Appetite 90 (2015) 254–263

Contents lists available at ScienceDirect

Appetite

journal homepage: www.elsevier.com/locate/appet

Research report

Measurement and validation of measures for impulsive food choice across obese and healthy-weight individuals

Kelsie L. Hendrickson, Erin B. Rasmussen *, Steven R. Lawyer

Idaho State University, USA

ARTICLE INFO

Article history:
Received 17 November 2014
Received in revised form 10 March 2015
Accepted 12 March 2015
Available online 18 March 2015

Keywords:
Delay discounting
Food
Food discounting
Impulsivity
Money choice questionnaire
Monetary discounting

ABSTRACT

The present study established a brief measure of delay discounting for food, the Food Choice Questionnaire (FCQ), and compared it to another more established measure of food discounting that uses the adjusting amount (AA) procedure. One hundred forty-four undergraduate participants completed either two measures of hypothetical food discounting (a computerized food AA procedure or the FCQ) or two measures of hypothetical money discounting [a computerized monetary AA procedure or the Monetary Choice questionnaire (MCQ)]. The money condition was used as a replication of previous work. Results indicated that the FCQ yielded consistent data that strongly correlated with the AA food discounting task. Moreover, a magnitude effect was found with the FCQ, such that smaller amounts of food were discounted more steeply than larger amounts. In addition, individuals with higher percent body fat (PBF) discounted food more steeply than individuals with lower PBF. The MCQ, which also produced a magnitude effect, and the monetary adjusting amount procedure yielded data that were orderly, consistent, and correlated strongly with one another, replicating previous literature. This study is the first to show that a novel measure of food discounting (the FCQ) yields consistent data strongly correlated with an established measure of food discounting and is sensitive to PBF. Moreover, the FCQ is easier and quicker to administer than the AA procedure, which may interest researchers who use discounting tasks in food-related research.

Introduction

In the United States, the prevalence of obesity has more than doubled since 1980 with current reports suggesting that nearly 35% of adults and 17% of youth are obese (Ogden, Carroll, Kit, & Flegal, 2014). Obesity is a medical condition associated with physical health risks (e.g., coronary heart disease, stroke, diabetes, musculoskeletal disorders, cancer), mental health disorders (e.g., depression) and economic strain (e.g., lost wages, increased insurance premiums; Cawley & Meyerhoefer, 2012; Colditz, 1992; National Heart, Lung, and Blood Institute, 2012; ten Hacken, 2009). The psychological and decision-making processes related to obesity have become critical areas of empirical and clinical interest (Centers for Disease Control and Prevention, 2011a; U.S. Department of Health and Human Services, 2001). An established psychological process that has been increasingly applied to eating and obesity is delay discounting, an aspect of impulsivity reflecting sensitivity to immediate rewards (Appelhans, 2009; Epstein, Salvy, Carr, Dearing, & Bickel, 2010; Rollins, Dearing, & Epstein, 2010).

Delay discounting

Humans, as well as non-humans (Boomhower & Rasmussen, 2014; Green, Fisher, Perlow, & Sherman, 1981; Mazur, 2000; Oliveira, Green, & Myerson, 2014; Richards, Mitchell, de Wit, & Seiden, 1997), tend to discount the value of a reward as a function of delay to its delivery. This tendency, known as delay discounting, refers to a pattern of choice in which smaller, more immediate rewards are preferred over larger, delayed ones (e.g., Ainslie, 1975; Ainslie, 1992; Green, 1982; Green & Myerson, 1993; Logue, 1988; Rachlin, 1974; Rachlin, 1989).

Delay discounting has been described as a trans-disease process (Bickel, Jarmolowicz, Mueller, Koffarnus, & Gatchalian, 2012; Bickel & Mueller, 2009), meaning that the tendency to discount delays is fundamental to a variety of behavioral problems related to health such as alcohol and substance use (e.g., Madden, Petry, Badger, & Bickel, 1997; Petry, 2001; Richards, Sabol, & de Wit, 1999; Vuchinich & Simpson, 1998; Wilhelm & Mitchell, 2008), nicotine use (e.g., Dallery & Locey, 2005; Mitchell, 1999), and sexual health (Johnson & Bruner, 2012; Lawyer, 2014; Lawyer & Schoepflin, 2013). Discounting processes also appear to underlie obesity. In one study, obese women discounted hypothetical monetary outcomes more strongly than healthy-weight women (Weller, Cook, Avsar, & Cox, 2008). Discounting in obesity also has been applied to

* Corresponding author.
E-mail address: rasmerin@isu.edu (E.B. Rasmussen).

http://dx.doi.org/10.1016/j.appet.2015.03.015
0195-6663/

food-related outcomes. Obese individuals show stronger preferences for smaller, sooner food-related outcomes than healthy-weight individuals (e.g., Hendrickson & Rasmussen, 2013; Rasmussen, Lawyer, & Reilly, 2010). These patterns have also been seen in non-human animals, where obese rats discount real food outcomes more than lean controls (e.g., Boomhower & Rasmussen, 2014; Boomhower, Rasmussen, & Doherty, 2013). Therefore, discounting food may be a fundamental process related to obesity.

Discounting procedures

One method of establishing patterns of delay discounting is to present individuals with a series of choices between a smaller sooner outcome (e.g., $8 now) vs. a larger delayed outcome (e.g., $10 in 1 day). Many individuals will choose the immediate reward ($8 now), but if the immediate reward is systematically reduced in value, an individual may reverse the preference and choose the larger, delayed outcome. The goal is to determine a series of *indifference points*, based on these preference reversals across a variety of delays (e.g., 1 day, 1 week, 1 month, 1 year). An indifference point refers to the value at which the smaller, sooner outcome is subjectively equivalent to the larger, delayed value, e.g., $7 now may be equivalent, or equally preferred to $10 in one week for an individual. When indifference points are plotted against each delay to the outcome's receipt, a measure of the subjective value of the larger, delayed reward is found in the slope of this curve. This descending hyperbolic curve shows the degree of sensitivity to delay – the steeper the slope, the more sensitive behavior is to delay and the more impulsive the individual. Many studies have shown that delay discounting curves are well-described by a Mazur's (1987) hyperbolic function (e.g., Green, Myerson, Shah, Estle, & Holt, 2007; Helms, Reeves, & Mitchell, 2006; Rachlin, Raineri, & Cross, 1991; Woolverton, Myerson, & Green, 2007):

$$V = A/(1+kD) \quad (1)$$

In this equation, V represents the discounted value of the delayed reward (or the indifference point), A is the amount of the delayed reward, D is the length of the delay to its delivery. The free parameter k refers to the relation between the subjective value of the delayed reward and the delay. The decay of the curve, then, or the steepness of the discounting function, represents sensitivity to delay (or impulsivity); higher k values represents greater impulsivity (Daugherty & Brase, 2010).

Perhaps the most commonly used method of measuring discounting with humans is the adjusting-amount (AA) procedure. In the AA task, the immediate reward amount is systematically increased or decreased until an indifference point is determined (Holt, Newquist, Smits, & Tiry, 2014; Rachlin et al., 1991; Richards et al., 1997; Richards, Zhang, Mitchell, & de Wit, 1999). Richards et al. (1999) developed a computerized version of the AA procedure that determines indifference points by titrating the amounts of the smaller, sooner reward (similar to what is described above) until a consistent indifference point is found for each delay. The task averages about 15 minutes, but can run longer, depending upon the consistency of participant responses. The AA procedure often presents participants with choices for monetary outcomes (e.g., Holt, Green, & Myerson, 2012; Myerson, Green, Hanson, Holt, & Estle, 2003; Whelan & McHugh, 2009) but has also been modified for other commodities (e.g., alcohol, food, music, sexual outcomes; Charlton & Fantino, 2008; Estle, Green, Myerson, & Holt, 2007; Lawyer, 2008; Lawyer, Williams, Prihodova, Rollins, & Lester, 2010; Rasmussen et al., 2010).

