)	4.5	1	1.2 ± 1.2	2		0		0
Other		0	11.5	1	6.8 ± 1.6	2	14.7 ± 15	5
Drawn Food Item Size								
Biggest (in^2)	22.3 ± 12**	47	17.6 ± 9**	92	14.8 ± 4.9**	39	14.1 ± 6.4**	103
Second (in^2)	12.8 ± 5.4*	46	10.8 ± 4.4**	88	10.3 ± 4.1*	39	9.2 ± 3.3**	100
Third (in^2)	9.8 ± 5.1**	42	7.4 ± 3.6	82	7.2 ± 2.2**	35	6.8 ± 2.8	95
Fourth (in^2)	5.4 ± 1.6	5	5.7 ± 2.7	14	5.4 ± 1.9	5	4.8 ± 2.2	20
Fifth (in^2)			4.2 ± 1.2	2			3.5 ± 2.6	3

Differences between 9” and 11” plates of the same gender using chi-square and t-tests
* $p < .05$, ** $p < .01$, *** $p < .001$

(in^2) equals inches squared

Discussion

Overall, this study showed that plate size can influence portrayals of appropriate meal and portion sizes. Meals, food portions, and food types can be assessed with plate mapping in the absence of normative external cues about foods among adults. Participants with bigger plates drew meals significantly larger than their small plate counterparts. Gender appeared to play a role in influencing meal size and composition.

Our first hypothesis, that participants would be sensitive to the size of the plate and draw greater amounts of food on larger plates to reflect the available space, was supported by data about the average plate area coverage. We found the difference between larger and smaller plates in overall mean food size to be about 8 in^2, or the area covered by a deck of cards. Depending on which food type created this difference and assuming the height was also equivalent to a deck of cards, this could represent a substantial amount of extra calories if the food is a meat (up to 300 calories) rather than a vegetable (about 40 calories). This increase in size also represents a full serving of meat or a half-cup of vegetables with respect to fulfilling the recommendations of the United States Department of Agriculture (USDA, 2011).

Our second hypothesis, that meal norms would influence participants to represent similar proportions of their plates filled with food was only found to be supported by the data when gender was considered. Men appear to be grounded in the norms that a certain portion of the plate should be covered by food, while women appear to be more cognizant of the area of the food itself than the vessel upon which the food is served.

Our third hypothesis considered course size and food type size differences across plates. We found that the first three food courses were bigger in size on larger plates, but 60% of the difference in meal size came from the biggest food being greater in size. Meat, grain, and vegetable courses all were drawn significantly bigger on 11" plates, with meat being about 4 in^2 bigger and grains and vegetables about 2.5 in^2 bigger.

The analyses of the gender moderation hypothesis showed that while both men and women drew bigger meals on larger plates, there were significant differences between men and women in the overall size, food type, and food course drawings. We used an Independent Samples T-Test to compare the differences in drawn foods and found the difference between larger and small plates for overall size of food drawn by men to be about 11.9 in^2 ($p=.001$) and for women to be about 5.2 in^2 ($p=.002$). Since about 60% of the plate size difference occurred for both genders in what was already the biggest food, the caloric difference between average drawings could be as low as about 30 calories (female drawing more vegetables) and as high as about 450 calories (male drawing a larger steak). These findings suggest an asymmetrical gender response to plates as environmental influences, with men being more sensitive to plate size in their plate composition than were women. Men also tended to draw far bigger meat portions than grain or vegetable portions when given a bigger plate, while women were more balanced in their meal drawings on different sized plates.

These findings about plate mapping in adults were similar to those found in college students (Sharp & Sobal, 2012). When provided 11" plates, participants from both studies drew 25% more food on their plates when compared to the overall area of food that was drawn on the 9” plates. Both studies found similar patterns in coverage percentage, with the 9” plates appearing to be more covered by food while actually having a smaller amount of food on them when compared to 11” plates. These two studies also support the hypothesis that a majority of the difference in meal size between plates would be found in the biggest food. These two studies differed in the average sizes of foods being drawn by the participants. While the college student sample had significant differences in drawn vegetable size when comparing female drawings on 9” and 11” plates, our present study of adults living in the community found significant differences in food size for both genders in meats and grains and for men in vegetables.

Implications and Applications

Assessment of dietary intake of individuals outside of laboratory settings is difficult to obtain for a week, 24 hour period, or even a single meal. In order to acquire data about an individual’s eating patterns, 24 hour food recalls and Food Frequency Questionnaires (FFQ) are often used despite their limitations and time demands on participants (IOM, 2005; Rumpler, Kramer, Rhodes, Moshfegh, & Paul, 2008). In a comparison of reported protein and energy consumption accuracy, Schatzkin et al. (2003) found that individuals using the FFQ underreported their protein and energy intakes by 30% while individuals using 24 hour recalls underreported these numbers by 10-20%. Some tools, such as food photographs or digital food images (Robson & Livingstone, 2000; Foster et al., 2006; Baranowski et al., 2011; Brito, Guimaraes, & Pereira, 2014), can be used to increase accuracy or speed of an individual’s recall and size estimation. In addition to these tools, plate mapping offers another method.

Plate mapping is an inexpensive and rapid method for collecting data about meals, portions, and foods, and may be used in conjunction with other types of food intake assessments. Plate mapping may also be useful for screening and prioritizing meal preference and food type importance at an individual level by offering insights about a person's conceptions of meal size, food preferences, or food aversions. Asking a participant to draw what they ate, plan to eat, or would like to eat for dinner may also enhance the connection between dietary theory and practice for participants by offering them a personalized visual representation of their meal preferences and routines (Camelon et al., 1998). Plate mapping offers an additional method for assessing eating preferences to provide information about meal-related characteristics and how portion sizes can be influenced.

When nutrition researchers consider which processes may increase or decrease caloric intake, understanding meal composition is important for deciding if an intervention protocol like changing plate size would be effective for everyone to the same degree. If changing plate size can influence portion servings (Wansink & van Ittersum, 2013), then knowing beforehand if a participant prefers higher calorie grains and meats or lower calorie vegetables and fruits as well as their interpretations of an appropriate meal size can help identify which nutrition interventions may provide the best results.

There are several limitations in this study. Plate mapping is a new measurement method and these results should be interpreted cautiously. The volunteer sample included relatively few male participants, which limits generalizability to men and statistical power for analyzing gender differences. The quasi-experimental research design involved only between-person comparisons, and should be replicated using within-person and longitudinal study designs.

Conclusion

We observed that plate size was associated with the amount and proportions of food that participants portrayed they would be eating for dinner that night. Some environmental modifications require little additional effort from participants and can have an impact on dietary behaviors (Engbers et al., 2005; van Kleef, Shimizu, & Wansink, 2011; Cowan & Devine, 2013), and changing plate size may help change food intake. Easily integrated environmental changes such as plate size change could be a useful method for modifying meal preferences and encouraging more appropriate eating habits (Camelon et al., 1998).

Individuals' consumption amounts, composition, and patterns can be influenced by many internal and external factors (Wadhera & Capaldi-Phillips, 2014). This study suggests that that people can portray their estimated dinner size and composition as a two dimensional drawing and these portrayals of meal size can be influenced by the size of the plate and are moderated by gender. Meal drawings on larger plates appeared emptier in the context of the plate and may influence participants to serve themselves more food or go back for second helpings. Our results suggest participants' estimates of dinner size may be influenced by plate size. This plate size effect appears to be more powerful for males than females and may encourage an asymmetrical difference in men's and women's consumption from larger plates.

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CHAPTER 4: VALIDATING THE PLATE MAPPING METHOD: COMPARING DRAWN FOODS AND ACTUAL FOODS OF UNIVERSITY STUDENTS IN A CAFETERIA

Introduction

While the USDA offers guidelines that educate the public about recommended eating practices (U.S. Department of Agriculture & U.S. Department of Health and Human Services, 2010), there is a dissonance between nutrition education and personal behavior. Environmental variables can influence food consumption (Sobal & Wansink, 2007). Plate size and portion size may influence the amount of food an individual consumes, with increases in plate or portion size consistently correlated with increased food intake (Diliberti et al., 2004; Fisher & Kral, 2008; Van Ittersum & Wansink, 2012). Some environmental modifications require little additional effort from participants to impact dietary behaviors (Engbers et al., 2005; van Kleef et al., 2011; Cowan & Devine, 2013). One potential environmental influence is the size of the vessel in which food is served (Kallbekken & Sælen, 2013).

Larger serving vessels are associated with people taking larger food portions (Sobal & Wansink, 2007; Wadhera & Capaldi-Phillips, 2014). An individual can select how much food is ordered or served onto a plate, but there is rarely much opportunity for the size of the plate or bowl itself to be altered or selected. While there is a distinct lack of range in plate sizes offered during a meal, research suggests that there is a range of overall caloric intake that can be consumed without the individual feeling overly hungry or overly full (Herman and Polivy,1984; Rolls, Bell, & Waugh, 2000) . If individuals can be influenced to marginally reduce the size of a meal, then altering or removing the food norms and cues present in the environment that promote larger meals may provide a low-involvement change that may influence body weight.

An initial study by Sharp and Sobal (2012) reported that the method labelled plate mapping could be used as a tool to understand meal portrayals by asking college students to draw what they would like to eat for dinner on a paper plate that was either 11” or 9” in diameter. They found that college students given an 11” plate drew an average total area of food that was 26% greater than those given a 9” plate. The largest food drawn on each size of plate was found to be the primary factor in the difference in area between plate sizes, with 70% of the total difference in meal size coming from the largest food drawn on plates. While the area of the largest food increased when comparing 11” plate drawings to 9” plate drawings, the relative percentage of plate area covered by the largest food on each size of plates remained the same. Gender was found to influence portrayals of meals in plate maps, with women drawing bigger vegetable portions than men when given larger plates.

In a similar study, Sharp, Sobal, Wethington, & Wansink (Submitted) used the same plate mapping protocols on a sample of adults in a medium sized city and found that the amount of food drawn was associated with the size of the plate provided when participants were asked to draw what they were planning to eat for dinner that evening. They found that while men and women both portrayed their estimated dinners to be bigger when using a larger 11” plate, men appeared to be more influenced by the size of their plates and drew more food (40% more) than women did (14% more) when compared to meal drawings on 9” plates.

The present study examines the construct validity (Markus & Lin, 2010) of plate mapping measurement by investigating capacity of college students to draw their meal in two-dimensions on two differently sized plates just prior to or just after consuming a lunchtime meal at a cafeteria on their campus. Using a plate mapping protocol to compare actual food portions and meals sizes to participant generated drawings of food portion and meal sizes can examine construct validity of plate mapping and quantify the degree that plate mapping can precisely measure participant perceptions of meal size in the context of a particular plate. Results of mathematical modeling to examine how dish size affects the potential energy available in a meal suggests that a small increase in dishware size can lead to a substantial increase in energy available to be consumed (Pratt, Croager, & Rosenberg, 2012). This reinforces the need to consider dishware size when developing strategies to prevent over-consumption.

We propose four hypotheses about how participants respond to the plate size and pre-versus post- meal temporal variations in this study. 1) Participants will be able to accurately draw the overall estimated sizes of the meal and food components they are about to consume. 2) Participants drawing their meals post-consumption will be less accurate in drawing on plates than participants drawing their meals pre-consumption. 3) Participants drawing on plates larger than the ones they were served their meals on will be less accurate in drawing their food portions and meal size as participants drawing on plates that were identical in size to the ones they were served their meals on. 4) Gender will moderate the accuracy of plate drawing, with women producing more accurate plate drawings than do men.

Methods

In a quasi-experimental design at one on-campus dining facility, a paper plate and a questionnaire were administered to students who had purchased a meal at a large university in the Northeastern U.S. For sixteen weekdays, students were approached during between the hours of 11:30 am and 1:30 pm either 1) as soon as they sat down to eat but before they had started eating (pre-consumption) or 2) after they had finished their meal but before they had gotten up from the table to leave the dining hall (post-consumption). The questionnaire consisted of a consent form and requested basic student demographics. When the questionnaire was completed, researchers instructed participants to “please accurately draw and label the foods in the meal that you (are about to/have just) consume(d). Please be as realistic as possible with the sizes of the foods on your plate” (APPENDIX B).

