Effects of Graphical Cues on Delay Discounting of Food and Money in Fast-food Consumers

Souk L. Chiang

California State University, Chico

Author Note

Souk L. Chiang, Department of Psychology, California State University, Chico. Correspondence regarding this article should be addressed to Souk L. Chiang, Department of Psychology, California State University, Chico, Chico, CA 95929. E-mail: schiang1@mail.csuchico.edu

Abstract

Obesity is a growing health concern and consumption of high-fat or calorie-dense food options such as “fast food” are one of the many factors contributing to the obesity epidemic. Individuals who consume fast-food items are often described as impulsive because their choices emphasize short-term gains (e.g., eating high-fat or calorie dense food options) to the exclusion of long-term gains (e.g., benefits associated with eating healthier foods). Delay discounting is a behavioral economic framework that describes the manner in which outcomes lose value as a function of time until their receipt. Research has shown that obese individuals discount delayed money and food more steeply than healthy-weight individuals. Studies have also shown that visual cues (e.g., food color and texture) influence food choices and consumption; however, no studies have examined the effects of fast-food-related cues in a delay discounting paradigm. The present mixed design study (N = 218) compared the between-subject effects of visual cues (Graphic vs. No Graphic) on hypothetical food and money discounting. We hypothesized that participants would discount delayed food more steeply in the presence of food-related graphics. Moreover, we hypothesized that participants would discount food more steeply than money. Although the common finding that food is discounted more steeply than money was replicated, the present study did not detect any significant effect of graphical cues on discounting of the two commodities, suggesting some limitations of the discounting model and the study design. Future research may wish to refine the proposed model and further investigate the influence of sensory cues on food-related decision-making.

Keywords: obesity, cue reactivity, delay discounting, fast food, online survey, human

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Obesity is a growing health concern in many industrialized countries around the world. The World Health Organization has estimated worldwide obesity rates to have increased 100 percent since 1980 (World Health Organization [WHO], 2016). In 2016, 650 million adults were obese worldwide. Among industrialized countries, the United States has one of the highest obesity rates. As of this date, approximately 37% of adults and 17% of youth are considered obese in the United States (Centers for Disease Control and Prevention [CDC], 2016) and the rate of obesity has been on the rise. From 1999-2014, adult obesity rates in the United States increased 6% for adults and 3% for youths (CDC, 2016).

Obesity is defined as having an excess amount of fat which could contribute to health problems and lead to chronic illness or death. Body mass index (BMI) is a commonly used method to measure and classify individuals into different weight classification. BMI is calculated by dividing the person's weight in kilograms by the square of the person's height in meters (kg/m^2) and is typically divided into four categories: underweight (16-18.5); healthy (18.5-25); overweight (25-30); and obese (> 30; CDC, 2016). From 1975 to 2016, mean BMI in the United States has risen from 24.9 to 28.9 (WHO, 2016). In 2013, the American Medical Association changed the classification of obesity from a condition to a disease. Considered a health epidemic in the United States, adulthood obesity is linked to an increase of risk for coronary heart diseases, diabetes mellitus, high blood pressure, musculoskeletal disorders and some cancers including breast, ovarian, prostate, liver, gallbladder, kidney, and colon cancer (WHO, 2016).

Excessive body weight and fat gain is attained when there is a positive energy balance which occurs when dietary energy intake exceeds energy output (i.e., calories burned). The trend within industrialized countries is that dietary energy intake is on the rise. For example, people in industrialized countries consumed on average 2,947 kcal/day in 1966 compared to 3,440 kcal/day in 2015 (WHO, n.d.). Concurrently, technological advances (e.g., television, personal computers) have contributed to the decline of energy output represented by the decreasing amount of time spent on physical activity and movement (e.g., Cabellero, 2007; Chan & Woo, 2010). This imbalance between energy intake and energy output steers much of the research focus on obesity.

According to the WHO (2016), obesity is a preventable disease. This means that individuals can make healthier food decisions by consuming more fresh fruits, vegetables and leaner choices of meat as well as reducing consumption of sugars and unhealthy fats. In addition, individuals can increase their energy output by increasing physical activity. The areas of focus for obesity prevention programs currently in place are: multi-focus cardiovascular prevention; prevention of weight gain; programs to increase physical activity; and eating disorder prevention (e.g., Stice et al., 2006). Although there are many prevention programs to address the obesity epidemic, for the vast majority of individuals, long-term weight loss has been unsustainable (e.g., Jeffrey, Drenowski, Epstein, Stunkard, Wilson, Wing, & Hill, 2000). Individuals participating in prevention programs (e.g., diet and physical activity) are no more likely than those who do not participate to be at a healthy weight after a three year follow-up (e.g., Mann, Tomiyama, Westling, Lew, Samuels, & Chatman, 2007).

One of the contributing factors to the rise in obesity is the increase in the prevalence of fast food restaurants. From 1970 to 1980, there was over a 400% increase in fast food restaurants (French, Harnack, & Jeffery, 2000). The USDA Continuing Survey of Food Intakes by Individuals showed that between 1994 and 1996, approximately 18% of adults ate fast food. Fast food intake frequency is positively correlated with weight gain and total percent body fat (e.g., McCrory, Fuss, Hays, Vinken, Greenberg, & Roberts, 1999). Data from the National Health and Nutrition Examination Survey showed that from 2007-2010 11.3% of total daily calories were from fast food and that BMI and percentage of daily calories from fast food were positively correlated.

Along with the increase in prevalence of fast food restaurants has been an increase of fast food related advertisement and marketing campaigns. In 2004, over 11 billion was spent on advertising by the food, beverage, and restaurant industries (Nelson, Story, Larson, Neumark-Szainter, & Lytle, 2008). The fast food industry promotes larger portion sizes and offer foods high in saturated fats and sugar appealing to children (Chan & Woo, 2010) and young adults (Nelson et al., 2008). This is a matter of concern because television advertisements for unhealthy food targeted to children leads to an increase in unhealthy food consumption for this demographic (Harris, Bargh, & Brownell, 2009). The National Center for Health Statistics reported that one third of children and adolescents consume fast food between 2011 and 2012 and that, on average, 12.4% and 11.3% of their daily calories were from fast food (Fryar & Ervin, 2013; Vikraman, Fryar, & Ogden, 2015). Based on the data, it stands to reason that advertising campaign strategies target children, adolescents and at-risk individuals (e.g., obese persons) by featuring large portion sizes (e.g., over-sized hamburgers) and embellishing food-related imagery to draw attention and make food-related cues more salient (Chan & Woo, 2010). By understanding the manner in which food-related imagery influences how individuals value food, researchers may be in a position to improve the effectiveness of obesity prevention programs.