Another common approach to measuring patterns of delay discounting is the Monetary Choice Questionnaire (MCQ; Kirby & Maraković, 1996). The MCQ is a psychometrically sound (Duckworth & Seligman, 2005; Kirby, 2009; Kirby & Petry, 2004; Kirby, Petry, & Bickel, 1999) 27-item questionnaire that estimates individual patterns of delay discounting for money by posing discounting questions that correspond to specific k values derived from the hyperbolic decay function. Individual discounting rates are estimated based on individual choice patterns derived from just a few questions. The MCQ is often faster (less than 5 minutes) and easier to administer than AA procedures using computers or cards, which may facilitate research with individuals with limited attention capabilities (e.g., children) or research protocols that take long durations of time to complete. Further, its paper-and-pencil quality is conducive to settings without computers designated to research. Importantly, discounting measures generated by the MCQ and the AA procedure for monetary outcomes are highly correlated, though not interchangeable (Epstein et al., 2003).

The purpose of the current study was to develop and validate a shorter and potentially more efficient methodological alternative for measuring delay discounting for hypothetical food. We evaluate the validity of this task in two ways. First, we compare delay discounting rates across different methodologies, specifically an AA procedure and a questionnaire-based measure, for monetary outcomes and then extend it to food-related outcomes. Second, we examine the degree to which percent body fat (PBF) status predicts discounting in the novel food discounting task.

Method

Participants

Participants were 144 undergraduates from Idaho State University (62% female) with an average age of 21.9 years old ($SD = 5.2$). Participants signed up for the study independently or were selected from another study that excluded overweight (body mass index [BMI] between 25 and 29.9) participants. The inclusion criteria for the study were: current undergraduate status, at least 18 years of age, no consumption of foods and liquids for at least two hours prior to their participation in the research, and non-endorsement of pregnancy (given the current focus on eating patterns), HIV, or hemophilia due to the collection of blood glucose samples. Most participants consumed food, on average, 7.7 hours ($SD = 4.5$) prior to the study with an average current subjective hunger of 53 ($SD = 31$) on a scale of 0 to 100. Participants were compensated with research credit in their psychology courses.

Each of the 144 participants was assigned randomly to complete discounting tasks for either hypothetical monetary outcomes ($n = 70$) or for hypothetical food outcomes ($n = 74$).

Measures

Demographics

Participants completed a questionnaire querying gender, ethnicity, income, and information on smoking, alcohol, and substance use patterns, eating disorders, nutritional choices, and physical activity.

Estimated cognitive ability

Participants completed the Shipley Institute of Living Scale (Shipley) to obtain an estimated IQ score (Zachary, 1986). The Shipley is a self-administered measure of cognitive functioning that strongly correlates to the Wechsler Adult Intelligence Scale (WAIS) Full Scale IQ (Zachary, 1986). This measure was administered to control for IQ, which has been shown to affect discounting.

Adjusting amount procedure for money (AA-M)

The AA-M is a delay discounting procedure that determines indifference points for hypothetical money using a computerized adjusting-amount procedure (Richards et al., 1999). On individual

desktop computers, participants answered a series of approximately 55 questions; the exact number for each individual was determined by the consistency of their responses. Participants chose between $10 to be received after one of several different delays (1, 2, 30, 180, and 365 days) and a smaller amount of money (e.g., $7) to be received immediately. The computer program presented questions individually with unlimited time, and then participants used the computer mouse to indicate their preferred choice. The section of the screen (top or bottom) on which the smaller, immediate option appeared was randomly presented with each question. After each response, the participant was asked "Are you sure?" on the screen. If they selected the "no" response, the computer presented the same question again; if they indicated "yes", the program continued with the next successive question. The placement of the "no" and "yes" responses also appeared on the left and right of the screen in a random manner. The amount of the immediate outcome was adjusted by the computer program (±$0.50) based on the previous responses to determine the indifference point, whereby the participant was indifferent between the two choices. For example, if the program asked the participant to choose between $7.50 right now and $10 in 1 day and the participant selected the immediate reward for this particular question, the next trial would present a smaller amount for the immediate reward (e.g., $2.50 now or $10 in 1 day). The range of values for the immediate value was restricted based on previous responses, thus decreasing the number of questions required to determine the indifference point for each delay. The algorithm for determining the adjusted values was not easily predictable, because the program presented questions in a pseudorandom order (i.e., not in terms of ascending or descending delays). Delay discounting questions were also interspersed with questions assessing another type of discounting (probability discounting). The task automatically ended once the indifference point was calculated for each of the 1, 2, 30, 180, and 365 day delays.

Adjusting amount procedure for food (AA-F)

The AA-F was a computerized delay discounting measure used in past research to study impulsive choice behavior for food (Hendrickson & Rasmussen, 2013; Rasmussen et al., 2010). Similar to the AA-M, the task used an adjusting amount procedure to determine indifference points for various delays. Before participants engaged in the discounting task, they were shown a 5/8 inch white cube and asked to imagine it as one bite of their favorite food; this cube standardized bite size across participants. They were not required to verbalize or record the type of food. Then, in a series of delay trials, participants were presented with questions asking about their preferences between 10 bites to be delivered after one of several delays (1, 2, 5, 10, or 20 hours) or a smaller amount (7 bites) to be delivered immediately. Each question was presented individually on the screen (e.g., 10 bites in 5 hours or 4.5 bites right now). There was no time limit to make a choice. After a choice was made, participants were asked "Are you sure?" Similar to the AA-M, if they selected the "no" response, the computer presented the same question again; if they selected "yes", the program continued to the next trial. The immediate amount of food was adjusted (±0.50 bites) until an indifference point was determined for each of the 1, 2, 5, 10, and 20 hour delays. Similar to other studies (Hendrickson & Rasmussen, 2013; Rasmussen et al., 2010) delay trials were interspersed with questions from another discounting measure (probability discounting), which likely obscured participants' abilities to recognize the adjusting nature of the task.

Monetary choice questionnaire (MCQ)

The MCQ assessed the rate of delay discounting for money using an estimation procedure (Kirby & Maraković, 1996; Kirby et al., 1999). Presented on a computer screen, the MCQ asked participants to choose between a small amount of money available immediately and a larger amount available after one of several delays, ranging from 7 to 186 days. There were 27 items, and like the AA procedures, the outcomes were hypothetical. There was no time limit, and participants could change their responses throughout the task if needed. The participant's discounting rate was determined by scoring procedures described by Kirby et al. (1999). The k values used in the MCQ have a range of 10 discrete parameter values: 0.00016, 0.00025, 0.00063, 0.0016, 0.0039, 0.010, 0.0126, 0.065, 0.16, and 0.25. As the parameter value increased, a more impulsive individual would be likely to select the immediate outcome. For example, indifference between $34 now and $50 in 30 days corresponds to a discounting rate parameter (k) of 0.016 (Kirby, 2009). If an individual chose the $34 now, then his or her discounting rate is greater than 0.016. On the next item, which corresponds to a 0.041 discounting rate, if s/he selected the larger, later reward then the individual's discounting rate parameter (k) would fall between 0.016 and 0.041. To measure the effect that reward magnitude has on discounting, the MCQ presented questions assessing small ($25–35), medium ($50–60), and large ($75–85) monetary outcomes with each item corresponding to a discounting rate (ranging from 0.00016 to 0.25). Each magnitude was assessed using nine questions. Each participant was given one k value per magnitude based upon his or her responses to the items for that magnitude.