Each participant received one size of plates of identical material, design, and color, but one plate was 9” in diameter and the other plate was 11” in diameter. The 9” plate was selected to match the size and color of the plates currently used in the dining facility. Only one size of plate and pre- or post-meal assessment was used to collect data on any given day with each plate size and meal time being collected on four out of the sixteen total days. A random number generator was used to determine the order of plate collection. Completed plates and questionnaires were collected immediately after the student was finished. Of the 291 plates collected, 248 were analyzed after excluding 40 students for not reporting the size of the salad purchased (small or large container) and 3 who were minors under the age of 18. Of the 248 plates analyzed, all plate drawings completely matched foods on the plates, with no student who omitted drawing any purchased food that had been recorded as being on their plate by one of the researchers. Participants were not compensated in any way for their time. The study was approved by the Cornell University Institutional Review Board.

Participants self-labelled the food items that they drew in order to confirm the contents of their meal and a researcher covertly recorded the food items on the actual plate. This was done to confirm that participants had correctly recalled their meal as well as to match drawn participant food estimations with research food measurements during data analysis.

Completed plates were coded to construct indicators for the concepts in the hypotheses. Foods were rated by size to avoid presumptions about which foods were main courses or side dishes and were then sorted into largest to smallest portions based on the size of their circumference. The horizontal dimensions of drawn food, specifically circumference and area, were used as a proxy for actual size of drawn foods based on mathematical modeling showing that horizontal area is an acceptable estimate of overall volume (Pratt, Croager, & Rosenberg, 2011). The independent variables were plate size and pre-consumption and post-consumption timing. Dependent outcome variables for this analyses were plate coverage (percent of plate covered), the food course (largest to smallest), and food size coverage (circumference and area). Moderating variables were size of plates used for drawing (9" or 11") and gender.

To compare participant drawings with estimated food size, the dining facility allowed us to observe their staff preparing each meal collected during the study so that measurements of food size could be obtained and a photograph could be taken for reference. For most foods, repeated measurements of the same food type were taken and the average size was used when comparing actual food size with drawn food size. Two researchers measured each food in order to verify the accuracy of measurements. A Pearson's r correlation was then used to measure the relationships between the participant drawn food portions and meal size and the actual measurements of food portions collected by the researchers. According to Cohen (1988), the guidelines for effect size categorization of correlation strength is r=.10 for a small effect, r=.30 for a medium effect, and r=.50 for a large effect. We use this categorization when evaluating the extent that participants were able to draw their meals and foods with relative accuracy. The significance threshold for all statistical analyses was set at .05.

Results

Among the 248 participants, 52% (n=130) drew on 9" plates and 48% (n=118) drew on 11" plates. Men and women comprised 50% each of the pre-consumption group while there were more men (59% n=61) than women (41% n=43) in the post-consumption group. Table 4.1 summarizes the results of male responses to plate size and temporal variables and Table 4.2 summarizes the results female responses to plate size and temporal variables. Results are reported by gender to examine if there were differences in how each group completed this task.

For pre-consumption males who drew on plates that were the same 9" diameter plates as their actual meal was on, there was a strong positive correlation between the overall size of the actual meal and participant's drawn meal (r=.80) as well as for the largest three foods on the plate (r=.87, r=.56, & r=.69) on the plate. There were not enough participants drawing four or more foods on their plate to provide enough cases to appropriately consider the correlation between participant drawings and actual food sizes. Fourth and fifth foods on a participant's plate are listed in the Tables but will otherwise not be discussed further. Pre-consumption females on 9" plates also showed strong positive correlation for the overall size of the meal (r=.75) as well as the three largest food (r=.79, r=.73, & r=.70).

Pre-consumption males with the larger 11" plates were moderately positively correlated between overall meal size and overall meal estimates (r=.76). The largest food estimate showed strong positive correlation (r=.81) but none of the other foods drawn on the plates showed significant correlations. Females in this group also showed strong positive correlation between overall meal size and meal drawing (r=.82) as well as a moderate positive correlation between the largest food estimate (r=.65) but no other significant correlations.

Participants who had consumed their meals and were required to immediately recall the size of their food portions were also appeared to be able to adequately estimate their actual meal size by drawing them on the provided plates. Post-consumption males on 9" plates showed moderate positive correlations for meal size and the first two largest food portions (r= .68, r=.59, & r=.56) and strong positive correlation for the third largest food (r=.84). Post-consumption females also showed strong positive correlation for all measurements (r=.74, r=.70, r=.88, & r=.80) when provided the same 9" diameter plated as they used for their actual meal.

Post-consumption males who were given larger 11" plates to draw their meals were strongly positively correlated in overall meal size (r=.76) but were only moderately positively correlated in estimating the size of their largest food (r=.38) and there was no statistically significant correlation for second and third food items. Post-consumption females were strongly positively correlated with overall meal size and first largest food (r=.73 & r=.58) but had no statistically significant correlation for second and third food items.

Our first hypothesis was that all participants would be able to accurately recall and draw the meals they have in front of them and are about to consume. This hypothesis was supported for all of our conditions, with participants drawing overall meal sizes with strong a positive correlation of r=.50 or greater.

Our third hypothesis was that participants drawing on their plates post-consumption will draw less accurately than participants drawing on their plates pre-consumption. This hypothesis was not supported as participants drew their overall meal sizes with a strong positive correlation of r=.50 or greater, although many of the correlations were lower for the post-consumption participants than the pre-consumption participants.

Our second hypothesis was that participants drawing on plates larger than the ones they were served their meals on will be less accurate in drawing their food portions and meal size as participants drawing on plates that were identical in size to the ones they were served their meals on. This hypothesis was not uniformly supported by the data as all participants were able to accurately draw the overall size of their meals, although many of the correlations were lower for the 11" plates than the 9" plates. The hypothesis was supported when considering the accuracy of drawings for the second and third largest foods. Participants given the 9” plates were able to draw their entire meals and the first three largest foods with a significant correlation of r=.50 or greater. Participants with the larger 11” plates drew the entire meal and largest food with a significant correlation of r=.50 or greater but did not draw their second or third largest foods with significance.

Our fourth hypothesis was that gender will moderate the accuracy of plate mapping, with women producing more accurate plate drawings than men. This hypothesis was supported when participants were given the larger 11” plates. Figures 4.1-4.8 summarize the R^2 values of participant’s drawn and real meal sizes. Paired T-tests were used to determine the differences between drawn and actual meals. This analysis reported of men provided with 11” plates drew meals that were significantly larger than they had consumed. The overestimation of meal size resulted in men drawing, on average, meals on 11” plates that 3.1 square inches bigger (p=.007) than their meal pre-consumption and 5.1 square inches bigger (p=.023) than their meal post-consumption. Women provided with 11” plates did not draw significantly larger meals when tested pre-consumption (p=.208) or post-consumption (0=.251).

TABLE 4.1: MALES COMPARISON OF DRAWN AND ACTUAL FOOD PORTION AND MEAL SIZE FOR PRE- AND POST-CONSUMPTION BY PLATE SIZE

Male 9" Plate Participants										
	Pre-Consumption Plate					**Post-Consumption Plate**				
	Drawn Food		Actual Food			Drawn Food		Actual Food		
Coverage		N		N	Correlation		N		N	Correlation
Total % Covered	70% ± 26%	42	71% ± 23%	42	.80**	62% ± 24%	32	67% ± 26%	32	.70**
Total Area Drawn	28.6 ± 10.5	42	28.7 ± 9.4	42	.80**	25.3 ± 9.6	32	27.3 ± 10.4	32	.70**
Food Item Size										
Largest	19.4 ± 8.8	42	18.7 ± 6.6	42	.87**	17.6 ± 7	32	17.9 ± 4.5	32	.59**
Second	10.2 ± 3.4	20	10.1 ± 2.4	20	.56**	11.3 ± 6.4	16	11.5 ± 3.6	16	.56*
Third	8.3 ± 2.9	15	9.1 ± 1.2	15	.69**	5.4 ± 1.8	9	8.1 ± 1.7	9	.84**
Fourth	5.4 ± 1.7	11	7.3 ± 1.2	11	-.27	3.8 ± 2	4	7.8 ± 1.2	4	.50
Fifth		0		0	x	4.2	1	4	1	x
Male 11" Plate Participants										
	Pre-Consumption Plate					**Post-Consumption Plate**				
	Drawn Food		Actual Food			Drawn Food		Actual Food		
Coverage		N		N	Correlation		N		N	Correlation
Total % Covered	55% ± 20%*	30	69% ± 19%*	30	.70**	55% ± 24%*	29	66% ± 22%*	29	.69**
Total Area Drawn	34.8 ± 15**	30	28.2 ± 7.6**	30	.70**	34.8 ± 15*	29	26.9 ± 8.8*	29	.69**
Food Item Size										
Largest	24.5 ± 9.6	30	19.6 ± 5.5	30	.812**	24.8 ± 7.7	29	18.2 ± 4.8	29	.38*
Second	11.7 ± 2.4	17	10.1 ± 2	17	.325	13.2 ± 5.3	15	10.1 ± 2.5	15	.45
Third	8.3 ± 1.5	9	8.6 ± 1.2	9	-.59	9.3 ± 4.8	8	9.6 ± 1.5	8	.42
Fourth	6.5 ± 1.1	5	6.8 ± .8	5	-.646	6.5 ± 2	2	8 ± .1	2	x
Fifth		0		0	x		0		0	x