Cue Reactivity

Cue reactivity has been extensively researched in a number of drug addiction studies (e.g., Boswell & Kober, 2015; Castellanos et al., 2009; Drummond, 2000; Nederkoorn & Jansen, 2000). In drug addiction studies, cue reactivity is a proposed mechanism that attempts to explain the rationale behind the addiction. Cue reactivity is typically considered to a conditioned response acquired via classical conditioning (e.g., Castellanos et al., 2009; Coelho, Jansen, Roefs, & Nederkoorn, 2009; Drummond, 2000; Nederkoorn & Jansen, 2000; Tetley, Brunstrom, & Griffiths, 2009). For example, when a neutral stimulus (NS; e.g., food-related cue) is repeatedly paired with an unconditioned stimulus (US; e.g., food), the NS will, in time, become the conditioned stimulus (CS) that elicits a conditioned response (CR) of craving. According to preparatory-response theory, a CR such as craving prepares the organism for the presentation of the US (food) and its consumption. In this way, cue reactivity results in food-related cues eliciting a craving response.

With respect to food consumption, external food cues (e.g., sight or smell of food) are related to cue-elicited cravings and food-seeking behaviors (e.g., Brignell, Griffiths, Bradley, & Mogg, 2009). External food cues elicit similar physiological craving responses to that of drug users such as increased heart rate and sweating (e.g., Boswell & Kober, 2016). In addition, repeated exposure to a food cues will elicit food-seeking behaviors and cravings even when the individual is not hungry (e.g., Harris, Bargh, & Brownell, 2009; Lowe & Butryn, 2007). Individual differences in sensitivity toward food cues may elicit different eating behaviors (e.g., Brignell et al., 2009; Tetley et al., 2009). Individuals who are highly sensitive to external food cues are more likely to overeat in response to the sight or smell of food (e.g., Hou et al., 2011). Obese individuals have been shown to have a heightened sensitivity to food cues compared to non-obese individuals (e.g, Brignell et al., 2009; Boswell & Kober, 2015; Hou et al., 2011;

Tetley et al., 2009). Thus, individuals with a heightened sensitivity to food-related cues are at a higher risk for food-seeking behavior and craving responses leading to overeating.

Studies in attentional bias towards food cues help to explain the individual differences in sensitivity. Individuals who are obese are more likely to attend to food cues in their environment (e.g., Brignell et al., 2009: Castellanos et al., 2009; Coelho et al., 2009; Hou et al., 2011; Tetley et al, 2009). Results from a visual probe task suggest that obese adults are more likely to attend to food images than non-food images compared to normal weight subjects (Brignell et al., 2009; Coehlho et al., 2009). Thus, there may be a relationship between attentional bias, sensitivity to external food cues (e.g., food images), and obesity.

Evidence for this relationship is provided by studies showing that individuals with attentional bias towards food images were slower to disengage from food cues (Lattimore & Mead, 2015). Furthermore, highly impulsive obese individuals were quicker (i.e., took less time) to detect higher caloric food than highly impulsive healthy weight individuals (Bongers et al., 2015). In the same study, highly impulsive obese individuals were more sensitive to food cues than neutral cues compared to highly impulsive healthy weight individuals. Bongers et al. (2015) reported that obese individuals found palatable foods more rewarding and salient and that degree of impulsivity enhanced those effects.

Impulsivity

Impulsivity is a multidimensional construct often described as lack of planning, lack of focus, sensation seeking, delay of gratification, disinhibition, lack of impulse control, lack of willpower, or lack of self-regulation (Moffitt et al., 2011). The literature on impulsivity and impulsivity-related traits is wide-ranging and implies that impulsivity is prominent in many aspects of our lives. Specifically, impulsivity is related to maladaptive behaviors such as drug use (e.g., Jentsch et al., 2014; MacKillop et al., 2011), gambling (e.g., Leppink, Redden, & Grant, 2016), sexual risk behaviors (e.g., Charnigo et al., 2013; Johnson & Bruner, 2012), and obesity (e.g., Moffitt et al., 2011; Weller et al., 2008). Moreover individuals differ dramatically in the way they behave impulsively or exhibit self-control.

Impulsive behavior does not occur in a vacuum. There are other factors that either enhance or mitigate impulsive decisions. Decision-making processes involve an interaction between individual differences and situational context (Appelt et al., 2011). As in the example of making a decision to purchase an item when one cannot afford it, individuals will vary in their behavior based on the strength of the impulse to purchase and the context of the situation in which the impulse occurs. Situational context can include items like time pressure, the salience of desired outcome or reward, and cognitive load (Appelt et al., 2011; Hofmann, Friese, & Strack, 2009). For instance, time pressure can negatively affect self-control by creating a sense of urgency of a situation (e.g., a sign that says "Last Chance to Buy!"). The salience of a reward can also weaken the resolve for self-control (Mischel, Ebbeson, & Zeiss, 1972). For example, when a food image (i.e., external food cue) elicits a strong physiological response (e.g., feelings of craving) and is the focus of attention, then it may be more difficult to resist temptation. One facet of impulsivity that may be influenced by environmental cues and physiological states is delay discounting.

Delay Discounting

Delay discounting is a behavioral framework that accurately describes the trade-offs between short-term gains and long-term gains. Specifically, delay discounting describes the manner in which rewards lose value as a function of time until their receipt (Madden & Johnson, 2010). Individuals who choose a smaller, immediate reward (e.g., short-term gains) over larger, delayed rewards (e.g., long-term gains) are said to be impulsive (e.g., Amlung et al, 2016; Applehans et al., 2011; Ely, Howard & Lowe, 2015; Epstein, Salvy, Carr, Dearing, & Bickel, 2010; Odum & Rainaud, 2003; Rasmussen, Lawyer, & Reilly, 2009).