Food choice questionnaire (FCQ)

For this novel food discounting measure, the MCQ was modified based upon k values from an existing dataset (Hendrickson & Rasmussen, 2013) to help reduce floor and ceiling effects, because food tends to be discounted more steeply than money (Charlton & Fantino, 2008; Estle et al., 2007; Odum, Baumann, & Rimington, 2006; Odum & Rainaud, 2003). Before participants completed the FCQ, they were shown a 5/8 inch white cube and asked to imagine it as one bite of their favorite food (similar to the AA-F). They were not required to identify the type of food. Then, on a computer screen, participants answered 27 fixed-set choices (see Table 1) between a smaller number of food bites available immediately and a larger amount available after one of several delays ranging from 0.5 to 24 hours. For all participants, the FCQ required less than 5 minutes to complete. There was no time limit, and participants could change their responses at any point throughout the task. Similar to the MCQ, there was a range of 10 discrete parameters used to assign each participant with a k value (see Table 1). The FCQ was scored using similar procedures as the MCQ. Grouped by magnitude size, Table 1 shows the choice trials and associated k values in the order of increasing delay to the larger, later food amount. Participants responded to trials in the same randomized order that followed the MCQ (see leftmost column of Table 1). The FCQ provided k values for small (8–13) bites, medium (25–35), and large (40–50) bites of delayed food outcomes.

Procedures

Participants completed the study individually in an office-sized room. They were asked to report the last time that they consumed food or liquid. If they reported less than 2 hours for consumption, they were asked to reschedule their visit. If they reported two or more hours, they proceeded to informed consent and then participated in the study. To measure height, participants removed their shoes and socks and were instructed to stand upright with their backs and heels against a wall with a measurement tape. For weight and body fat measurements, they were asked to step backwards on a Tanita® scale. A small blood glucose sample was also collected from one of their fingers and analyzed using an Accu-Chek® Compact Plus glucose meter to help ensure no consumption of large quantities of food or liquid directly prior to participation. If a participant's body mass index (BMI) fell in the underweight or normal categories (BMI < 25) and their blood glucose was at or below 120 *mg/dl*,

Table 1
Food Choice Questionnaire item values and associated discounting rates (k) at indifference.

Order	Reward values			Indifference *k*
	SS (bites)	*LL* (bites)	Delay (hours)	
Small delayed rewards (8–13 bites)				
13	5	8	24	0.0252
20	4	10	17	0.0855
26	5	13	12	0.134
22	5	10	6	0.167
3	4	8	5	0.201
18	8	13	2	0.319
5	5	8	1.5	0.381
7	9	13	1	0.454
11	7	10	0.5	0.854
Medium delayed rewards (25–35 bites)				
1	19	30	23	0.0252
6	11	25	15	0.0855
24	15	35	10	0.134
16	15	35	8	0.167
10	15	30	5	0.201
21	14	25	2.5	0.319
14	16	25	1.5	0.381
8	24	35	1	0.454
27	21	30	0.5	0.854
Large delayed rewards (40–50 bites)				
9	28	45	24	0.0252
17	22	50	15	0.0855
12	17	40	10	0.134
15	23	50	7	0.167
2	20	40	5	0.201
25	25	45	2.5	0.319
23	25.5	40	1.5	0.381
19	31	45	1	0.454
4	35	50	0.5	0.854

they continued with the study. Similarly, if a participant's BMI fell in the overweight or obese categories (BMI ≥ 25), their blood glucose was required to be at or below 140 *mg/dl* to continue with the session. These values are consistent with blood sugar levels 2-hours post meal for an individual without diabetes (see American College of Endocrinology, 2002). Next, qualifying participants completed the demographics questionnaire, an intelligence measure, and discounting tasks consistent with their randomly assigned group. The order of the adjusting-amount delay discounting tasks (AA-M or AA-F) and the choice questionnaires (MCQ or FCQ) was counterbalanced across participants to help eliminate potential order effects.

For the AA discounting tasks, the participant was seated at a desk with a single desktop computer. Depending on the random assignment for condition (money or food), the researcher either read the script for either the AA-M or AA-F. The AA-F wording is presented in brackets:

> "In the task that follows, you will have the opportunity to choose between different amounts of money [food] available after different delays or with different probabilities. [For this task, imagine the block in front of you as one bite of your favorite food. Answer the questions as if what you would eat would be your favorite kind of food and as if the only options you would have to choose from would be those given in the question.] The test consists of about 110 questions, such as the following: (a) would you rather have $10 [10 bites of your favorite food] in 30 days [3 hours] or $2 [2 bites] at the end of the session [in 1 hour], or (b) would you rather have $5 [5 bites] for sure at the end of the session or $10 [10 bites] with a 25% chance? You will not receive any of the rewards that you choose, but we want you to make your decisions as though you were really going to get the rewards you choose."

Similarly, before the participants began the choice questionnaires, they were given the instructions for either the MCQ or the FCQ (wording in brackets):

> "We are going to ask you to make some decisions about which of two rewards you would prefer. You will not receive the rewards that you choose, but we want you to make your decisions as though you were really going to get them. [You will have the opportunity to choose between food amounts after different delays. For this task, imagine the block in front of you as one bite of your favorite food. Answer the questions as if what you would eat would be your favorite kind of food and as if the only options you would have to choose from would be those in the question.] Please take the choices seriously. Select your choice for each question and answer every question as though you will actually receive that choice. The choices you make are up to you."

After completing the discounting tasks, participants received a debriefing form and were asked if they had any questions or concerns regarding the session. Each participant received the appropriate number of course credits for their participation.

Data analysis

The data were analyzed using SPSS 20 and GraphPad Prism statistical software. Due to an administration error, discounting rates for three participants were not obtained. Therefore, the number of participants with complete data sets was 69 and 72 for money and food groups, respectively.

Adjusting-amount procedures

Equation 1 was fit to each individual's indifference points for each measure and *k* values were determined for each individual. Area under the curve values (AUC; Myerson, Green, & Warusawitharana, 2001) also were calculated for each individual curve to provide an atheoretical measure of discounting. AUC values tend to be more normally distributed compared to *k*. Values range between 0 (maximal discounting or most impulsive) and 1 (no discounting or most self-controlled). To examine potential error associated with random responding or inattentiveness on the AA-M and AA-F, we used Johnson and Bickel's (2008) algorithm to assess the orderliness of the data. An individual's data were identified as 'nonsystematic' if any indifference point was at least 20% greater than the indifference point preceding it, starting with the second shortest delay and/or if the last indifference point was not less than the first indifference point by at least 10% of the value of the largest reward value. Frequency of nonsystematic responding was used for descriptive purposes only. All analyses included data from all participants.

Parametric correlations were conducted between *k* values generated by the discounting tasks. In addition, these values were correlated with age, gender, income, subjective hunger, time since last meal, time since last snack, time since last drink, glucose level, waist circumference, BMI, and PBF. Then, linear relationships between health variables and discounting rates were analyzed by hierarchical regression analyses.