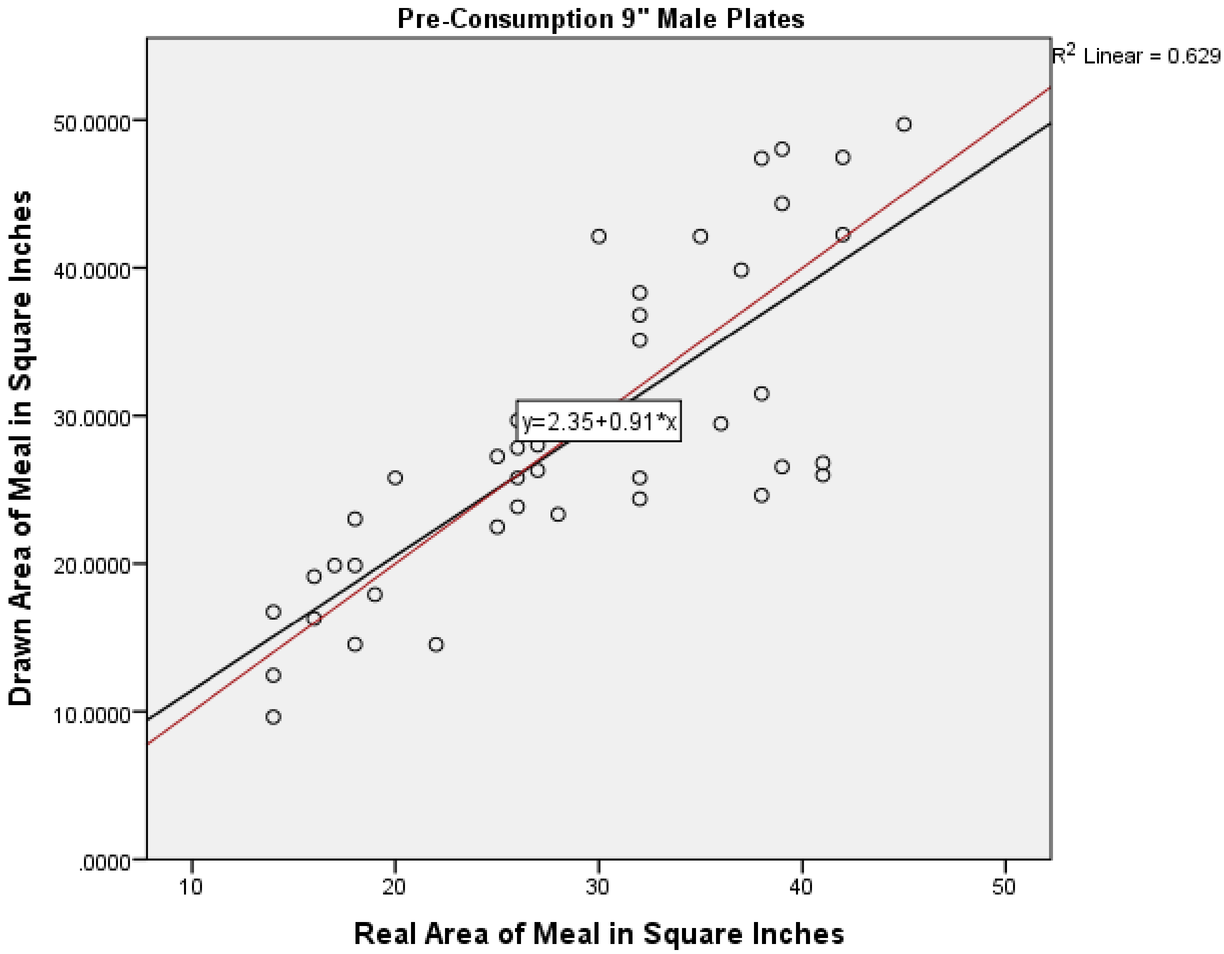
* $p > .05$; ** $p > .01$

TABLE 4.2: FEMALES COMPARISON OF DRAWN AND ACTUAL FOOD PORTION AND MEAL SIZE FOR PRE- AND POST-CONSUMPTION BY PLATE SIZE

Female 9" Plate Participants										
	Pre-Consumption Plate					Post-Consumption Plate				
	Drawn Food		Actual Food			Drawn Food		Actual Food		
Coverage		N		N	Correlation		N		N	Correlation
Total % Covered	69% ± 22%	36	72% ± 21%	36	.75**	58% ± 24%	20	64% ± 22%	20	.74**
Total Area Drawn	28 ± 9.1	36	29.4 ± 8.7	36	.75**	23.5 ± 9.5	20	26.1 ± 9	20	.74**
Food Item Size										
Largest	18.3 ± 7.1	36	18.4 ± 4.8	36	.79**	17 ± 7	20	18.1 ± 4.2	20	.70*
Second	9.3 ± 3.6	21	9.7 ± 3.6	21	.73*	8.6 ± 3.8	10	10.9 ± 3.5	10	.88**
Third	7.4 ± 1.8	15	8.7 ± 1.3	15	.70**	7.5 ± 3.1	5	8.4 ± 1.7	5	.80**
Fourth	5.7 ± .8	8	7.6 ± 1.4	8	.25	5.8	1	7.8	1	x
Fifth	3.7 ± 1.1	2	5	2	x	4.2	0	4	0	x
Female 11" Plate Participants										
	Pre-Consumption Plate					Post-Consumption Plate				
	Drawn Food		Actual Food			Drawn Food		Actual Food		
Coverage		N		N	Correlation		N		N	Correlation
Total % Covered	50% ± 18%	37	69% ± 26%	37	.82*	43% ± 18%	23	66% ± 20%	23	.74**
Total Area Drawn	31.8 ± 11.7	37	28 ± 10.6	37	.82*	27.6 ± 11.7	23	26.1 ± 8.2	23	.74**
Food Item Size										
Largest	20.3 ± 8.4	37	17.2 ± 4.2	37	.65**	21.1 ± 8.2	23	18.8 ± 4.2	23	.58**
Second	11.7 ± 3.5	21	10.2 ± 3.4	21	.38	9.8 ± 6.1	10	11 ± 2.0	10	.50
Third	9.6 ± 1.8	13	9.3 ± 1	13	-.08	10.2 ± 1.6	5	9.6 ± 1.3	5	.43
Fourth	6.8 ± 1.8	8	8.1 ± .6	8	.01		0		0	x
Fifth	5.1	1	6	1	x		0		0	x

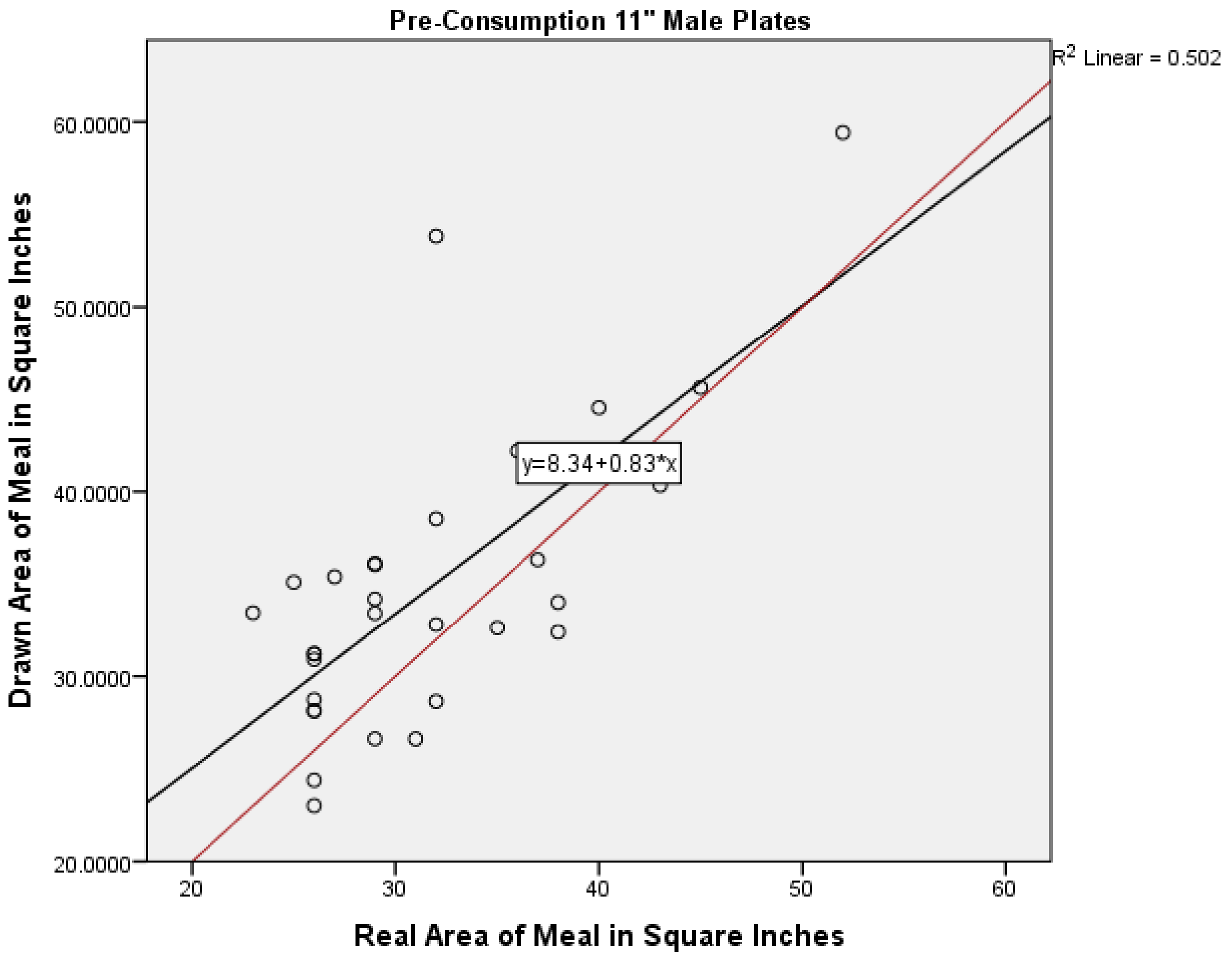
* p > .05; ** p > .01

FIGURE 4.1: MALES COMPARISON OF REAL AND DRAWN MEAL SIZE FOR PRE-CONSUMPTION 9" PLATES



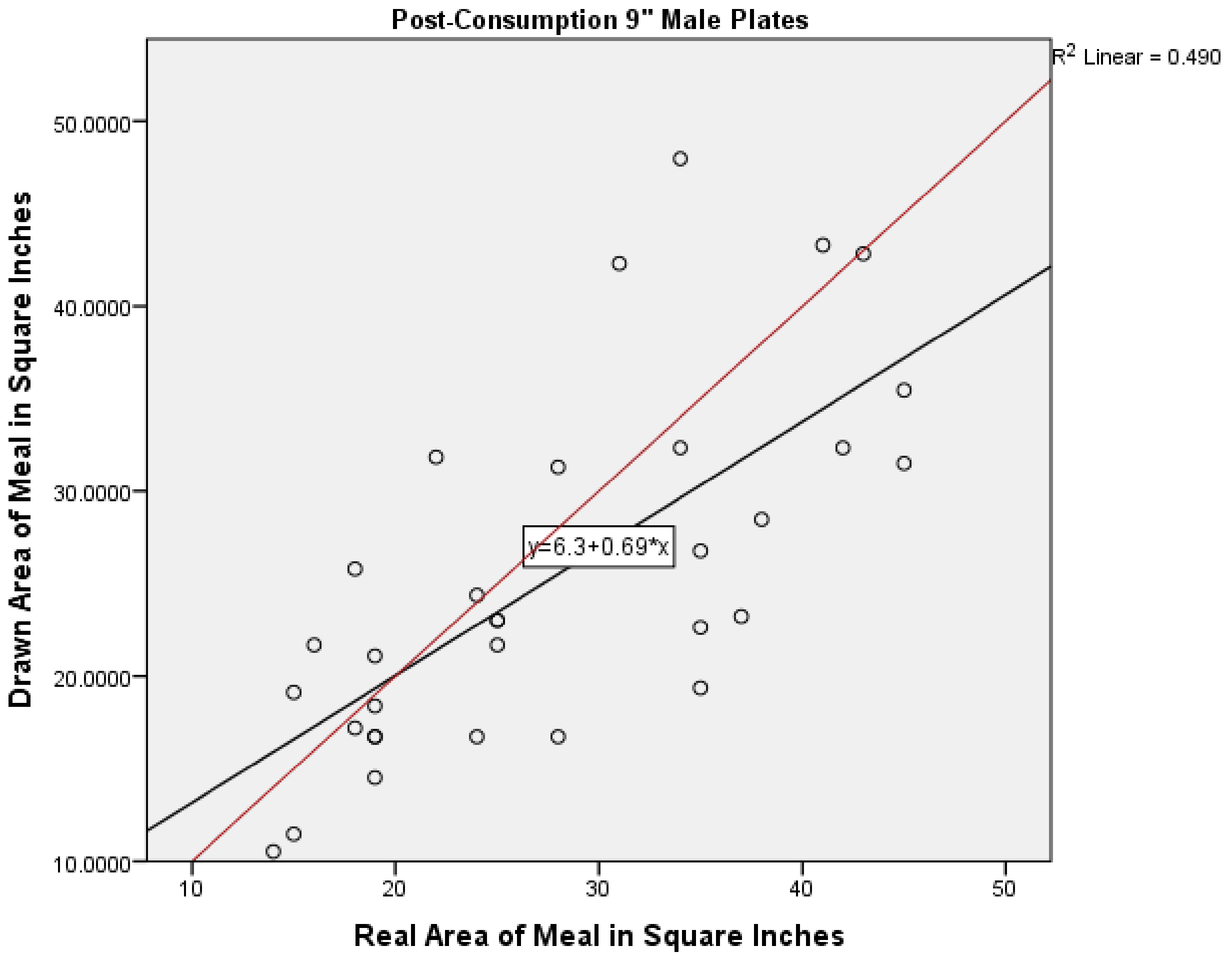
Red line indicates expected responses where x = y. Black line indicates best fit line of drawn meal responses vs actual meal size.