The most popular method for assessing delay discounting involves asking participants to choose between smaller-sooner and larger-later monetary rewards. Participants are presented with a series of choices between smaller immediate and larger delayed rewards (e.g., receive $10 now or $100 later). In an adjusting-amount procedure, the larger delayed reward is a fixed amount and the smaller immediate amount is systematically adjusted across trials until an indifference point is reached (Richards et al., 1997). Indifference points are observed when the present value of the delayed reward is subjectively equivalent in value to the smaller immediate reward (Mazur, 1987; Odum & Rainaud, 2003). Indifference points are elicited for a series of larger-later reward delays (e.g., 1 week, 2 weeks, 1 month) and then plotted for each delay to produce a discounting curve (Madden & Johnson, 2010; see Fig. 1 for an illustrative curve).

Research has suggested that individuals who are obese discount delayed money and food more steeply than healthy-weight individuals (e.g., Hendrickson & Rasmussen, 2013; Weller et al., 2008). Individuals who consume high-fat or calorie-dense foods are often described as impulsive because their choices emphasize short-term gains (i.e., pleasurable sensations from eating high-fat calorie-dense food options such as fast food) and involve long-term health risks (e.g., obesity, heart disease, diabetes, high blood pressure, high cholesterol; Rollins, Dearing, & Epstein, 2010). An extensive literature has attempted to explain the factors that influence steep discounting of food in obese individuals (e.g., Applehans et al., 2011; Epstein, Salvy, Carr, Dearing, & Bickel, 2010; Epstein, Lin, Carr, & Fletcher, 2012; Rollins, Dearing, & Epstein, 2010).

One area of focus has been on the effects of food reinforcement. Subjective values of food reinforcement are hypothesized to determine choices between available food alternatives (Epstein et al., 2010). According to Epstein et al. (2010) “reinforcement is a fundamental determinant of choice” (p. 439) and those reinforcers serve to motivate our behaviors. Rollins et al. (2010) assessed the relationship between palatable food intake and food reward sensitivity, which was operationalized as one’s motivation to eat a particular food and the sensory pleasure derived from consuming it. Participants completed a monetary delay discounting task to measure inhibitory control (i.e., impulsivity). Greater palatable food intake was associated with greater food reward sensitivity and was moderated by degree of impulsivity. In other words, individuals who discounted delayed money more steeply were more prone to consume foods that had a high reinforcing value (i.e., palatable foods).

Applehans et al. (2012) examined the relationship between fast food and restaurant food consumption frequency and obesity through delay discounting. Applehans et al. (2012) proposed that steeper discounting would be associated with higher consumption of ready-to-eat and away-from-home food and greater energy intake from those foods. Overweight and obese women were recruited and the results of the study suggested that, as predicted, those with steeper discounting had greater energy intake from eating away-from-home and ready-to eat-foods.

The Present Study

The present study sought to examine the effects of graphical cues on delay discounting of money and food rewards. To our knowledge, no study has compared graphical cues (i.e., cue reactivity) on hypothetical money and food rewards in a delay discounting paradigm. We hypothesized that individuals would discount delayed food more steeply in the presence of food-related graphical cues versus in the absence of food-related graphical cues. Because this hypothesis is relatively novel, we assessed discounting of hypothetical money as well, a commodity that has been studied extensively in the discounting literature. In accordance with previous studies (e.g., Estle, Green, Myerson, & Holt, 2007; Odum, Baumann, & Rimington, 2006; Odum & Baumann; 2007; Odum & Rinaud, 2003), we hypothesized that individuals would discount food more steeply than money.

Methods

Participants

Students enrolled in undergraduate psychology coursework at a public university in the western United States were recruited as participants. The study was advertised via flyers posted in the Psychology department, online (Sona Systems, Inc., Tallinn, Estonia), and through in-class announcements and word of mouth.

To be eligible to participate in the study, individuals needed to have been at least 18 years old, consumed “fast food” in the past two weeks, and selected a preferred fast-food item from a provided list (described below). For the purposes of the study, “fast food” was defined as items available at fast-food restaurants (Popeye’s, Burger King, Taco Bell, Jack in the Box, Wendy’s, In & Out, McDonald’s, Kentucky Fried Chicken, Carl’s Jr.), excluding items that are relatively healthy (e.g., salads, fruit cups, oatmeal). To determine if participants had eaten fast food recently, they were shown a list of fast-food restaurants and asked to select those restaurants from which they had eaten fast food in the past two weeks. If a participant chose at least one fast-food restaurant from the provided list, they were shown a list of seven fast-food items and asked to select the item that they would most prefer to eat (assuming the items were free). If participants selected “I would not want to eat any of these,” then they were ineligible to participate in the main survey; otherwise, participants were eligible to participate.

Two hundred and ninety individuals completed the online screening questionnaire, and of these individuals, 218 (171 women) participated in the study. Participant demographic information is shown in Table 1. All participants in this study were volunteers and received extra credit towards their coursework for participating in the study. The Institutional Review Board of CSU, Chico approved this study.

Materials

Fast-food image selection. Prior to the present study, participants in a pilot study were shown 50 fast-food images and were asked to rate each image on four dimensions ("Appealing," "Attractive," "Enticing," and "Appetizing"). Specifically, participants were shown, one at a time and in a random order, five representative images of each of ten common fast-food items (burrito, cheeseburger, chicken sandwich, fish sandwich, French fries, fried chicken, hamburger, hot dog, roast beef sandwich, and taco) and rated each image on a scale ranging from 0 to 100. With one exception (discussed below), the image from each fast-food category associated with the highest mean rating across all four dimensions was selected for further analysis. The exception to this rule was the French fries image, which despite receiving the lowest overall mean rating within its category, was the most highly rated representative food image in the pilot study. In subsequent statistical analyses conducted using the ten representative food images (one-way repeated-measures analysis of variance [ANOVA]), three food items (fish sandwich, hot dog, and roast beef sandwich) were rated as being significantly less appealing, attractive, enticing, and appetizing (all p values from Tukey's multiple comparisons $< .05$) compared to the other food items and were therefore excluded from further analysis. The remaining seven food items did not differ significantly from one another on any of the four dimensions (84 post-hoc comparisons), except for the cheeseburger and the hamburger on the Appetizing dimension (p = .04).