MCQ and FCQ

An estimate of a participant's discounting parameter values (*k* in Equation 1) was made by using the pattern of choices made across the 27 questions on the Monetary Choice Questionnaire (MCQ) or the Food Choice Questionnaire (FCQ). The questions define ten "bins" or ranges of discounting rates within three delayed outcome sizes. Thus, each participant received three *k* values: one for small, one for medium, and one for large outcomes. Two bins serve as endpoints and the remaining eight are bounded above and below other bins. For example, the first trial offered participants on the FCQ is

Table 2
Mean and standard deviations for demographic and health variables for total sample and across conditions.

	Total ($N = 141$) Mean (SD)	Money condition ($n = 69$) Mean (SD)	Food condition ($n = 72$) Mean (SD)
Age	21.96 (5.22)	21.97 (5.41)	21.94 (5.06)
% Female[a]	61%	54%	68%
% Caucasian[a]	77%	73%	81%
% income <$10,000[a]	16%	17%	14%
Glucose level (*mg/dl*)	87.19 (11.15)	87.52 (11.42)	86.86 (10.95)
Subjective hunger	52.57 (30.66)	54.80 (30.03)	50.43 (31.32)
Time since last snack (hours)	7.71 (4.50)	7.72 (4.81)	7.71 (4.22)
Time since last meal (hours)	9.37 (5.53)	9.43 (6.18)	9.30 (4.87)
Body mass index	26.49 (5.02)	26.25 (4.49)	26.71 (5.51)
Percent body fat	27.95 (8.66)	27.07 (8.69)	28.79 (8.61)
Waist circumference (cm)	86.38 (14.36)	86.33 (13.78)	86.43 (15.00)
Estimated full scale IQ	101.47 (9.02)	101.90 (9.17)	101.06 (8.91)

[a] Largest group by percentage.

a choice between 19 bites now and 30 bites in 23 hours with a predetermined *k* value of 0.0252. A participant with a discount rate of 0.0252 would be indifferent between these two choices. However, if a participant selected the delayed outcome, then it could be concluded that the person had a discount rate of less than 0.0252 (more self-controlled), and likewise, if the immediate outcome was chosen, then her discount rate would be greater than 0.0252 (more impulsive). When two *k* values were equally consistent (i.e., the discount rate fell between two of the *k* values), we used the geometric mean to determine the midpoint between the interval and to avoid underweighting the smaller of the two parameters.

Some participants' choices were not perfectly consistent with a single *k* value, so we assigned a *k* value that yielded the highest proportion of choices consistent with that assignment using the geometric mean of those values (see Kirby & Maraković, 1996 for more details on parameter estimation procedures). Response consistency (i.e., orderliness of the data) was also calculated based upon the number of responses consistent with the best estimate of a participant's *k* value for either the MCQ or FCQ (see Kirby et al., 1999). Random responding would be evidenced by a consistency rate of 50%.

Results

Demographics

Demographic data, excluding the three participants with incomplete discounting data, are described in Table 2. There were no statistical differences between individuals in the two conditions.

Delay discounting

Orderliness in the data

Overall, the majority (>80%) of participants responded in a systematic pattern across discounting tasks. For the adjusting amount procedures, more participants responded systematically for hypothetical money on the AA-M (93%, n = 67) than for hypothetical food on the AA-F (81%, n = 58), $\chi^2(1) = 5.34$, $p = 0.03$. For the MCQ, almost all of the participants' choices for monetary outcomes were consistent across MCQ small (99%), medium (99%), and large (99%) magnitudes. For the FCQ, participants were 94% consistent on the small, medium, and large outcomes.

AA discounting

Figure 1 shows delay discounting curves for hypothetical money (top) and food (bottom) for descriptive purposes. The hyperbolic discounting function provided a good fit to group median data across the two discounting tasks as evidenced by R^2 values (all values ≥ 0.94). In terms of the distribution of R^2 values, the median individual R^2 value for money outcomes was 0.91 (IQR = 0.70–0.96) and ranged from 0.10 to 0.998. The median individual R^2 values for food outcomes was 0.77 (IQR = 0.61–.89) and ranged from 0.08 to 0.99. Four individuals yielded uninterpretable R^2 values for food (i.e., zero or negative R^2 values), which is a noted drawback to using R^2 as an indicator of model fit when using nonlinear regression (see Johnson & Bickel, 2008). Overall, estimates of fit values are consistent with previous studies (e.g., Hendrickson & Rasmussen, 2013; Rasmussen et al., 2010). Those values in addition to the systematic data described using the Johnson and Bickel (2008) algorithm indicate that the hyperbolic decay function fit the majority of data quite well for both money and food outcomes.

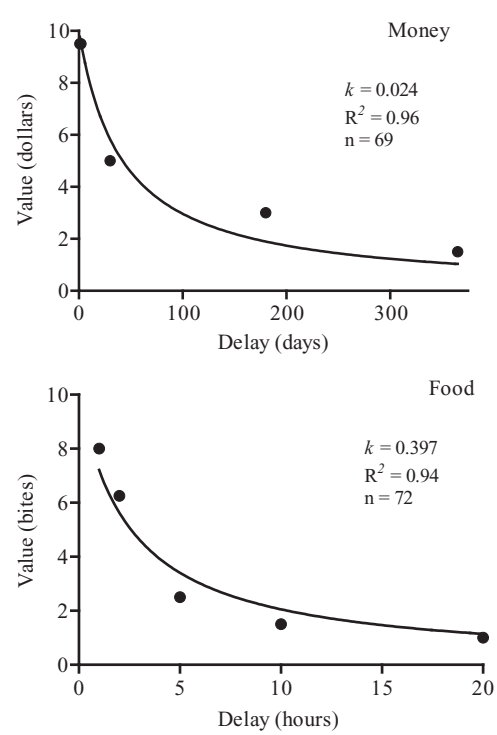

Fig. 1. Median indifference values of all participants as a function of delay for money (top) and food (bottom) using the adjusting amount (AA) procedure. Fit lines represent best fit of hyperbolic discounting function. In some cases, two data points overlapped at short delays for money.

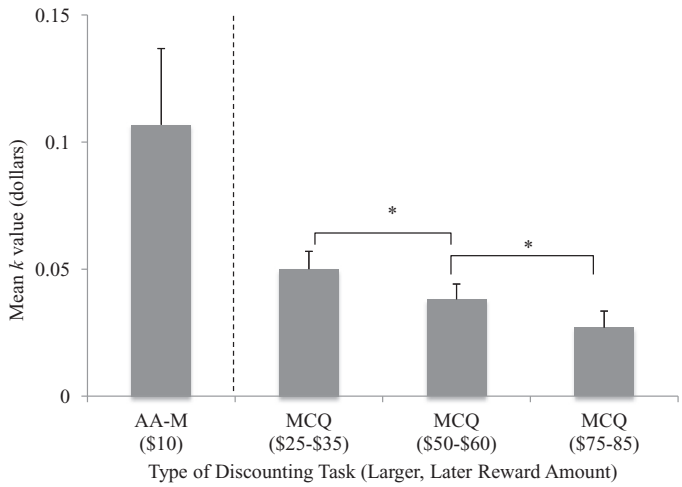

Fig. 2. Mean k values for all participants across the Adjusting Amount Procedure for Money (AA-M) and the Monetary Choice Questionnaire (MCQ) with three different magnitudes: small, medium, and large. Error bars represent 1 SEM. $^{*}p < 0.05$.