FIGURE 4.2: MALES COMPARISON OF REAL AND DRAWN MEAL SIZE FOR PRE-CONSUMPTION 11” PLATES



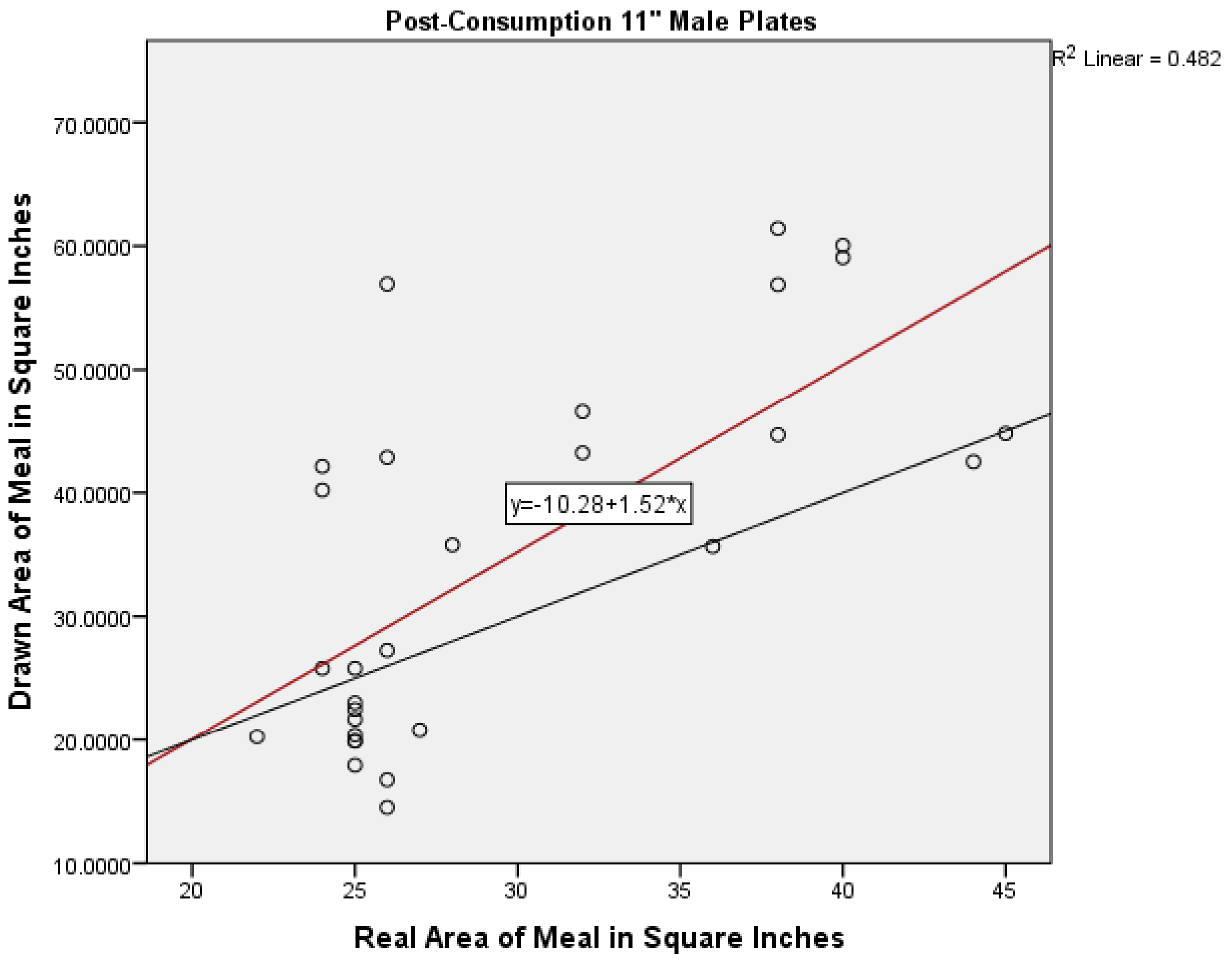
Red line indicates expected responses where x = y. Black line indicates best fit line of drawn meal responses vs actual meal size.

FIGURE 4.3: MALES COMPARISON OF REAL AND DRAWN MEAL SIZE FOR POST-CONSUMPTION 9" PLATES



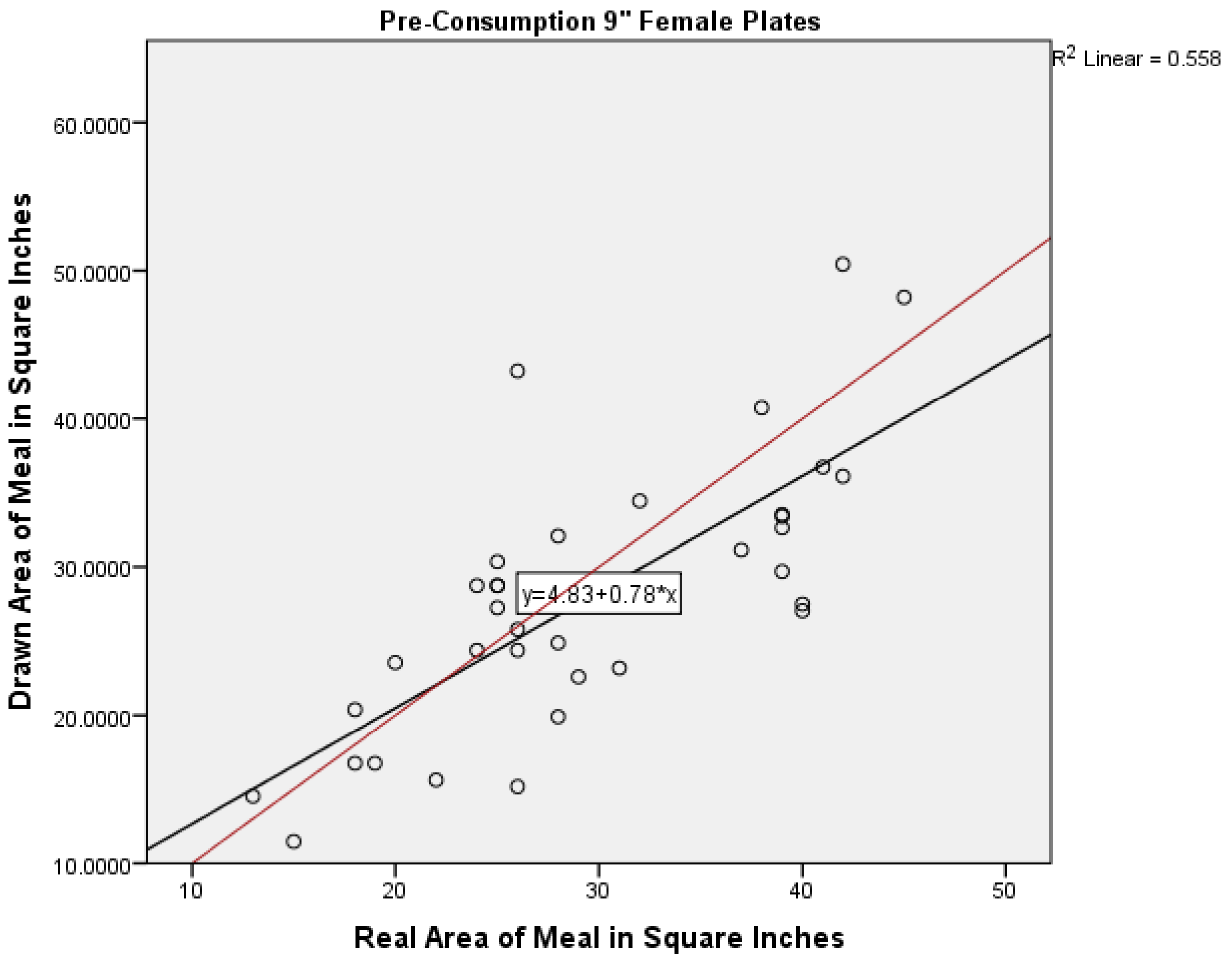
Red line indicates expected responses where x = y. Black line indicates best fit line of drawn meal responses vs actual meal size.

FIGURE 4.4: MALES COMPARISON OF REAL AND DRAWN MEAL SIZE FOR POST-CONSUMPTION 11" PLATES



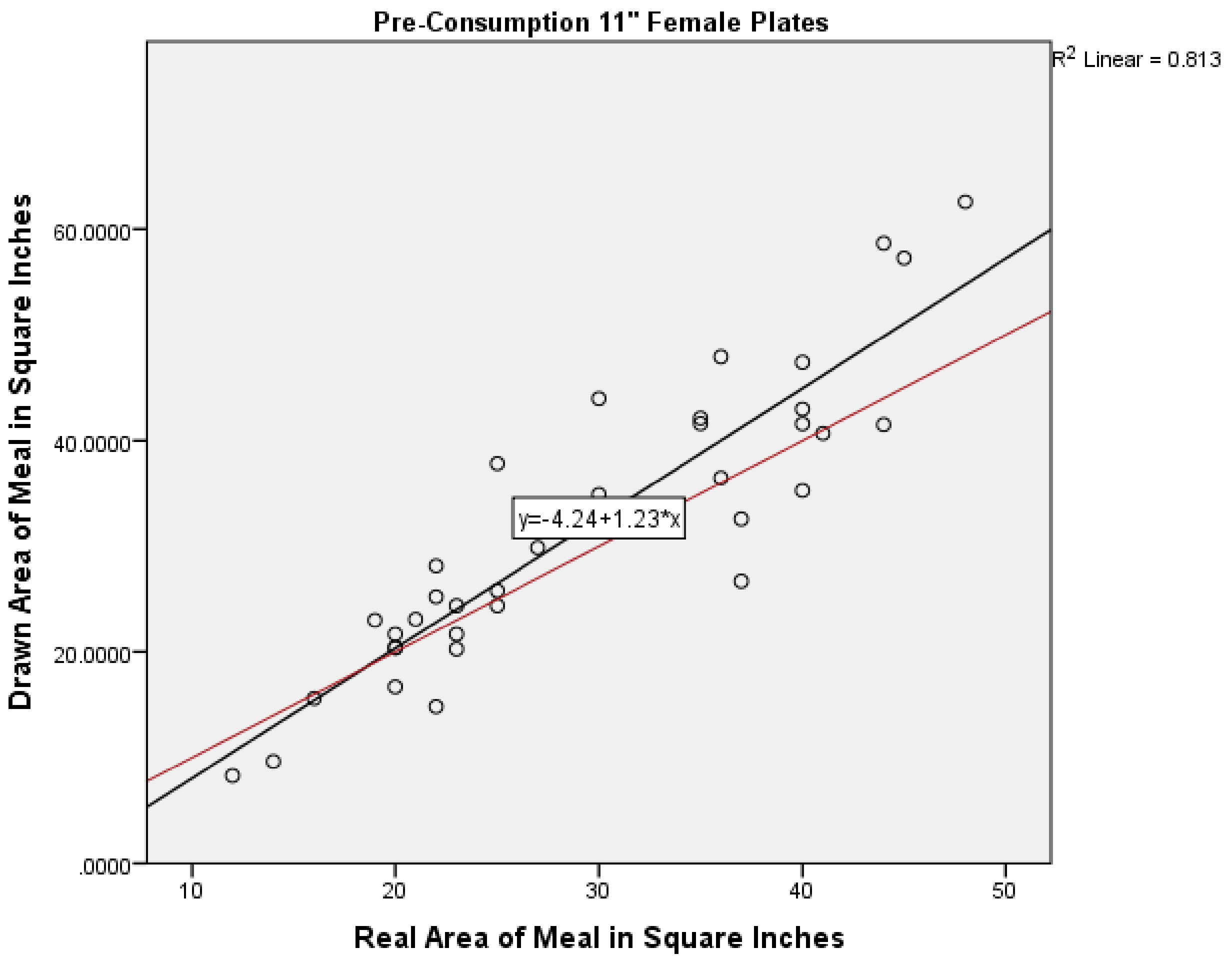
Red line indicates expected responses where x = y. Black line indicates best fit line of drawn meal responses vs actual meal size.