Demographic questionnaire. Participants in the present study answered demographic questions pertaining to age, sex, ethnicity, race, height, weight and class standing. Participants also answered food-related questions relating to their hunger level (measured on a Likert scale of 0 to 10, 0 = "extremely hungry" and 10 = "extremely full") and frequency of fast-food consumption in the past year, past month, and past week. In addition, participants selected between seven images of fast-food items (burrito, cheeseburger, chicken sandwich, French fries, fried chicken, hamburger, and taco) to indicate their preferred food item (assuming the items were free). Participants were not required to choose the same food item they chose in the online screening questionnaire.

Three-Factor Eating Questionnaire (TFEQ-R18). The TFEQ-R18 is a revised version of the original Three Factor Eating Questionnaire (Stunkard & Messick, 1985), which measures three aspects of eating behavior: cognitive restraint, uncontrolled eating, and emotional eating (Karlssson, Persson, Sjostrom, & Sullivan, 2000). The TFEQ-R18 contains 18 items: six items measuring cognitive restraint (e.g., "I deliberately take small helpings as a means of controlling my weight."); nine items measuring uncontrolled eating (e.g., "Sometimes when I start eating, I just can't seem to stop."); and three items measuring emotional eating (e.g., "When I feel anxious, I find myself eating.") Participants rated each item on a 4-point response scale ranging from "Definitely True" to "Definitely False." Scores are summed separately for cognitive restraint, uncontrolled eating, and emotional eating subscales.

Power of Food Scale (PFS). The PFS measures three levels of proximity to food (Food Available, Food Present, and Food Tasted) related to eating behaviors (Lowe et al., 2009). The

15 items are rated on a 5-point response scale ranging from "Don't Agree at All" to "Strongly Agree." With respect to the three PFS factors, there are six items in Food Available (e.g., "I find myself thinking about food even when I'm not physically hungry"), four items in Food Present (e.g., "When I know a delicious food is available, I can't help myself from thinking about having some), and five items in Food Tasted (e.g., "Just before I taste a favorite food, I feel intense anticipation"). The total PFS score is an average score of all items; the subscale score is an average of each of the three proximity levels.

Food-Money Indifference Point Elicitation Questions. To ensure food and money reward magnitudes were comparable, participants made repeated choices between immediately available amounts of money ($5) or ten bites of the food item they had chosen earlier in the survey. The adjusted monetary amount following 4 choices was taken as the indifference point (i.e., the amount of money deemed roughly equivalent to ten bites of their chosen food item). Each participant's indifference point later served as the larger, delayed reward amount in the monetary discounting task.

Monetary Discounting Task (MDT). The MDT involved a series of choices between choosing a smaller amount of money now ("smaller-sooner" reward) or a larger amount of money after a delay (i.e., the indifference point from the elicitation questions described above). Within each of six delay blocks (1 minute, 2 minute, 5 minutes, 10 minutes, 30 minutes, and 1 hour), the MDT used an adjusting-amount procedure (Richards, Sabol, & de Wit, 1999) to determine indifference points between smaller-sooner and larger-later monetary rewards. The adjusting-amount procedure involves a choice between a larger-later fixed amount of money and an adjusting smaller-sooner amount of money. The smaller-sooner amount of money is systematically adjusted until it reaches an indifference point where the smaller-sooner amount of money is perceived equal in value to the larger-later amount of money.

Prior to beginning the MDT, participants read the following instructions. The text “money” in the instructions was shown in red to underscore this difference between the MDT and Food Discounting Task (described below):

> In the following part of the study you will be given choices between amounts of money. Your task will be to decide which amount of money you prefer. You will make your selection by choosing one of the two options. If you would prefer to receive the delayed option, we ask that you pretend you would be required to remain at your computer for the entire duration of that delay. You would still have access to the Internet, but could only leave the computer to use the restroom. In other words, pretend you could not earn or spend any money during the delay. Please note that the options will switch randomly across trials. The following choices are hypothetical. You will not actually receive the money. There are no “right” or “wrong” answers. Please just pick the option that you would prefer.

At the beginning of each delay block, participants were shown the larger-later reward delay (i.e., “The delay to $X is now 1 minute” with the text “1 minute” shown in red). The first question in each delay block involved a choice between a smaller-sooner amount (half of the larger-later amount) and a larger-later amount (e.g., “Would you rather have $0.50 now or $1.00 in 1 minute?”). If the smaller-sooner option was chosen, then the smaller-sooner amount would adjust downward by half of the difference between the smaller-sooner amount and larger-later amount (e.g., $0.25 in the example above). If the larger-later option was chosen, then the smaller-sooner amount would adjust upward by half of the difference between the smaller-sooner amount and larger-later amount (e.g., $0.75 in the example above). Subsequent adjustments to the smaller-sooner amount were made by halving the previous adjustment amount (e.g., $0.125 [shown as $0.13]) and adding or subtracting the adjustment amount to the smaller-sooner amount (see Figure 2 for a schematic of the adjusting-amount procedure). The adjusted, smaller-sooner amount after 4 trials served as the indifference point for that particular delay block.

Food Discounting Task (FDT). The FDT was identical to the MDT with a few important exceptions. First, the FDT involved choices between fewer bites of the preferred fast food item now (smaller-sooner reward) or waiting for 10 bites of the preferred fast food item after a delay (larger-later reward). Second, the first trial within each FDT delay block involved a choice between 5 bites now or 10 bites after the relevant delay. As with the MDT, the adjusted, smaller-sooner amount after 4 trials served as the indifference point for that particular delay block.