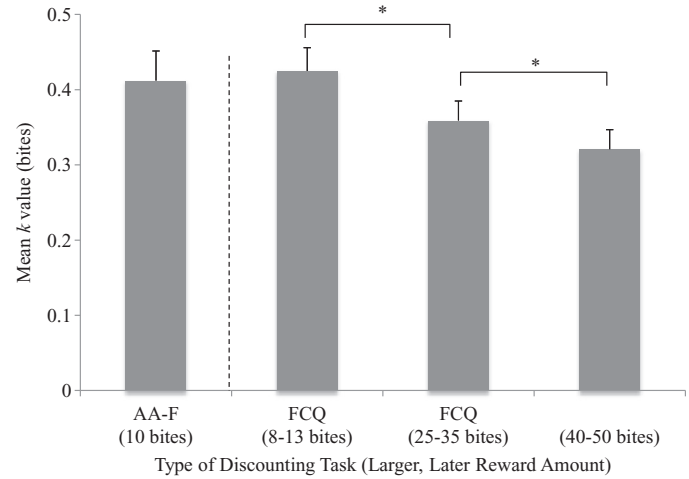

Fig. 3. Mean k values for all participants across the Adjusting Amount Procedure for Food (AA-F) and the Food Choice Questionnaire (FCQ) with three different magnitudes: small, medium, and large. Error bars represent 1 SEM. $^{*}p \leq 0.052$.

Monetary discounting

Mean k values for the AA-M and for the MCQ small, medium, and large magnitudes are shown in Fig. 2. Because of skewness, k values were transformed using the natural log (ln[k]) prior to running parametric analyses, which is a common practice in the discounting literature given their non-normal distributions (e.g., Amlung & MacKillop, 2011; Charlton & Fantino, 2008; Johnson et al., 2010; Kirby & Santiesteban, 2003; Reynolds & Fields, 2012). A within-subjects ANOVA conducted on the three MCQ k values (for each magnitude) revealed a significant difference, suggesting that participants discounted magnitudes of money at different rates, $F(2, 136) = 42.46$, $p < 0.01$, $\eta^2 = 0.55$. Post-hoc analyses revealed that large amounts of money were discounted the least, followed by medium, and then small outcomes, with all three magnitudes differing significantly from one another ($ps < 0.01$), similar to non-parametric analyses.

Table 2 describes Pearson product-moment correlations among the AA-M task, MCQ, and related health variables. Across discounting tasks, Pearson product-moment correlations revealed that discounting values measured by the AA-M were strongly correlated with the MCQ with similar strengths (all r's ≤ 0.5, $ps < 0.01$).

Health variables associated with monetary discounting

Table 3 also shows that BMI and PBF were significantly correlated, such that those who had a higher BMI also tended to have a greater PBF. Glucose levels were significantly correlated with discounting values on the AA-M and with discounting under the small magnitude on the MCQ. Subjective hunger was also negatively correlated with discounting on the smaller magnitude MCQ, although it was not significantly correlated with glucose levels. Intellectual functioning in this sample was not significantly correlated with the MCQ or the AA-M k ($p > 0.06$). Similarly, no other demographic (i.e., age, gender, income), health (i.e., BMI, PBF, waist circumference), or consumption-related variable (i.e., time since last meal, time since last snack, time since last drink) was significantly correlated with monetary discounting variables.

Food discounting

Mean k values for the AA-F, FCQ small, medium, large magnitudes are shown in Fig. 3. Due to skewness, values were log-transformed so parametric statistical analyses could be performed. A within-subjects ANOVA revealed a significant main effect for magnitude on the FCQ, $F(2, 142) = 6.23$, $p < 0.01$, $\eta^2 = 0.11$. Post-hoc analyses revealed that large amounts of food were discounted the least, followed by medium, and then small outcomes, with all three magnitudes differing significantly from one another ($ps \leq 0.052$).

Health variables associated with food discounting

Table 4 shows correlations among health variables and food transformed discounting rates. BMI and PBF were positively correlated ($r = 0.65$, $p < 0.001$), similar to data from the monetary condition. PBF was positively correlated to all k values, suggesting that individuals with higher PBF also tend to be more impulsive for food-related outcomes. BMI did not correlate with any food discounting

Table 3
Pearson product-moment correlations (r) between health variables and monetary discounting tasks.

Variable	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*
1. Glucose	–							
2. Subjective hunger	–0.19	–						
3. BMI	0.12	–0.20	–					
4. PBF	0.14	–0.27[a]	0.61[b]	–				
5. MCQ small (ln[k])	0.29[a]	–0.30[a]	0.15	0.15	–			
6. MCQ medium (ln[k])	0.14	–0.23	0.11	0.02	0.81[b]	–		
7. MCQ large (ln[k])	0.22	–0.21	0.11	0.04	0.80[b]	0.84[b]	–	
8. AA-M (ln[k])	0.28[a]	0.22	–0.02	0.03	0.55[b]	0.61[b]	0.59[b]	–
9. AA-M AUC	–0.20	–0.22	0.08	–0.02	–0.54[b]	–0.57[b]	–0.56[b]	–0.93[b]

[a] $p \leq 0.05$.
[b] $p \leq 0.001$.
Note: BMI = Body Mass Index; PBF = Percent Body Fat; AUC = Area Under the Curve; (ln[k]) = natural log transformation of k; $n = 69$.

Table 4
Pearson product-moment correlations (r) between health variables and food discounting tasks.

Variable	1	2	3	4	5	6	7	8
1. Glucose	–							
2. Subjective hunger	–0.17	–						
3. BMI	–0.07	–0.14	–					
4. PBF	–0.002	–0.23[a]	0.68[d]	–				
5. FCQ small (ln[*k*])	–0.27[a]	0.26[b]	0.12	0.23[b]	–			
6. FCQ medium (ln[*k*])	–0.12	0.37[d]	–0.03	0.18	0.77[d]	–		
7. FCQ large (ln[*k*])	0.08	0.22	0.09	0.23[a]	0.46[d]	0.74[d]	–	
8. AA-F *k* (ln[*k*])	–0.15	0.38[c]	–0.03	0.24[b]	0.55[d]	0.67[d]	0.52[d]	
9. AA-F AUC	0.22	–0.32[d]	0.06	–0.23[b]	–0.49[d]	–0.60[d]	–0.47[d]	

[a] $p = 0.058$.
[b] $p \leq 0.05$.
[c] $p \leq 0.01$.
[d] $p \leq 0.001$.
Note: BMI = Body Mass Index; PBF = Percent Body Fat; AUC = Area Under the Curve; (ln[*k*]) = natural log transformation of *k*; $n = 72$.

measure. Subjective hunger significantly correlated with small and medium magnitude food discounting rates, and time since last snack was correlated with AA-F *k* ($r = 0.26$, $p < 0.05$) and AUC ($r = -0.31$, $p < 0.01$) values. Estimated IQ was also negatively correlated with *k* and AUC values from the AA-F (*rs* = –0.24, $p < 0.05$), though it was not significantly correlated with any specific magnitude of the FCQ. Gender was only significantly related to the large FCQ magnitude ($r = -0.28$, $p < 0.05$). No other demographic (i.e., age, ethnicity), health (i.e., waist circumference, glucose level), or consumption-related (i.e., time since last meal, time since last drink) variables were significantly correlated with food discounting.