FIGURE 4.5: FEMALES COMPARISON OF REAL AND DRAWN MEAL SIZE FOR PRE-CONSUMPTION 9" PLATES



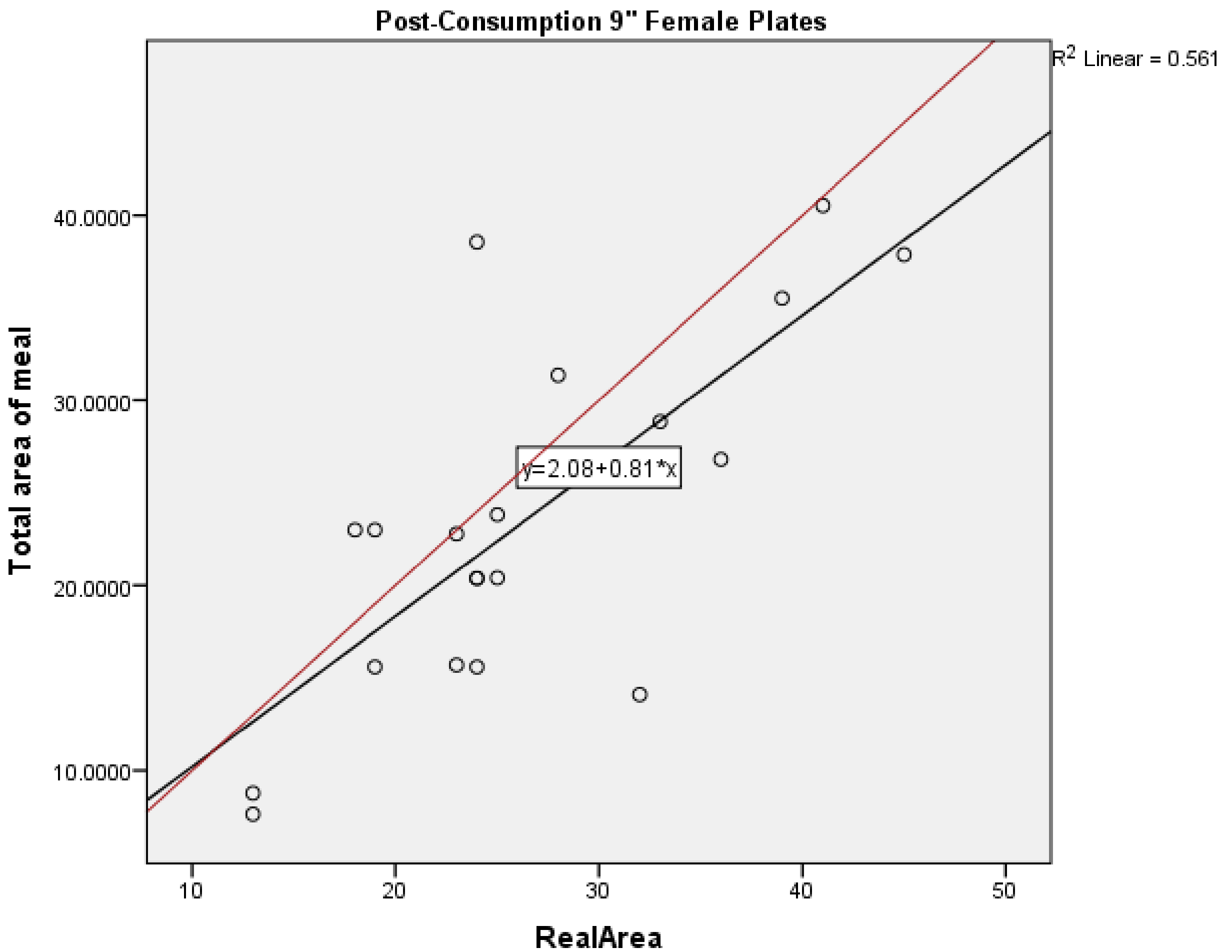
Red line indicates expected responses where x = y. Black line indicates best fit line of drawn meal responses vs actual meal size.

FIGURE 4.6: FEMALES COMPARISON OF REAL AND DRAWN MEAL SIZE FOR PRE-CONSUMPTION 11” PLATES



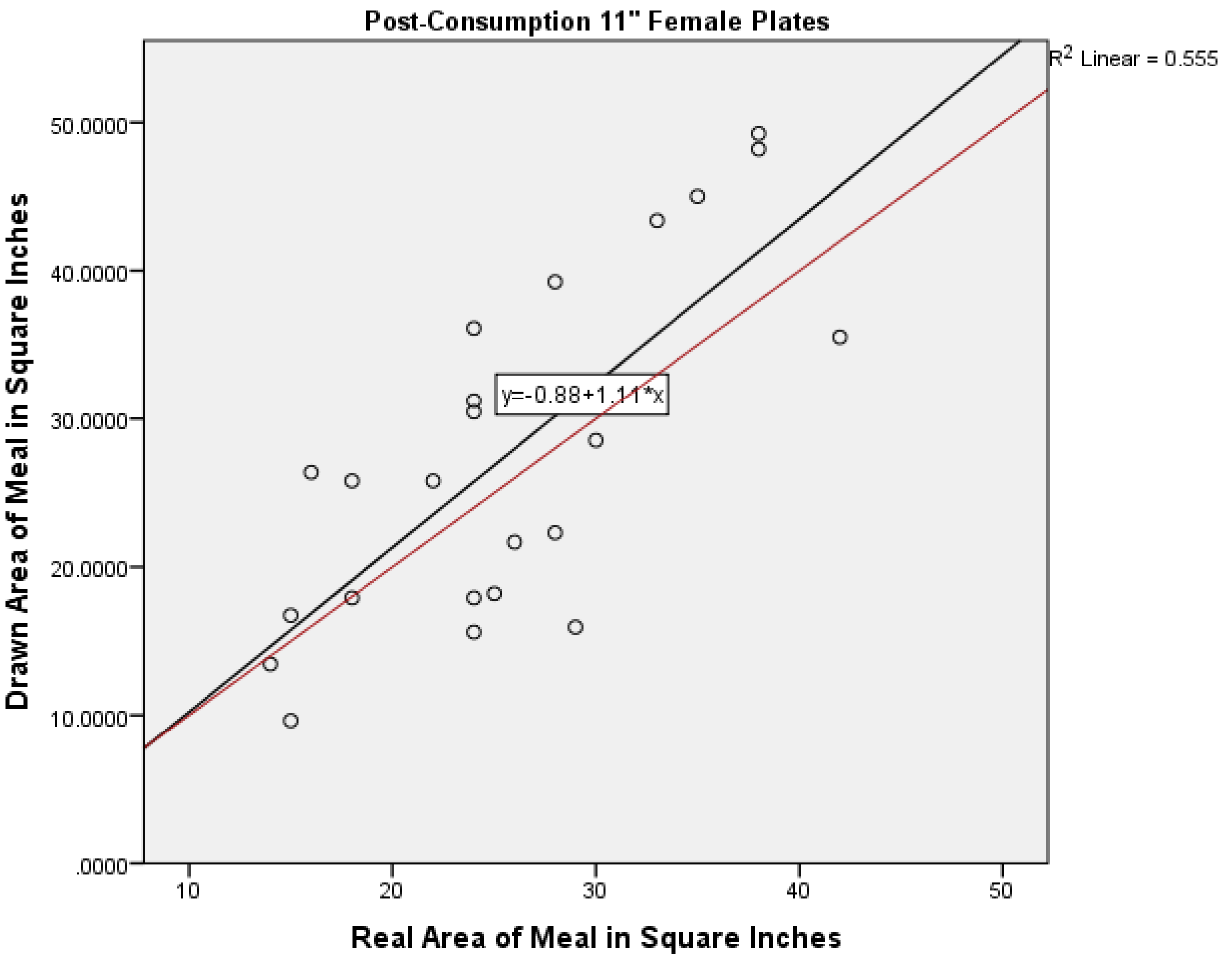
Red line indicates expected responses where x = y. Black line indicates best fit line of drawn meal responses vs actual meal size.

FIGURE 4.7: FEMALES COMPARISON OF REAL AND DRAWN MEAL SIZE FOR POST-CONSUMPTION 9” PLATES



Red line indicates expected responses where x = y. Black line indicates best fit line of drawn meal responses vs actual meal size.

FIGURE 4.8: FEMALES COMPARISON OF REAL AND DRAWN MEAL SIZE FOR POST-CONSUMPTION 11" PLATES



Red line indicates expected responses where x = y. Black line indicates best fit line of drawn meal responses vs actual meal size.

Discussion

This study examined the usefulness of plate mapping as a technique for representing foods. These findings suggest that students could draw appropriately sized foods on a paper plate when the plate was the same size as an actual plate of food. The drawings of the overall meal size and largest course were strongly correlated with actual meal and food size for identical sized plates, but participants, especially males, had difficulty drawing appropriately sized food on plates that were larger than the actual plates even when the food could be observed while they drew. There appears to be an asymmetrical gender response to plate size as an environmental influence, where men focus more on their foods looking proportionally appropriate to the provided plate while women are better at drawing actual portion size. The more correlated meal drawings on the 9” diameter plates when compared to the larger 11” plates reinforces the concept that plate size may be an important environmental influence both on how much we estimate that we will eat as well as how much we estimate that we ate.

While there was no statistically significant difference in the mean overall size of the actual meals that all participants purchased for lunch, males appeared to be sensitive to the size of the provided plate when drawing their meals. On average, post-consumption males provided with 11” plates drew about 5 square inches ($p < .01$), or nearly the size of a standard business card, more food than males provided with a 9” plate. This difference occurred, but to a lesser effect, when the male participant was able to use his physical meal as a reference and draw prior to eating. This finding reinforces prior research showing that individuals provided with larger vessels have previously been associated with larger serving food portions (Sobal & Wansink, 2007; Wadhera & Capaldi-Phillips, 2014; Wansink, 2004).

Applications

It has been suggested that an increase in portion sizes has been associated with body weight increases (Young & Nestle, 2002; Ledikwe, Ello-Martin, & Rolls, 2005). Changing plate size may be a potential public health strategy to alter food intake and influence how much and which types of food a person will serve or is served. Dietary advice may have the potential to have large social impacts, so strategies that observe or alter consumption norms should focus on encouraging individuals to eat healthier, more varied, or lower calorie foods. Reduced portion sizes lead to reduced food intake (Jeffery et al., 2007; Freedman & Brochado, 2010) and external food cues anchor individual perceptions of portion size and influence responses (Fedoroff, Polivy, & Herman, 1997; Jansen & van den Hout, 1991; Koh & Pliner, 2009). Plates are micro-level built environments that offer visible platescapes (Sobal & Wansink, 2007) for individuals to use as a base for the size of their food portions and total meal size. Larger plates may influence the amount and types of foods served onto them, shaping food intake and nutrient ingestion.

Health workers seeking to gather information about a participant's dietary practices may also benefit from understanding potential inaccuracies that arise from trying to collect data on an unusually sized plate. Attention to plate size and providing participants with the opportunity to draw an example meal may be useful for examining meal preferences and the importance of specific foods. This increased knowledge may offer insights into a person's views of meal size, food preferences, or meal aversions and provide a culinary starting point for dietary recommendations. This study shows that asking a person to estimate meal size on a larger than appropriate plate can lead to overestimated meal sizes even when the meal to be estimated is placed directly in front of a participant during the drawing task.