Procedure

Prior to the online screening questionnaire, an informed consent form provided information about the study. Potential participants then completed an online screening questionnaire to determine eligibility. Participants who were determined to be eligible were provided with an invitation code to access the main online survey through the Psychology Department’s SONA website (Sona Systems, Inc., Tallinn, Estonia). All survey materials were administered online via Qualtrics (Qualtrics, Inc., Provo, UT).

Eligible participants began the main survey by completing a demographic questionnaire. At the end of this section, participants were shown images of seven fast food items (burrito, cheeseburger, chicken sandwich, French fries, fried chicken, hamburger, and taco) and asked to select their preferred item. Participants who chose “I would not want to eat any of these items” option, reported not consuming fast food in the past month or year, or preferred not to respond to either frequency question, bypassed the discounting tasks and completed the TFEQ-R18 and the PFS before finishing the survey.

After a participant selected their preferred fast-food item, they completed the elicitation questionnaire to determine the amount of money that was equivalent to ten bites of food; the indifference point obtained from this elicitation questionnaire served as the larger-later monetary amount in the MDT.

Prior to completing the delay discounting tasks (MDT and FDT), participants were randomly assigned to “Graphic” or “No Graphic” groups. In the Graphic group, the MDT contained an image of money (represented by coins) whereas the FDT contained the image of the participant’s selected fast-food item. All images were displayed above the discounting questions. In the No Graphic group, only the discounting questions were displayed. Participants in each group then completed the MDT and FDT in a randomized order.

Upon completion of the delay discounting tasks, participants were asked to complete the TFEQ-R18 and the PFS. A debriefing statement followed, outlining the purpose of the study and how the data will be helpful in informing possible interventions based on the study findings. Participants were then asked to click on a button to automatically close the survey to receive credit on the Psychology Department’s SONA website.

Data Analysis

Means and standard deviations were calculated for continuous variables (e.g., age, hunger levels) and percentages were calculated for categorical variables (e.g., sex, class standing). BMI was calculated by dividing self-reported weight in pounds by self-reported height in inches squared and multiplying by the conversion factor of 703. The median for BMI was calculated due to the presence of outliers. Data was assessed normally and non-parametric statistics were used when necessary.

TFEQ-R18 and PFS data were examined for missing values. If any questions were not answered, data for that questionnaire were excluded. Means and standard deviations were calculated for each TFEQ-R18 scale (cognitive restraint, uncontrolled eating, and emotional eating) and PFS subscale (Food Available, Food Present, and Food Tasted) and for the total PFS questionnaire. Correlational analyses were performed to assess relationships between TFEQ-R18 and PFS subscales and money and food discounting.

Data from the discounting tasks were examined for missing values. If any data points were missing from either task, data were excluded from computation (but otherwise included in non-discounting analyses). Individual indifference points were plotted and the area-under-the-discounting-curve (AUC) was calculated (GraphPad Prism version 6.03 for Windows, GraphPad Software, La Jolla, CA). AUC values range from 0 to 1, with smaller values indicating steeper discounting (i.e., less likely to wait; Myerson, Green, & Warusawitharana, 2001). A two-factor mixed-design analysis of variance (ANOVA; SPSS v23, Armonk, NY) was used to compare AUC values between groups (Graphic vs. No Graphic) and commodity type (Money vs. Food).

Results

Two hundred and ninety participants completed the online screening questionnaire. Of these participants, 221 (76.2%) were eligible to participate in the main survey. Three participants (1.4%) did not complete the main survey and were excluded from analysis, resulting in a sample size of 218. Table 1 contains participant demographic information.

Mean scores for the TFEQ-R18 subscales of cognitive restraint, uncontrolled eating, and emotional eating were 2.5 (SD = 0.3), 2.5 (SD = 0.4), and 2.6 (SD = 0.8), respectively. Mean scores for the PFS subscales of food available, food present, and food tasted were 2.2 (*SD* = 0.9), 2.9 (*SD* = 1.1), and 2.8 (*SD* = 0.9), respectively. Based on the correlational analyses, there were no significant relationships between the TFEQ-R18 and PFS subscales and money and food discounting.

Four participants from the No Graphic group were excluded due to missing data points. The final number of participants for each group was 108 (Graphic) and 104 (No Graphic). Regardless of group assignment, indifference points generally decreased as delay to either commodity increased (Figure 3). Mean AUC values for money and food in the Graphic group were 0.67 (*SD* = 0.29) and 0.45 (*SD* = 0.28), respectively. Mean AUC values for money and food in the No Graphic group were 0.68 (*SD* = 0.29) and 0.43 (*SD* = 0.25), respectively (Figure 4).

Based on the mixed-design ANOVA, there was no significant interaction between group assignment and commodity ($p = 0.55$). Likewise, there was no significant main effect of group assignment on AUC ($p = 0.79$). However, a significant main effect of commodity was detected, $F(1,210) = 106.4$, $p < .001$, $\eta^2 = .34$, indicating greater discounting of food relative to money, regardless of group assignment.

Discussion

The present study examined the effects of graphical cues on delay discounting of money and food rewards. We found no main effect of graphical cues, regardless of the commodity (food or money); however, we detected a significant main effect of commodity type, regardless of group assignment (Graphic or No Graphic). In sum, the group that encountered graphical images of food and money while performing the respective delay discounting tasks did not differ significantly from those who did not view the graphical images.

One possible explanation of our null finding related to the graphical cues is that the food-related cue was an image rather than a real food item. In laboratory settings, participants would be able to see the food item as well as smell and taste it. More sensory cues involved in experiencing the food cue may lead to a higher degree of sensitivity, thus, leading to steeper discounting. In fact, laboratory studies have shown that when food stimuli are present, participants are more likely to consume the food item (e.g., Ely, Howard, & Lowe, 2015; Logue & King, 1991).