To determine the relations between health variables and discounting rates for food across all participants, a series of hierarchical linear regression analyses were conducted to establish the unique variability contributed by the health variables to discounting. To control for subjective hunger, time since last snack, (as they were statistically associated to PBF and food discounting in the sample) and BMI, these variables were entered in the first step and PBF was entered in the second step. The discounting rates were entered as the dependent variables (see Table 5). PBF was significantly and uniquely related to all discounting parameters measured by the AA-F (*k*) and FCQ (*k*s for small, medium, and large magnitudes) even after controlling for subjective hunger, time since last snack, and BMI. It accounted for the most variance in predicting AA-F AUC (20%). Regression coefficients for health and dietary variables apart from PBF and subjective hunger (i.e., BMI, time since last meal, time since last snack, time since last drink, and glucose) did not significantly predict small and large magnitudes of the FCQ. BMI only remained statistically significant in the model for the FCQ medium magnitude and the AA-F (*p*s < 0.05).

Discussion

One aim of this study was to replicate discounting rates for hypothetical money across two delay discounting procedures and then to extend the comparison of methodologies to discounting rates for hypothetical food. To do this, we compared an adjusting amount procedure (AA-M; Richards et al., 1999) with a questionnaire-based method – the Monetary Choice Questionnaire (MCQ; Kirby & Maraković, 1996). Using the MCQ measure, we established and validated a shorter methodological alternative for measuring sensitivity to delay for hypothetical food outcomes – the Food Choice Questionnaire (FCQ) – and compare it to an already established adjusting amount procedure (AA-F). Several empirical outcomes support the validity of the FCQ.

Table 5
Hierarchical regression coefficients for percent body fat in relation to discounting rates across Food Choice Questionnaire (FCQ) and Adjusting-Amount Choice Procedure for Food (AA-F) tasks controlling for subjective hunger, time since last snack, and BMI.

Task	*b* (SE)	β	*t* (df)	$R^2\Delta$	*p*
FCQ small (ln[*k*])	0.04 (0.02)	0.36	2.36 (4, 67)	0.07	0.02
FCQ medium (ln[*k*])	0.05 (0.01)	0.49	3.44 (4, 67)	0.13	0.001
FCQ large (ln[*k*])	0.04 (0.01)	0.38	2.39 (4, 67)	0.07	0.02
AA-F k(ln[*k*])	0.08 (0.02)	0.59	4.62 (4, 67)	0.19	<0.001
AA-F AUC	–0.02 (0.01)	–0.62	–4.73 (4, 67)	0.20	<0.001

Replication of money discounting

First, as demonstrated by other studies (e.g., Epstein et al., 2003; Amlung & MacKillop, 2011), data from the questionnaire-based method (MCQ) was related strongly to those from the adjusting amount procedure (AA-M) across small, medium, and large magnitudes of money. The strength of the correlations between the AA-M and each magnitude of the MCQ was similar to one another (*rs* between 0.54 and 0.61). The correlations among MCQ magnitudes were also very similar (*rs* ≥ 0.80 to 0.84). When comparing mean discounting values between MCQ small, medium, and large monetary outcomes, there was a magnitude effect in that individuals discounted large amounts of money the least, followed by medium, and then small amounts. This is also consistent with previous literature using the MCQ (e.g., Amlung & MacKillop, 2011; Kirby & Maraković, 1996; Kirby et al., 1999).

Lastly, both types of monetary discounting tasks produced orderly discounting patterns. For the MCQ, consistency was defined by Kirby and Maraković's (1996) parameter estimation procedure. All three magnitudes of the MCQ produced consistency values of 99%. These values are similar to those reported in other studies (Kirby & Finch, 2010; Kirby et al., 1999). The criteria for orderliness for the AA-M were identified by Johnson and Bickel's (2008) algorithm. Ninety-three percent met the criteria for the AA-M, and these values are consistent with other studies using the adjusting-amount procedure (Amlung & MacKillop, 2011; Johnson & Bruner, 2012; Lawyer et al., 2010).

Food discounting

The FCQ generated discounting rates that highly correlated among small, medium, and large food magnitude amounts. In addition, these values correlated highly with those on the AA-F. In addition, a magnitude effect was found for food outcomes, such that individuals discounted large amounts of food less steeply than medium and small amounts. Individuals showed the most impulsive choice pattern for small amounts of food. This pattern is similar to the one found for monetary outcomes in the present

study and others (Green, Myerson, & McFadden, 1997; Jarmolowicz et al., 2014; Kirby, 2009), although it is somewhat novel to the food discounting literature with human populations. Jimura, Myerson, Hilgard, Braver, and Green (2009), for example, showed that liquid rewards were discounted more steeply in small amounts than large amounts, though this was for real rewards using an adjusting procedure. Odum et al. (2006) did not demonstrate a magnitude effect using different amounts of hypothetical food rewards via an adjusting amount procedure, although in their task, participants were asked to imagine equivalent values of their preferred food (e.g., $100 worth of pizza). These methodological differences may have played a role in the discrepancy of results between these studies. No study, to our knowledge, has evidenced a magnitude effect for hypothetical food outcomes using a choice questionnaire methodology.

Food discounting rates for small and large magnitudes derived from the FCQ were also significantly associated with percent body fat (PBF). While the medium magnitude was not statistically significant at the $p < 0.05$ level, it showed a similar pattern). It may be that subjective hunger played a role in this result as it was correlated to both food discounting and PBF. Indeed, when controlling for subjective hunger, time since last snack, and BMI in the regression analyses, PBF predicted all three magnitudes of food discounting.

The vast majority of participants responded in an orderly manner on both food discounting tasks. However, participants completed the FCQ in less time (≤5 minutes) than the AA-F (15 minutes). Using the same criteria as the MCQ, participants demonstrated consistency rates of 94% for small, medium, and large magnitudes. For the AA-F tasks, approximately 81% were systematic using the, Johnson and Bickel (2008) algorithm. The AA-F value is consistent with previous studies (Hendrickson & Rasmussen, 2013; Rasmussen et al., 2010). Because the criteria for orderliness of the AA-F and FCQ measures are qualitatively different, these data are only meant to be descriptive in nature and should not be compared. Nonetheless, because the data under both tasks are orderly, both measures could be useful to researchers who may wish to measure food discounting.

Percent body fat

Percent body fat positively correlated with discounting values from both the AA-F and the FCQ. Moreover, percent body fat was a significant predictor of discounting patterns for food across both the AA-F and the FCQ, with participants with high PBF discounting more steeply than those with low PBF. These effects were found even when subjective hunger and BMI were controlled. Hendrickson and Rasmussen (2013) and Rasmussen et al. (2010) also found similar results using the AA-F, but this study was the first to do so with the FCQ.

Body mass index did not correlate significantly with food discounting at any magnitude, either on the AA-F or FCQ. This discrepancy with PBF is notable, in that it is consistent with data from other studies that used the AA-F task (Hendrickson & Rasmussen, 2013; Rasmussen et al., 2010). It may be that BMI, compared to PBF, is too broad of an estimate and/or not sensitive enough to predict delay discounting for hypothetical food using the selected magnitudes. In addition, the use of BMI rather than PBF has been criticized as a diagnostic tool for obesity (e.g., Garn, Leonard, & Hawthorne, 1986), because it relies solely on height and weight, and does not differentiate between excess fat, muscle, or bone mass (Centers for Disease Control and Prevention, 2011b). PBF, on the other hand, accounts for these limitations by dividing an individual's total body fat by their total mass. It is a more valid measure of body fat and also better predicts illness and mortality (Pi-Sunyer, 2002). The FCQ's lack of association with BMI may also be a limitation of the current study's participant pool. We recruited some of the current study's participants from a different study; these individuals were excluded from that study because of their overweight BMI status (between 25 and 29.9). This led to a possibly inflated proportion of individuals in the current study's sample that had an overweight BMI compared to what might be expected if all participants signed up independently. We are hopeful that future research will elucidate these results.