Limitations

There are several limitations in this study. Plate mapping is a newly developed measurement procedure and needs further testing and refinement. A measurement limitation is that this study did not record self-reported feelings of hunger or satiety before or after the experiment, leaving open the questions of whether or not hunger levels influenced the accuracy of drawn meal size in participants pre-consumption or if levels of satiety influenced the accuracy of drawn meal recall in participants post-consumption. The use of a college student sample may limit generalizability of these results to other populations.

Conclusion

Overall, this study found that the technique of plate mapping, where people draw meals on a paper plate, adequately represents actual meals if the paper plate is the same size as the actual plate. The similarity of female's drawings on both same sized and larger plates suggests that women are less plate sensitive and men are more influenced by plate size. Future studies are needed to examine caloric differences due to environmental influences like plate size, and whether health professionals can manipulate plate size differences to improve positive healthy food choices.

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CHAPTER 5: USING PLATE MAPPING TO EXAMINE PORTION SIZE AND PLATE COMPOSITION FOR LARGE AND SMALL DIVIDED PLATES*

*Sharp, D.E., Sobal, J., & Wansink, B. (2014). Using plate mapping to examine portion size and plate composition for large and small divided plates. *Eat Behav,* 15(4) 658-663.

Introduction

Food portion size is an important influence upon what people eat and the nutrients that enter their bodies. Plates are containers for serving and holding foods for consumption, and the size and shape of plates can influence how much food people put on their plates. While past studies have only focused on undivided plates, this study examined how people portrayed meals on different sized divided plates. Moreover, it expands upon a new method – plate mapping – that offers a potentially useful technique for the next generation of research involving the serving of food.

Divided plates segregate a plate surface into separate areas using raised ridges. Plates are objects of material culture into which eating values and norms are physically inscribed. Most plates are circular, and most divided plates have three compartments. One compartment is usually larger than the other two, representing social norms of a core “main course” (often a meat/protein food) plus two secondary “side dishes” (often a starch food and vegetable food) as represented by the cultural formula for a meal structure of A+2b (Charles and Kerr, 1988; Douglas, 1972; Murcott, 1982). Divided plates are also known as compartmentalized, partitioned, or segmented plates, and are commonly used for feeding children, institutional foodservice, and informal outdoor eating events. Prior studies have used divided plates and manipulated the size of foods in compartments (Kral, Kabay, Roe, & Rolls, 2012), but have not quantitatively examined the relationship of divided plate size with conceptions of appropriate food servings. This study used divided plates to examine how food portions and meal composition are associated with plate size.

Plate mapping asks participants to accurately draw and label the foods in a meal on a paper plate (Sharp & Sobal, 2012) to represent their cognitive schema of a platescape (Sobal & Wansink, 2007). Plate maps project cultural scripts for appropriate meal portions and sizes of food into plate drawings. Plate mapping has been previously used among college students (Sharp & Sobal, 2012) to examine plate sensitivity and plate composition.

Plate sensitivity refers to how people react to different types and sizes of plates. Research about plate size for non-divided plates shows that people draw bigger portions of specific foods and bigger overall meal sizes on larger plates (Sharp & Sobal, 2012). Laboratory studies, however, report mixed plate size effects on food serving and consumption (DeSantis et al., 2013; Koh & Pliner, 2009; Rolls et al.; Shah et al.; Yip et al.)

Plate composition describes the types of foods on plates as represented by the number of main and side dishes and the proportions of main and side dishes. Research about non-divided plate size has shown that people draw bigger main courses and vegetable portions on larger plates (Sharp & Sobal, 2012).

Plate size communicates information about the types and amount of food expected to be served on and eaten from a plate. Overall, larger plates and other food containers encourage people to serve and eat more food (Wansink, 2006) and different types of foods (Sharp and Sobal, 2012). Previous studies of plate size have largely been conducted in laboratory settings (DiSantis et al., 2013; Koh & Pliner, 2009; Rolls, Roe, Halverson, & Meengs, 2007; Shah, Schroeder, Winn, & Adams-Huet, 2011; Yip, Wiessing, Budgett, & Poppitt, 2013), but such direct observational methods are time consuming, expensive, and involve high response burden for participants. An alternative procedure for evaluating plate size is “plate mapping” (Sharp & Sobal, 2012).

Gender has been studied in food and eating and shown to have an influence on both food choices and eating (O’Doherty, Jensen, & Holme, 1999). Men appear to be less concerned about health and may be more sensitive than women about plate size when they make food choices, selecting less healthy foods like meats rather than fruits and vegetables (Rolls, Federoff, & Guthrie, 1991; Wardle et al., 2004). Gender may operate as a moderating variable in relationships between plate size and the sizes and types of foods on a plate, with women drawing bigger vegetable portions on larger non-divided plates (Sharp & Sobal, 2012). A review of previous plate sensitivity articles suggest that gender moderation has not been well represented in this literature. Koh and Plinter (2009), Yip et al. (2013), and Shah et al. (2011) all reported results using female participants while Penaforte et al. (2013) and Wansink, van Ittersum, and Painter (2006) state their findings from a mixed gender sample without reporting if responses differed significantly by gender. While Rolls et al. (2007) examined gender and found no significance in food consumption amounts when plate size was changed, Sharp and

Sobal (2012) found that gender differences were significant when estimating expected meal size.

Divided plates have rarely been studied in food choice research. To fill this gap in knowledge, we used plate mapping to compare large and small divided plates. We propose four hypotheses about divided plate sizes and plate mapping 1) plate sensitivity, 2) meal norms, 3) meal composition (type of food and food course), and 4) gender moderation.

The plate sensitivity hypothesis posits that people are mindless about portion size and fill divided plates to capacity, drawing bigger overall meal sizes on larger divided plates. The plate sensitivity hypothesis proposes that larger plates will be covered with more food than are smaller plates.

The meal norms hypothesis posits that people draw meals to conform to normative conceptions about how full a plate should be, filling divided plates to levels that seem appropriate to the plate size. The meal norms hypothesis proposes that the same percentage of larger and smaller divided plates will be covered with food.

The meal composition hypothesis posits that plate size influences serving of different foods in uneven ways. The hypothesis has two parts. The type of food hypothesis proposes that bigger vegetable dishes will be drawn on larger divided plates. The food course hypothesis proposes that bigger main courses will be drawn on larger plates than smaller plates.

The gender moderation hypothesis posits that gender differences occur in plate size effects upon food choice. The gender moderation hypothesis proposes that men are more sensitive to plate size than are women, with men drawing larger main courses on plates than women draw on plates.

Methods

Students attending one university course in 2011 and students attending the same course in 2012 taught by the same instructor were asked to participate in this study. In 2011 students were asked to draw on a large divided plate and in 2012 students drew on a small divided plate in this quasi-experimental design (Shadish, Cook, & Campbell, 2001). Each class got plates of only one size to avoid potential biases if students noticed that plate sizes differed among members of the class.

The large plate had a total outside diameter of 10.25” and a depth of 1”, had a 1” wide outer rim and the interior dividing ridges of the plate were .25” wide, making the total usable food area of 52.5 square inches, with 29.5 square inches in the main compartment and 11.5 square inches in each of the two symmetrical side compartments. The small plate had a total outside diameter of 9.5” and a depth of .5”, had a 1” wide outer rim and interior divisions of the plate were .25” wide, making the total usable food area 43 square inches, with 21.7 square inches in the main compartment and 10.5 square inches in each of the two symmetrical side compartments.

At the beginning of class, one paper plate and an attached questionnaire were given to each student as they entered the classroom. The questionnaire provided consent information plus demographic questions about age and gender. The instructions for the plate drawing asked students to “Please accurately draw and label the foods in a meal that you would enjoy eating for dinner tonight. Please be as realistic as possible with your drawings of the foods" (Appendix C) No images of foods or examples of drawings were provided to avoid cues that could bias the food drawings (Tversky & Kahneman, 1974). Each class received one size of plate that was from the same manufacturer (Chinet, De Soto, Kansas, USA) using the same material, design, and color to prevent potential biases if students had been given two different sizes or types of plates in the same classroom. Students were given class time to complete the plate drawing and questionnaire and turn in their materials. No compensation of course credit or other forms was given for participation. The University Institutional Review Board deemed this study exempt.

The researchers were not able to count the exact number of students attending each class session. The minimum estimated response rate was 76% in 2011 and 64% in 2012 based on the number of returned plates divided by the number of students officially registered for the course, although often registered students do not attend class. Based on researcher observations that 0 unused plates in 2011 and 2 in 2012 were returned after class, the response rate was higher than this minimum. Of the 55 plates returned completed in 2011 and 54 in 2012, 98 (90%) were analyzed after excluding 4 plates in 2011 and 5 plates in 2012 who did not follow the written protocols. No plates were excluded because participants were minors under age 18 or omitted their age in the questionnaire.

The completed plate maps were coded by manually measuring the circumference of each drawn food on the plate to calculate the size of each separate food portion, following the procedure of earlier plate mapping studies (Sharp & Sobal, 2012). Horizontal food area is an appropriate estimate of food item volume (Pratt, Croager, & Rosenberg, 2011). Coders were trained, monitored, and checked by double coding each plate. Sums of all the food portions on each plate were calculated to represent the total plate area covered to examine the plate sensitivity hypothesis. The proportion of plate coverage was calculated to examine the meal norms hypothesis. Food items were coded by food type into the categories of meat, cereal grain, vegetable, root vegetable and tuber, fruit, legume, dessert, and other to examine the meal composition hypothesis. Drawn foods that included more than one different food were classified as the type that included the most calories or took up the most space. Foods were also coded into categories by size ranging from the largest food in the meal to the fifth largest, which were used to represent the main course and side courses. The number of compartments in these plates containing food was also coded.

In this study the independent variable was plate size, and the dependent outcome variables were meal area, percent of plate covered, food type, and food item size. Gender was examined as a moderating variable and age was assessed to characterize the sample.

Analyses first produced descriptive statistics for all variables using percentages and means ± standard deviations. Next, bivariate comparisons of larger and smaller plates were made using Chi-square and t-tests to examine the plate sensitivity, meal norms, and plate composition hypotheses. Finally, further bivariate comparisons between gender, plate size, and the plate drawing variables were performed to examine the gender moderation hypothesis.

Results

A total of 98 plates were included in the analysis. Men drew 32 (33%) plate maps and women drew 66 (67%) (Table 5.1). Similar numbers of larger plates (n=49, 50%) and smaller plates (n=49, 50%) were analyzed. The mean age of the sample was about 21 years.

All three compartments on the plates had food drawn in them on 84% (84) of all plates, 79% (42) among large plates and 79% (41) among small plates. The main compartment and only one side compartment had food drawn on 12% (12) of plates, 14% (7) of large and 10% (5) of small plates. When the main compartment was facing the eater, empty compartments occurred on the left side for 5% (5) of plates, 4% (2) among large plates and 6% (3) among small plates. Empty compartments occurred on the right side for 8% (4) of the total sample, 2% (1) among large plates and 6% (3) among small plates. Only the main compartment had food drawn on 2% (2) of all plates, none among large plates and 4% (2) among small plates. Zero plates included food drawings in side compartments but not the main compartments.

The plate sensitivity hypothesis that larger plates would elicit larger food area drawings than smaller plates was supported by these data. The total area of food drawn on larger plates was 37% bigger than food drawn on smaller plates (Table 5.1).

The meal norms hypothesis that the proportion of plate coverage would be the same between larger and smaller plates was supported. The percentage of the plate covered by drawn food was nearly significant between larger and smaller plates (Table 5.1).

Overall, 305 different food items were drawn on this sample of 98 plates (Table 5.1). The most frequent food type was vegetables (98), followed by meats (79), and then cereals (71). Fewer people drew roots (26) or fruits (14), and some drew a variety of other food types (17). Most people drew three food items, with 98 drawings of the largest food, 96 the second largest food, and 84 of the third largest food. Only 22 people drew a fourth food and 3 a fifth food.