Although our findings were not consistent with previous studies of food cue reactivity (e.g., Brignell et al., 2009; Bongers et al, 2015; Hou et al., 2011; Tetley et al, 2009), our study was the first, to our knowledge, to control for the presence of food-related graphical cues by omitting graphics altogether (i.e., the No Graphic group). Other studies have controlled for food-related cues by providing a cardboard cut-out of a pizza slice (Tetley et al., 2009), by exposing participants to non-food images that were visually matched to food images in color, complexity, and visual appearance (Yeomans & Brace, 2015), and by using non-food items in a visual probe task (Castellanos et al., 2009). Ideally, a non-food-related graphical cue would have been preferred in the present study. Moving forward, we suggest that future research consider including such controls if using graphical cues or, preferably, using real fast food items (i.e., multisensory stimuli) in a laboratory setting to accurately assess cue reactivity.

Consistent with previous research, we did observe a significant main effect of commodity type. Participants discounted food more steeply than money, regardless of whether these commodities were accompanied by a graphic or not. This finding replicates prior research and confirms that our model is at least somewhat valid with respect to the discounting task itself.

Our discounting task was unique, however, in that we were interested in common fast-food items that reflected what was available in the community. Additionally, our study was able to personalize the FDT based on the participant's choice of fast-food item. By personalizing the food item to the individual, there was a higher likelihood that the food item would serve as a reinforcer for that participant. In contrast, researchers have chosen food items for participants in prior discounting studies (e.g., Estle, Green, Myerson, & Holt, 2007; Odum & Baumann, 2007; Odum, Baumann, & Rimington, 2006; Odum & Rainaud, 2003).

An additional component of the study that was personalized is that participants were able to determine, based on their choices, a larger-later amount in the MDT that was subjectively equivalent to ten bites of their chosen fast food item. This allowed the larger-later reward to be equivalent in both the FDT and MDT, permitting comparisons of discounting across both tasks. This equivalence procedure differs from previous designs in that most commonly, participants are asked how many food items are equivalent to a set amount of dollars (i.e., "How many candy bars can you buy with $100?"). Although the number of candy bars that can be purchased is equal in terms of monetary value, it may not be equivalent in subjective value (i.e., if given the choice, the participant would most likely choose to receive $100 over $100 worth of candy bars). Additionally, we chose to assess discounting of "bites" of food, which enabled us to examine a relatively lower larger-later amount (e.g., $5) and shorter larger-later delays (e.g., 30 minutes). By using smaller units of measurement, it allowed for comparable values between food and money, an increasingly realistic expectation for consumption of the fast food item (e.g., 10 bites vs. 10 hamburgers), and a more realistic expectation of the durations of delays associated with receiving the larger-later reward. In sum, we believe these unique features of our study increase the ecological validity of our model and may suggest an improvement over prior methods in delay discounting.

There were some limitations to the present study. First, participants in the study varied in their self-reported hunger level. Although moderately hungry, with a mean score of 5.3 on a scale from 0 (extremely hungry) to 10 (extremely full), participants may not have been sufficiently food-deprived to have these graphical cues exacerbate discounting. Food deprivation is a factor that may influence impulsivity (e.g., Logue & King, 1991; Rasmussen, Lawyer, & Reilly, 2010; Raynor & Epstein, 2003). In the absence of appropriate food deprivation, participants may not have been sensitive to the fast-food cues. At the same time, participants who viewed money-related graphical cues also did not show differences in discounting compared to those who did not view these cues, suggesting that the null finding may not be entirely attributable to a lack of hunger.

Another potential limitation is that we did not recruit a sufficient sub-sample of overweight or obese individuals. While this was not an aspect of our study design, prior research has suggested that there may be significant differences between healthy weight and obese individuals. For example, Castellanos et al., (2009) reported that obese individuals were more focused on food images than healthy individuals regardless of hunger state. In another example, highly impulsive obese individuals were more sensitive to food-related cues than highly impulsive healthy weight individuals (e.g., Bongers et al., 2015). In our present study, only 14% of the participants were obese (i.e., BMI > 30). Thus, the sub-sample may not have been sufficiently represented to detect any significant differences between obese and healthy weight individuals. Future research may wish to compare the extent to which graphical cues affect discounting among high-BMI individuals and low-BMI individuals.

Similarly, participants' scores on assessments of self-reported eating behaviors (TFEQ-R18, PFS) were lower relative to other samples (e.g.,Applehans et al, 2011; Ely, Howard & Lowe, 2015; Epstein et al., 2012; Rollins, Dearing & Epstein, 2010; Yeomans & Brace, 2015.) These low scores may indicate our sample was not as sensitive to the food images we showed them, which may have led to our null finding.

Other limitations included our decision to include only those individuals who reported consuming fast food in the past two weeks. Had we increased the acceptable period of time in which fast food was consumed (e.g., one month), we may have been able to capture behaviors of individuals who eat fast food but perhaps have exhibited more self-control (i.e., less reactivity) towards graphic food-related cues (e.g., advertisements). In addition, the present study was conducted entirely online and based on participant self-report. A laboratory study may have ensured that participants were not distracted during task completion. Along these lines, all of the outcomes and delays in the present study were hypothetical. Although research has shown that hypothetical outcomes are discounted similarly to real outcomes (e.g., Johnson, Herrmann, & Johnson, 2015; Robertson & Rasmussen, 2018), there is some evidence that opportunity costs (i.e., what is asked of participants during larger-later reward delays) have an effect on delay discounting rates (Johnson, Hermann, & Johnson, 2015). In their study, Johnson et al. (2015) reported that participants discounted less steeply when they were instructed that they did not have to wait during the specified larger-later reward delay (low opportunity cost) compared to participants who were instructed that they had to wait at their computers in order to receive their reward (high opportunity cost). Thus, availability of alternative reinforcers may have some effect on discounting. Finally, our sample mainly consisted of female undergraduate students which may have limited the generalizability of our findings.

In conclusion, the present study found that graphical cues had no effect in discounting rates among undergraduate students. However, the present study did find a significant effect of commodity type. These findings may indicate that graphical cues alone may not be sufficient enough to prompt impulsive behaviors towards food (e.g., over-eating) and that other factors relating to cues (e.g., frequency and duration of exposure to cues) may moderate the effects of cue reactivity. Future research may wish to refine the proposed model and further investigate the influence of sensory cues on food-related decision-making.