Limitations

These findings should be considered in the context of potential limitations. First, the participant pool was largely limited to undergraduate adults. A previous study suggests that age combined with lower income may be a variable that influences monetary choice behavior, though this particular study compared a community sample of adults across a wider range of ages (e.g., Green, Fry, & Myerson, 1994). Research on delay discounting that considers age in college and non-college samples may be beneficial for further understanding mechanisms underlying discounting processes. Also, the current sample contained a higher number of overweight individuals compared to what might be seen in typical samples. A sample of BMIs (and potentially PBFs) that represents the population may be more generalizable to those of the general adult population.

Lastly, this study did not compare discounting rates between money and food commodities, as the outcome units were qualitatively distinct (dollars vs. bites) and temporally different (days vs. hours). Other studies that have equated these properties have shown that food tends to be discounted more steeply than money (e.g., Charlton & Fantino, 2008; Odum et al., 2006), although no studies to date have compared the MCQ and a similar questionnaire for food discounting.

The establishment and validation of the FCQ provides an alternative method for measuring food discounting. Based upon findings from the current study, this measure provides orderly data with values that are similar to those generated by the AA-F task and allows researchers to examine discounting rates for food outcomes with various magnitudes in a time-efficient manner. Moreover, it replicates PBF findings from other studies (Hendrickson & Rasmussen, 2013; Rasmussen et al., 2010). Although this study presented the FCQ on a computer, it is also amenable to paper-and-pencil, thus allowing for use in settings that may not allow computer use (e.g., correctional facilities). Moreover, its brevity may be conducive to populations in which brief testing is preferred or necessary (e.g., children, teens, or those in medical settings). Indeed, the MCQ is often presented to participants in paper-and-pencil format (Kirby & Maraković, 1996).

Future research on the use of the FCQ across the developmental lifespan and populations outside of the university setting (e.g., clinical populations) would be beneficial. It would also be useful to explore other psychometric properties of the FCQ including converging validity with other discounting tasks modified for food outcomes and test–retest reliability.

References

Ainslie, G. (1975). Specious reward. A behavioral theory of impulsiveness and impulse control. *Psychological Bulletin*, *82*(4), 463–496. doi:10.1037/h0076860.

Ainslie, G. (1992). *Picoeconomics. The strategic interaction of successive motivational states within the person*. New York, NY, US: Cambridge University Press.

American College of Endocrinology. (2002). American College of Endocrinology Consensus Statement on Guidelines for Glycemic Control. *Endocrine Practice*, *8*(Suppl. 1), 5–11.

Amlung, M., & MacKillop, J. (2011). Delayed reward discounting and alcohol misuse. The roles of response consistency and reward magnitude. *Journal of Experimental Psychopathology*, *2*(3), 418–431.

Appelhans, B. M. (2009). Neurobehavioral inhibition of reward-driven feeding. Implications for dieting and obesity. *Obesity (Silver Spring)*, *17*(4), 640–647. (19307381).

Bickel, W. K., Jarmolowicz, D. P., Mueller, E. T., Koffarnus, M. N., & Gatchalian, K. M. (2012). Excessive discounting of delayed reinforcers as a trans-disease process contributing to addiction and other disease-related vulnerabilities. Emerging evidence. *Pharmacology & Therapeutics*, *134*(3), 287–297. doi:10.1016/j.pharmthera.2012.02.004.

Bickel, W. K., & Mueller, E. (2009). Toward the study of trans-disease processes. A novel approach with special reference to the study of co-morbidity. *Journal of Dual Diagnosis*, *5*(2), 131–138. doi:10.1080/15504260902869147.

Boomhower, S. R., Rasmussen, E. B., & Doherty, T. S. (2013). Impulsive-choice patterns for food in genetically lean and obese Zucker rats. *Behavioural Brain Research*, *241*, 214–221. doi:10.1016/j.bbr.2012.12.013.

Boomhower, S., & Rasmussen, E. (2014). Haloperidol and rimonabant increase delay discounting in rats fed high-fat and standard-chow diets. *Behavioural Pharmacology*, *25*, 705–716.

Cawley, J., & Meyerhoefer, C. (2012). The medical care costs of obesity. An instrumental variables approach. *Journal of Health Economics*, *31*(1), 219–230. doi:10.1016/j.jhealeco.2011.10.003.

Centers for Disease Control and Prevention. *Halting the epidemic by making health easier at a glance*. (2011a). <http://www.cdc.gov/chronicdisease/resources/publications/aag/obesity.htm>. Last accessed 14.04.30.

Centers for Disease Control and Prevention. *About BMI for adults*. (2011b). <http://www.cdc.gov/healthyweight/assessing/bmi/adult_bmi/index.html>. Last accessed 14.04.30.

Charlton, S. R., & Fantino, E. (2008). Commodity specific rates of temporal discounting. Does metabolic function underlie differences in rates of discounting? *Behavioural Processes*, *77*(3), 334–342. doi:10.1016/j.beproc.2007.08.002.

Colditz, G. (1992). Economic costs of obesity. *The American Journal of Clinical Nutrition*, *55*(Suppl. 2), 503S–507S.

Dallery, J., & Locey, M. L. (2005). Effects of acute and chronic nicotine on impulsive choice in rats. *Behavioural Pharmacology*, *16*(1), 15–23. doi:10.1097/00008877-200502000-00002.

Daugherty, J. R., & Brase, G. L. (2010). Taking time to be healthy. Predicting health behaviors with delay discounting and time perspective. *Personality and Individual Differences*, *48*(2), 202–207. doi:10.1016/j.paid.2009.10.007.

Duckworth, A. L., & Seligman, M. E. P. (2005). Self-discipline outdoes IQ in predicting academic performance of adolescents. *Psychological Science*, *16*(12), 939–944.

Epstein, L. H., Richards, J. B., Saad, F. G., Paluch, R. A., Roemmich, J. N., & Lerman, C. (2003). Comparison between two measures of delay discounting in smokers. *Experimental and Clinical Psychopharmacology*, *11*(2), 131–138. doi:10.1037/1064-1297.11.2.131.

Epstein, L. H., Salvy, S. J., Carr, K. A., Dearing, K. K., & Bickel, W. K. (2010). Food reinforcement, delay discounting and obesity. *Physiology & Behavior*, *100*(5), 438–445. doi:10.1016/j.physbeh.2010.04.029.

Estle, S. J., Green, L., Myerson, J., & Holt, D. D. (2007). Discounting of monetary and directly consumable rewards. *Psychological Science*, *18*(1), 58–63. doi:10.1111/j.1467-9280.2007.01849.x.

Garn, S. M., Leonard, W. R., & Hawthorne, V. M. (1986). Three limitations of the body mass index. *The American Journal of Clinical Nutrition*, *44*(6), 996–997.

Green, L. (1982). Self-control behavior in animals. In V. L. Smith (Ed.), *Research in experimental economics* (Vol. 2, pp. 129–150). Greenwich, CT: JAI Press.