The plate composition hypothesis predicted that the food types would differ between larger and smaller plates, with bigger vegetable portions and bigger main courses on larger plates, and the hypothesis was supported by the data. The area covered by drawn vegetables was 46% (3.4 square inches) bigger on large plates than small plates, but the drawn areas of meats, cereals, and root vegetables did not differ significantly between large and small plates (Table 5.1). Food items sizes differed significantly between large and small plates, with the largest food 35% (4.2 square inches) bigger on large plates, the second largest food 38% (2.1 square inches) bigger, and third largest food 25% (1.4 square inches) bigger (Table 5.1).

The gender moderation hypothesis predicted that men would be more sensitive to plate size, especially main courses. There were no significant differences between men and women in total food area or proportion of plate covered for large and small plates. No significant gender differences occurred in food item size or most food types, except for meat on large plates (Table 5.2). Men drew 50% bigger meat portions (15.4 square inches) than women drew (10.3 square inches) on large plates, but there were no significant gender differences in food item sizes drawn on small plates. Comparing each gender between plates, we observed that men and women both drew bigger overall dinners on larger plates with a majority of the difference in size occurring in the largest plate compartment on the dish. Men drew significantly larger meat and vegetable portions when controlling for plate size and women drew significantly larger vegetable portions (Table 5.2).

TABLE 5.1: DEMOGRAPHICS, PLATE COVERAGE, FOOD TYPE, AND FOOD SIZE FOR LARGE AND SMALL DIVIDED PLATES

	Total Sample	N	**10.5" Plate**	N	**9.5" Plate**	N	**Difference** P value
Demographics							
Male	34%	37	25%	13	43%	24	
Female	66%	72	75%	39	57%	33	
Height	67.1 ± 3.7	109	66.6 ± 3.4	52	67.6 ± 3.9	57	.15
Weight	142.8 ± 32.8	109	140.4 ± 31.8	52	145 ± 30.8	57	.44
BMI	22.1 ± 3.3	109	22.1 ± 3.3	52	22.1 ± 3.4	57	.95
Age	20.72 ± 1.6	109	20.8 ± 1.8	52	20.6 ± 1.4	57	.49
Coverage							
Total % Plate Covered	60% ± 20%	98	63% ± 18%	49	56% ± 17%	49	.06
Total Area Food Drawn	26.1 ± 12.1	98	33.1 ± 9.8	49	24.2 ± 7.3	49	.001***
Food Type							
Meat	11 ± 5.0	79	11.8 ± 5.8	38	10.2 ± 4.0	41	.15
Cereal Grains	9.8 ± 6.1	71	10.8 ± 6.7	44	8.2 ± 4.4	24	.1
Vegetable	9.1 ± 5.4	98	10.7 ± 6.1	51	7.3 ± 3.9	47	.002**
Root	7.6 ± 3.1	26	9.1 ± 2.9	7	7.0 ± 3.6	19	.182
Fruit	4.8 ± 2.2	14	4.7 ± 2.1	8	5.1 ± 2.5	6	.75
Legume	6.3 ± 2.8	6	9.6 ± .01	2	4.7 ± 1.6	4	.015*
Dessert	5.4 ± 3.6	2	2.9	1	8	1	x
Other	7.8 ± 5.7	9	6.1 ± 2.3	5	9.9 ± 8.2	4	.35
Food Item Size							
Largest	14.4 ± 5.7	98	16.3 ± 5.9	49	12.1 ± 4.8	49	.001***
Second	8.2 ± 3.8	96	9.1 ± 4.3	49	7.0 ± 2.8	46	.01**
Third	6.4 ± 2.6	84	7.0 ± 2.7	42	5.6 ± 2.0	41	.01**
Fourth	5.0 ± 2.1	22	5.6 ± 2.0	12	4.2 ± 2	9	.116
Fifth	3.8 ± 1.3	3	4.5 ± .8	2	2.4	1	.29
Food Item Size of Largest Dish							
Meat	13.2 ± 5.0	51	14.8 ± 5.5	23	11.9 ± 4.2	28	0.04*
Cereal	16.2 ± 6.1	24	18.5 ± 6.1	14	13.1 ± 4.7	10	0.03*
Vegetable	14.7 ± 5.6	22	16.9 ± 6.2	12	12.2 ± 3.8	10	0.05*
Root	6.2	1			6.2	1	x

*p < .05; ** p < .01; *** p < .001

TABLE 5.2: DEMOGRAPHICS, PLATE COVERAGE, FOOD TYPE, AND FOOD SIZE FOR LARGE AND SMALL DIVIDED PLATES BY GENDER

	10.5" Plates					9.5" Plates			
	Males		**Females**			**Males**		**Females**	
		N		N	**p-value**		N		N
Demographics									
Height	70.2 ± 3	13	64.4 ± 2.7	39	.001***	70.7 ± 3.1	24	65.5 ± 2.7	32
Weight	170.4 ± 47	13	130.4 ± 15.7	39	.001***	168.7 ± 25.4	24	128.4 ± 21.9	32
BMI	24 ± 4.7	13	21.4 ± 2.4	39	.011*	23.7 ± 3.2	24	21 ± 3.1	32
Age	21.2 ± 2.8	13	20.7 ± 1.4	39	.37	20.7 ± 1.5	24	20.5 ± 1.2	32
Coverage									
Total % Plate Covered	65% ± 19%	12	62% ± 19%	37	.64	56% ± 15%	20	56% ± 18%	28
Total Area Food Drawn	34.2 ± 10.0	12	32.7 ± 12.4	37	.64	24 ± 6.5	20	24 ± 7.9	28
Food Type									
Meat	15.4 ± 6.8	11	10.3 ± 4.7	27	.01**	10.7 ± 3.6	17	9.7 ± 4.4	23
Cereal	9.7 ± 7.3	12	11.2 ± 6.6	32	.51	8.0 ± 3.9	13	8.4 ± 4.9	14
Vegetable	9.6 ± 2.5	8	10.9 ± 6.6	43	.61	6.4 ± 3.6	18	7.8 ± 4.1	28
Root	9.4 ± 2.3	4	8.7 ± 4.2	3	.77	8.1 ± 4.8	9	5.7 ± 1.2	9
Fruit	-		4.7 ± 2.1	8	-	5.9 ± 2.1	4	3.5 ± 3.2	2
Legume	9.6	1	9.6	1	-	5.4	1	4.5 ± 1.9	3
Dessert	-		2.9	1	-	6.4	1		0
Other	-		6.1 ± 2.3	5	-		0	9.9 ± 8.2	4
Food Item Size									
Largest	17.8 ± 6.4	12	15.8 ± 5.8	37	.33	12.2 ± 3.3	20	12.0 ± 4.9	29
Second	8.6 ± 2.7	12	9.3± 4.7	37	.64	6.9 ± 2.8	20	7.0 ± 2.8	26
Third	8.2 ± 2.8	11	5.6 ± 2.6	31	.09	5.2 ± 1.9	20	5.8 ± 2.0	21
Fourth	4.5	1	5.7 ± 2.1	11	.59	5.7	1	4.0 ± 2.0	8
Fifth			4.5 ± .8	2				2.4	1
Food Item Size of Largest Dish									
Meat	16.5 ± 6.2	10	13.4 ± 4.7	13	0.2	11.8 ± 3.1	13	12.0 ± 5.4	12
Cereal	24.4 ± 2.0	2	17.5 ± 6.0	12	0.14	13.8 ± 4.0	5	12.4 ± 5.6	5
Vegetable		0	16.9 ± 6.2	12		11.1 ± 3.3	2	12.4 ± 4.1	7

*p < .05; ** p < .01; *** p < .001

TABLE 2 (CONTINUED): DEMOGRAPHICS, PLATE COVERAGE, FOOD TYPE, AND FOOD SIZE FOR LARGE AND SMALL DIVIDED PLATES BY GENDER

	Between Plate Differences	
	Males	**Females**
Demographics	p-value	p-value
Height	0.91	.88
Weight	0.75	.66
BMI	0.714	.52
Age	0.56	.553
Coverage		
Total % Plate Covered	0.13	.18
Total Area Food Drawn	0.007**	.001***
Food Type		
Meat	0.023*	.66
Cereal	0.51	.17
Vegetable	0.03*	.03*
Root	0.62	.06
Fruit	-	.53
Legume	-	.14
Dessert	-	-
Other	0.35	-
Food Item Size		
Largest	0.003**	.006**
Second	0.108	.029*
Third	0.002**	.26
Fourth		.08
Fifth		
Food Item Size of Largest Dish		
Meat	0.03*	.481
Cereal	0.02*	.131
Vegetable	-	.09

*p < .05; ** p < .01; *** p < .001

Discussion

Plates are common in many meals, and they may influence what and how much food people eat and their subsequent calorie and nutrient intake. We studied divided plates and found that their size was associated with drawn food portion sizes and types.

The plate sensitivity hypothesis was supported for divided plates. This may be explained by the DelBoeuf illusion where an object appears smaller when surrounded by larger items (Van Ittersum & Wansink, 2012; Wansink, Painter, & North 2005), with foods looking larger when they are on a smaller plate. While plates were covered with about the same percent of food, the larger plates held on average about 9.5” in^2 more food on them. In drawing bigger overall amounts of food, our large plate participants reinforce how environmental cues can be relevant when discussing food and nutrition

The meal norms hypothesis was supported for divided plates. People appear to cover about the same proportion of larger and smaller plates with drawn foods. This makes the plates appear contextually similar while offering differently sized meals.

The meal composition hypothesis was supported for divided plates. Larger plates had bigger main courses and vegetable dishes on them, congruent with prior studies of undivided plates (Sharp & Sobal, 2011). The overall larger vegetable dishes was primarily influenced by the high proportion of females in the sample, with women having more favorable attitudes toward vegetables and consuming them more often (Baker & Wardle, 2003; Emanuel, McCully, Gallagher, & Updegraff, 2012). In a similar fashion, the significant difference in predicted meat dish size in men across plate sizes is a topic that would benefit from additional scrutiny.

The gender moderation hypothesis was partially supported for divided plates. Men drew bigger meat portions on larger plates but no other significant food size differences were seen in this sample. When selecting foods, men with larger plates predominantly drew meat dishes in the main compartment, with 83% electing to do so. Women drawing on larger plates were more varied with meat, cereal, and vegetable dishes each being drawn as the main compartment dish about 33% of the time. This suggests the men in our study who were given large plates considered meat to be a main course and vegetables to be a side dish while women given large plates were more willing to use meat as a side dish and vegetables as a main course.

When comparing the largest foods on each plate, we found that individuals given the larger plates drew significantly bigger foods in the main compartment than individuals given the smaller plates. This size difference was also significant after controlling for gender. There may be a priming effect (Levitsky, Iyer, & Pacanowski, 2012) of larger plates that elicits bigger estimated portions than smaller plates even in the absence of any other tangible food cues.

Plate mapping was useful in examining plate size differences for divided plates. Participants quickly and inexpensively drew plate maps, and very few did not produce usable maps. Plate mapping may be a useful addition to other forms of dietary assessment (Gibson, 2005).

Comparing the findings of the present study of plate mapping on divided plates to prior data about plate mapping using non-divided open plate formats (Sharp & Sobal, 2012) revealed several differences in food choices between these two plate types in college students. Divided plates had more plate sensitivity, with a 1 inch difference in divided plate size diameter (equivalent to a 9.5 $inches^2$ area increase in overall size) producing the same increase in overall meal size (8.9 $inches^2$ versus 10 $inches^2$) on divided than open plates with a 2 inch difference in diameter (equivalent to a 23 $inches^2$ increase in overall area). Divided plates exhibited more meal norm effects, with 52% of divided plate participants producing an A+2b format drawing compared to 36% of open plate participants drawing meals fitting the A+2b meal format. Divided plates had more meal composition differences, with the 84% of divided plate participants drawing at least three food items compared to 73% of open plates, and 96% of divided plates having at least two food items compared with 86% of open plates. With divided plates there was a significant difference in the size of meat and vegetables on large plates when gender was controlled, while on open plates there was no difference in the size of meats but there were gender differences in the size of vegetables drawn.