Ethics Statement

All procedures performed in studies involving human participants were in accordance with ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

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Table 1

Participant Demographics

Sample	Mean (SD)	Median (Q1,Q3)	n (%)
Age, years	21.9 (5.8)		
Self-reported hunger level [a]	5.3 (2.3)		
Fast Food Consumption, days			
Past year	71.6 (66.3)		
Past month	7.6 (5.4)		
Past week	1.8 (1.4)		
BMI		23.6 (21.3,27.4)	
Sex			
Male			47 (22.0)
Female			171 (78.0)
Ethnicity			
Hispanic or Latino			80 (36.7)
Not Hispanic or Latino			135 (61.9)
Prefer not to respond			3 (1.4)
Race			
White/Caucasian			130 (59.6)
American Indian or Alaska Native			3 (1.4)
Black/African – American			11 (5.0)
Asian			18 (8.3)
More than one race			11 (5.1)
Prefer not to respond			45 (20.6)
Class standing			
Freshman			36 (16.5)
Sophomore			38 (17.4)
Junior			54 (24.8)
Senior			86 (39.4)
Graduate student taking undergraduate courses			4 (1.8)

[a] Based on a scale ranging from 0 (“extremely hungry”) to 10 (“extremely full”).

Figure Captions

Figure 1. A representative discounting curve. LL = larger-later outcome.

Figure 2. Schematic example of adjusting-amount procedure in the MDT.

Figure 3. Delay discounting curves from the FDT (circles) and MDT (squares). Data from the Graphic and No Graphic conditions are shown as filled and empty symbols, respectively. LL = larger-later outcome.

Figure 4. Mean AUC values for FDT (black bars) and MDT (gray bars) in Graphic and No Graphic conditions. Error bars represent one standard deviation from the mean. AUC = area-under-the-curve.

Figure 1

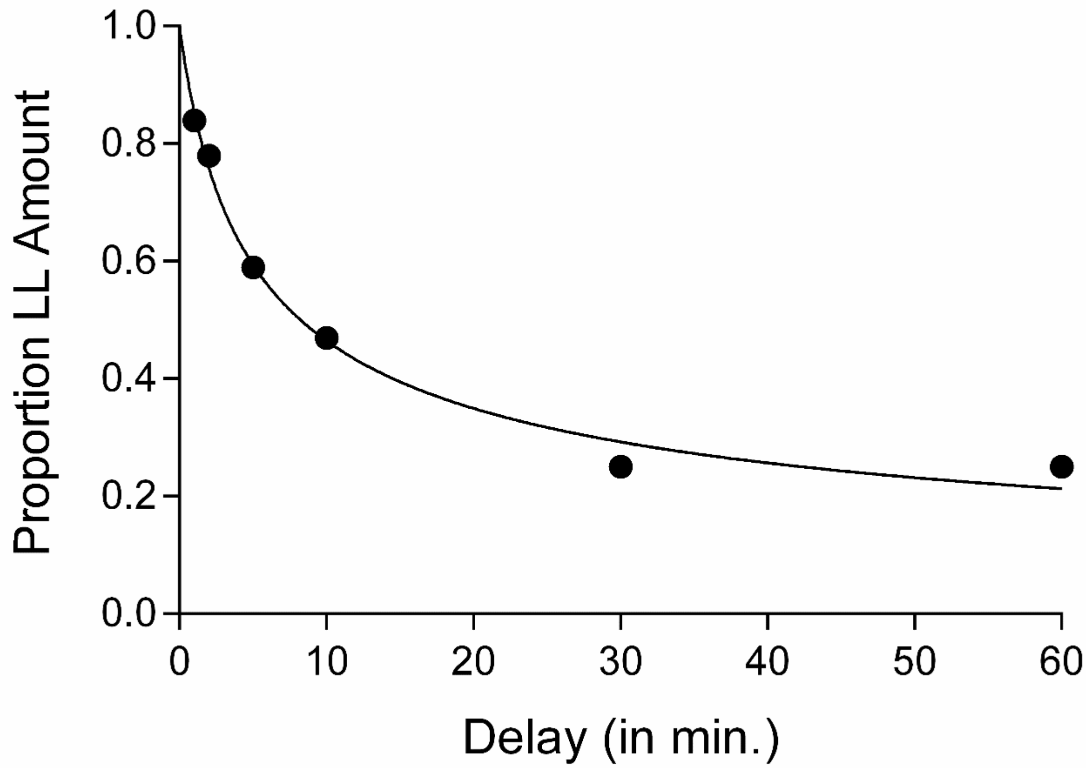
Proportion LL Amount
1.0
0.8
0.6
0.4
0.2
0.0
0
10
20
30
40
50
60
Delay (in min.)

Figure 2

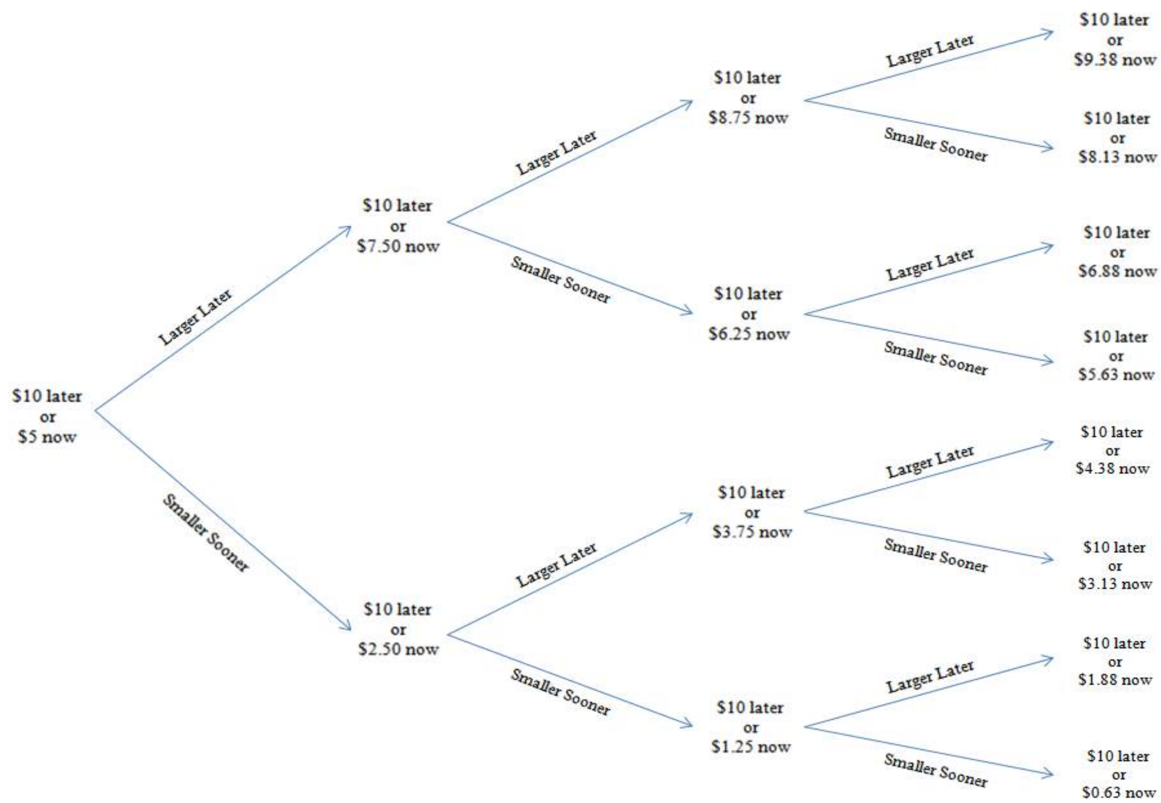
$10 later
or
$5 now
Larger Later
Smaller Sooner
$10 later
or
$7.50 now
$10 later
or
$2.50 now
Larger Later
Smaller Sooner
Larger Later
Smaller Sooner
$10 later
or
$8.75 now
$10 later
or
$6.25 now
$10 later
or
$3.75 now
$10 later
or
$1.25 now
Larger Later
Smaller Sooner
$10 later
or
$9.38 now
$10 later
or
$8.13 now
$10 later
or
$6.88 now
$10 later
or
$5.63 now
$10 later
or
$4.38 now
$10 later
or
$3.13 now
$10 later
or
$1.88 now
$10 later
or
$0.63 now

Figure 3

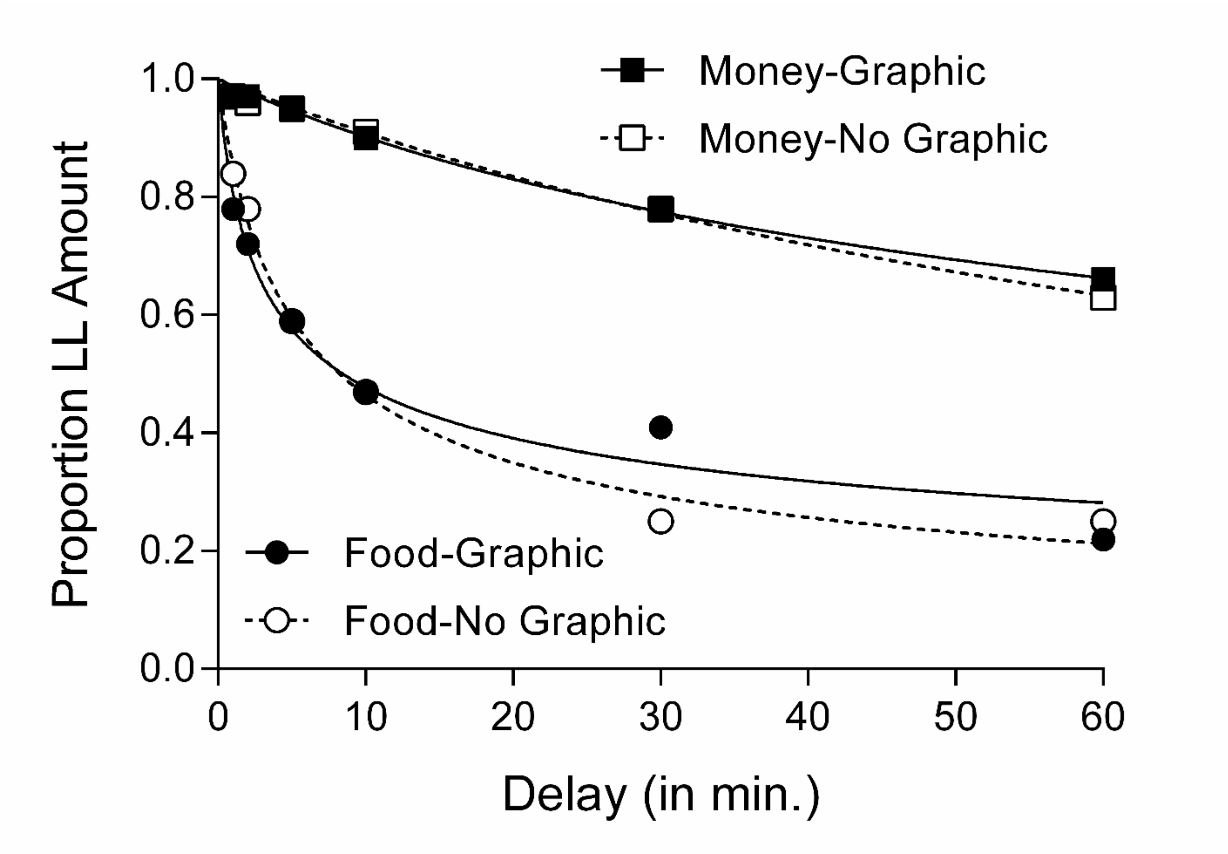
Money-Graphic
Money-No Graphic
Food-Graphic
Food-No Graphic
Proportion LL Amount
1.0
0.8
0.6
0.4
0.2
0.0
0
10
20
30
40
50
60
Delay (in min.)

Figure 4