There were several limitations of this study. The quasi-experimental design was not as strong as a randomized controlled trial or cross-over design. Plate mapping is a newly developed measurement procedure and needs further testing and refinement. The sample was small, included only students, and had few men. Future studies should use different designs, measures, and samples to more fully understand divided plates, plate sizes, and food choices. There are also a number of cultural issues that could be explored. A study of plating preferences of Americans, Italians, and Japanese showed a wide range of how many items they preferred to have on their plate as well as the preferred location of main courses (meat) compared to side dishes (Zampollo, Wansink, Kniffin, Shimizu, & Omori, 2012). A similar study involving parents and children showed that the children prefer the plating of food that has multiple separate piles of food (such as two small piles of each item instead of one larger pile) which do not touch each other (Zampollo, Kniffin, Wansink, & Shimizu, 2012).

Implications of these findings for practice suggest that changing plate size and compartmentalization may modify meal size and composition. Plates are micro-level built environments that offer visible platescapes (Sobal & Wansink, 2007) where people construct meals. The size and format of plates may influence the amount and types of foods served, shaping food intake and nutrient ingestion. Some have recommended that reducing plate size may be used to manage body weight (e.g. Story & French, 2002), and divided plates may encourage selection and consumption of more distinct foods which leads to less food consumption and weight loss (Chang et al., 2012). However, further experimental studies are needed to support implementation of plate sizes and formats as interventions. For instance, compartmentalization might be a successful way to introduce children to a wider range of foods and to give meals an element of challenge to clean one’s plate in a more discrete manner than if it is one larger group of food (Zampollo et al.).

In conclusion, this study replicated prior use of plate mapping, with many similar findings. Use of divided plates adds information about that type of plate design to the literature, and suggests that divided plates may have some different influences on food choices than non-divided plates.

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CHAPTER 6: CONCLUSION

Several important relationships between plate size and portion size were seen through the lens of plate mapping. When provided a larger plate, participants consistently drew more food on average than those given smaller plates. This occurred whether the participants were asked to estimate the size of a meal they were going to eat later that day, to estimate the size of a meal in front of them that they were about to consume, or to estimate the size of a meal that they had just consumed. The biggest food item on the plate was usually greater in size when drawn on the larger 11” plate. Men appeared to be more sensitive than women to the size of the plate and often provided less accurate meal drawings on a larger plate for the meal that they had just eaten or were about to eat. Men also drew much larger meals that they intended to eat that night than women did on 11” plates, while men who were given the smaller 9” plates drew similar sized meals to those drawn by women. There also was a gendered difference in the types of foods drawn on 11” plates as women often increased the size of their vegetable portions while men did not.

Knowledge gained from using plate mapping links health-related factors to the nutrition literature. By illustrating how plate size and gender can modify the types and amounts of food an individual expects to put on their plate, this research provides insights about potential mechanism’s in the relationship between portion size and consumption size. Plate mapping research also increases understanding of relationships of environmental influences with food portion sizes and reinforces the understanding the environment can be used in favor of or opposed to healthy food choices. Gaining a better understanding of the mechanisms and processes that influence consumption habits can help increase awareness of these cues for both academics as well as consumers of food and benefit short- and long-term health goals.

The cross-sectional research designs in these studies could have limited understanding. Further work using longitudinal experiments and additional methodological approaches that ask qualitative questions could be used to better examine the relationship between plate size and meal estimations as well as describe in greater detail how participants went about drawing their meals and if they believed that plate size had any quantitative effects on the size of their meals or selection of individual foods.

The findings from the samples of these four studies presented cannot be generalized to other populations. These studies assume participants consume foods from plates that are not shared with other meal participants. This pattern is not a universal eating norm and cultures whose populations do not eat food from plates may find little or no benefit from this research. Countries or local communities that suffer from chronic food insecurity may also find limited applicability as these studies assumed that participants had access to more food than they could eat at a single sitting and that additional food was available and affordable enough that participants did not need to over-consume food in preparation for an eventual time of famine.

The self-reported nature of the participants drawing their expected meal sizes could have affected the construct validity of the variables assessed. Research that combines drawn meal estimation and drawn meal recall with measurements of actual meals would increase precision and further validate plate mapping as a method of collecting data about participant consumption expectations and practices. The self-reported drawings may provide an additional avenue of nutrition intervention as health educators could use this method as an ice-breaker activity to warm up to participants and get them thinking about food and food choices.

It would be useful to pursue this vein of research and examine plate mapping in a more physical manifestation. Designing a series of incremental plate size interventions to examine a more subtle form of plate size manipulations than the larger step-wise versions previously published (Rolls et al., 2007; Shah et al., 2011; Libotte, Siegrist, & Bucher, 2014; Robinson et al., 2014) may reduce a participant's recognition of or resistance to meal size changes. Complimentary qualitative research that asks participants to review and explain their plate drawings may provide an increased understanding of and help construct a narrative of how portion and meal sizes were estimated.

Better understanding the effects of plate size on food portion and overall meal size may not only help explain our nation's current struggle with overweight and obesity related health issues but may also lead to the creation of more accurate nutrition research and more effective and more personalized nutrition interventions for dieticians and nutrition educators. Researchers who are aware of the environmental effects of micro-built environments (Sobal & Wansink, 2007) such as plate size can specify and control these mechanisms in their research to increase the accuracy of their results.

In similar fashion, dieticians and other nutrition and health educators can highlight plate size in nutrition and health programs as one of many small or "effortless" behavioral nudges that could have noticeable long-term benefits for health. As package size and serving sizes have increased due to reduced manufacturing costs and increased product availability, it is possible that these much larger food items have led to an increase in our own perceptions of how much food is required to become sated (Poothullil, 2002). By incorporating plate size changes into the education narrative alongside with portion size changes, participants may become more aware of the relationship between the environmental and consumption norms and actively seek to rid themselves of these small but important obesogenic influences. While behavioral choices, such as how much food to put on the plate, have to be made at every meal, changing the environment, such as replacing a large plate set with a more moderate one, needs to only be done once.

Change may also come from commercial operations that are not typically discussed when considering potential nutrition interventions such a large department and housewares stores. For example, there has been a 36% increase in the diameter of the American dinner plate in recent decades (Wansink, 2006). This size increase represents a doubling of the overall area of the plate available to place food on (about 65 inches squared vs. about 113 inches squared). Having double the space means that double the calories can be served on the larger plates before they are full to capacity. While the case has not been made that individuals have doubled their caloric intake based on the area available on plates, the research reported here suggests that, in general, larger 11” plates would influence the amount of self-serving that is greater than on the smaller 9” plates. That difference may be as small as 60 calories per dinner, but if only the 9” dinner plates that our parents or grandparents used were available for purchase at department stores, an individual could potentially reduce an their caloric intake by 10,950 calories or about 3 pounds per year.

This work also reinforces how broad and multidisciplinary nutrition research and nutrition interventions can be and contributes to the field of nutrition by increasing our knowledge of individual perceptions of food size and presentations of a meal. It also provides information about how individuals estimate meal size before, during, and after a meal in order to better understand meal projection and recall. Using easily integrated environmental changes, dietary advice, and graphics similar to the MyPlate icon could reinforce nutrition education messages with visual representations and provide a better understanding of meal preferences while encouraging more appropriate eating habits. Dietary advice may have the capacity to lead to large social impacts, and these results suggest strategies designed to encourage individuals to eat a healthier, more varied, or lower calorie diet may benefit from involving plate size and design.

While many people look for a pill or diet program that would improve our nation's health profile, it is possible that a series of smaller, less newsworthy changes to culture, environment, physical activity, education, and behavior may provide the motivation and capacity for individuals to control their expanding waistlines. Understanding the causes of our current unhealthy population are vital to being able to promote solutions rather than just making assumptions. This research about plate mapping provides a unique but important step in the drive towards reducing mindless overconsumption and improving our national short- and long-term health goals.

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APPENDIX A

Are you: [ ] Male [ ] Female

How old are you? ______years

How tall are you: ____feet _____inches

How much do you weigh? _______(lbs)

Are you a Freshman Sophomore Junior Senior Graduate Student (Circle One)

What is your major?______________________

Ethnicity (Circle One)

African America/Black Asian/Pacific Islander

Caucasian/European American Latino/Latina

Others: _________________

How many hours ago did you eat a full meal? ___________hours

How many years have you lived in the United States? _________ years

How good do you feel when you cooperate with others to cook a meal? (Circle one)
Not at all 1 2 3 4 5 6 7 Extremely

Would you rather depend on yourself more than others to cook a meal? (Circle one)
Not at all 1 2 3 4 5 6 7 Extremely

How important is it for you to maintain a healthy diet? (Circle one)
Not at all 1 2 3 4 5 6 7 Extremely

Compared to a food's taste, how important is it for this food to also be filling ? (Circle one)
Taste is always more important 1 2 3 4 5 6 7 Satiety is always more important

Where do you eat most of your dinners? (Check one)
[ ]Dining Hall [ ]Fraternity/Sorority [ ] House/Apartment [ ] Restaurant [ ] Fast Food [ ]Other Places

How many days in a usual week do you eat meat for dinner? _____ days

Would you prefer to eat meat: [ ] Less often [ ] About the same as now [ ] More often [ ] Don't eat meat

On the provided plate we would like you to accurately draw and label the foods in a meal that you would enjoy eating for dinner tonight. <u>Be as realistic as possible with the sizes of your food drawings.</u>
Thank you for your participation.

APPENDIX B

Are you: [ ] Male   [ ] Female

How old are you? ______years

How tall are you: ____feet _____inches

How much do you weigh? _______(lbs)

Are you a Freshman   Sophomore   Junior   Senior   Graduate Student   (Circle One)

Please accurately draw and label the foods in the meal that you have just consumed. Please be as realistic as possible with the sizes of the foods on your plate.

Thank you for your participation.

Are you: [ ] Male [ ] Female

How old are you? ______years

How tall are you: ____feet _____inches

How much do you weigh? _______(lbs)

Are you a Freshman Sophomore Junior Senior Graduate Student (Circle One)

Please accurately draw and label the foods in the meal that you are about to consume. Please be as realistic as possible with the sizes of the foods on your plate.

Thank you for your participation.

APPENDIX C

Please tell us about yourself!

Last 4 digits of your student ID ___________

Are you: [ ] Male [ ] Female

How old are you? ______years

How tall are you: ____feet _____inches or ____________centimeters

How much do you weigh? _______(lbs)

Are you a Freshman Sophomore Junior Senior Graduate Student (Circle One)

What is your major?_______________________

What is your Ethnicity?_____________________

What's in Meal?

How many hours ago did you eat a full meal? ___________hours

How many years have you lived in the United States? _________ years

How good do you feel when you cooperate with others to cook a meal? (Circle one)
Not good at all 1 2 3 4 5 6 7 Extremely good

Would you rather depend on yourself more than others to cook a meal? (Circle one)
I would rather depend on others 1 2 3 4 5 6 7 I would rather depend on myself

How important is it for you to maintain a healthy diet? (Circle one)
Not important at all 1 2 3 4 5 6 7 Very important

Compared to a food's taste, how important is it for this food to also be filling ? (Circle one)
Taste is always more important 1 2 3 4 5 6 7 Being full is always more important

Where do you eat most of your dinners? (Check one)
[ ]Dining Hall [ ]Fraternity/Sorority [ ] House/Apt [ ] Restaurant [ ] Fast Food [ ]Other

How many days in a usual week do you eat meat for dinner? ___________ days

Would you prefer to eat meat: [ ]Less often [ ]The same [ ]More often [ ]Don't eat meat

On the provided plate you were given, we would like you to accurately draw and name the foods in a meal that you would enjoy eating for dinner tonight.
<u>Be as realistic as possible with the sizes of your food drawings.</u>
Thank you for your participation.