Green, L., Fisher, E. B., Perlow, S., & Sherman, L. (1981). Preference reversal and self control. Choice as a function of reward amount and delay. *Behaviour Analysis Letters*, *1*(1), 43–51.

Green, L., Fry, A. F., & Myerson, J. (1994). Discounting of delayed rewards. A life-span comparison. *Psychological Science*, *5*(1), 33–36. doi:10.1111/j.1467-9280.1994.tb00610.x.

Green, L., & Myerson, J. (1993). Alternative frameworks for the analysis of self control. *Behavior and Philosophy*, *21*(2), 37–47.

Green, L., Myerson, J., & McFadden, E. (1997). Rate of temporal reward decreases with amount of reward. *Memory & Cognition*, *25*, 715–723.

Green, L., Myerson, J., Shah, A. K., Estle, S. J., & Holt, D. D. (2007). Do adjusting-amount and adjusting-delay procedures produce equivalent estimates of subjective value in pigeons? *Journal of the Experimental Analysis of Behavior*, *87*(3), 337–347.

Helms, C. M., Reeves, J. M., & Mitchell, S. H. (2006). Impact of strain and d-amphetamine on impulsivity (delay discounting) in inbred mice. *Psychopharmacology*, *188*(2), 144–151.

Hendrickson, K. L., & Rasmussen, E. B. (2013). Effects of mindful eating training on delay and probability discounting for food and money in obese and healthy-weight individuals. *Behaviour Research and Therapy*, *51*(7), 399–409. doi:10.1016/j.brat.2013.04.002.

Holt, D. D., Green, L., & Myerson, J. (2012). Estimating the subjective value of future rewards. Comparison of adjusting-amount and adjusting-delay procedures. *Behavioural Processes*, *90*, 302–310.

Holt, D. D., Newquist, M. H., Smits, R. R., & Tiry, A. M. (2014). Discounting of food, sex, and money. *Psychonomic Bulletin & Review*, *21*(3), 794–802. doi:10.3758/s13423-013-0557-2.

Jarmolowicz, D. P., Bradley, J., Cherry, C., Reed, D. D., Bruce, J. M., Crespi, J. M., et al. (2014). Robust relation between temporal discounting rates and body mass. *Appetite*, *78*, 63–67.

Jimura, K., Myerson, J., Hilgard, J., Braver, T. S., & Green, L. (2009). Are people really more patient than other animals? Evidence from human discounting of real liquid rewards. *Psychonomic Bulletin & Review*, *16*(6), 1071–1075. doi:10.3758/PBR.16.6.1071.

Johnson, M., & Bruner, N. (2012). The sexual discounting task. HIV risk behavior and the discounting of delayed sexual rewards in cocaine dependence. *Drug and Alcohol Dependence*, *123*(1–3), 15–21. doi:10.1016/j.drugalcdep.2011.09.032.

Johnson, M. W., & Bickel, W. K. (2008). An algorithm for identifying nonsystematic delay-discounting data. *Experimental and Clinical Psychopharmacology*, *16*(3), 264–274. doi:10.1037/1064-1297.16.3.264.

Johnson, M. W., Bickel, W. K., Baker, F., Moore, B. A., Badger, G. J., & Budney, A. J. (2010). Delay discounting in current and former marijuana-dependent individuals. *Experimental and Clinical Psychopharmacology*, *18*(1), 99–107. doi:10.1037/a0018333.

Kirby, K. N. (2009). One-year temporal stability of delay-discount rates. *Psychonomic Bulletin & Review*, *16*(3), 457–462. doi:10.3758/pbr.16.3.457.

Kirby, K. N., & Finch, J. C. (2010). The hierarchical structure of self-reported impulsivity. *Personality and Individual Differences*, *48*(6), 704–713. doi:10.1016/j.paid.2010.01.019.

Kirby, K. N., & Maraković, N. N. (1996). Delay-discounting probabilistic rewards. Rates decrease as amounts increase. *Psychonomic Bulletin & Review*, *3*(1), 100–104. doi:10.3758/bf03210748.

Kirby, K. N., & Petry, N. M. (2004). Heroin and cocaine abusers have higher discount rates for delayed rewards than alcoholics or non-drug-using controls. *Addiction (Abingdon, England)*, *99*(4), 461–471. doi:10.1111/j.1360-0443.2003.00669.x.

Kirby, K. N., Petry, N. M., & Bickel, W. K. (1999). Heroin addicts have higher discount rates for delayed rewards than non-drug-using controls. *Journal of Experimental Psychology. General*, *128*(1), 78–87.

Kirby, K. N., & Santiesteban, M. (2003). Concave utility, transaction costs, and risk in measuring discounting of delayed rewards. *Journal of Experimental Psychology. Learning, Memory, and Cognition*, *29*(1), 66–79.

Lawyer, S. R. (2008). Probability and delay discounting of erotic stimuli. *Behavioural Processes*, *79*(1), 36–42. doi:10.1016/j.beproc.2008.04.009.

Lawyer, S. R. (2014) Behavioral mechanisms of impulsivity among high versus low sexual risk-takers. Manuscript under review.

Lawyer, S. R., & Schoepflin, F. J. (2013). Predicting domain-specific outcomes using delay and probability discounting for sexual versus monetary outcomes. *Behavioural Processes*, *96*, 71–78. doi:10.1016/j.beproc.2013.03.001.

Lawyer, S. R., Williams, S. A., Prihodova, T., Rollins, J. D., & Lester, A. C. (2010). Probability and delay discounting of hypothetical sexual outcomes. *Behavioural Processes*, *84*(3), 687–692. doi:10.1016/j.beproc.2010.04.002.

Logue, A. W. (1988). Research on self-control. An integrating framework. *Behavioral and Brain Sciences*, *11*(4), 665–709. doi:10.1017/S0140525X00053978.

Madden, G. J., Petry, N. M., Badger, G. J., & Bickel, W. K. (1997). Impulsive and self-control choices in opioid-dependent patients and non-drug-using control patients. Drug and monetary rewards. *Experimental and Clinical Psychopharmacology*, *5*(3), 256–262. doi:10.1037/1064-1297.5.3.256.

Mazur, J. E. (1987). An adjusting procedure for studying delayed reinforcement. In M. L. Commons, J. E. Mazur, J. A. Nevin, & H. Rachlin (Eds.), *The effect of delay and of intervening events on reinforcement value* (pp. 55–73). Hillsdale, NJ, England: Lawrence Erlbaum Associates, Inc.

Mazur, J. E. (2000). Tradeoffs among delay, rate, and amount of reinforcement. *Behavioural Processes*, *49*(1), 1–10. doi:10.1016/S0376-6357(00)00070-X.

Mitchell, S. H. (1999). Measures of impulsivity in cigarette smokers and nonsmokers. *Psychopharmacology*, *146*(4), 455–464. doi:10.1007/pl00005491.

Myerson, J., Green, L., Hanson, J. S., Holt, D. D., & Estle, S. J. (2003). Discounting of delayed and probabilistic rewards. Processes and traits. *Journal of Economic Psychology*, *24*, 619–635.

Myerson, J., Green, L., & Warusawitharana, M. (2001). Area under the curve as a measure of discounting. *Journal of the Experimental Analysis of Behavior*, *76*(2), 235–243.

National Heart, Lung, and Blood Institute. What are Overweight and Obesity? *Overweight and Obesity*. (2012). <http://www.nhlbi.nih.gov/health/health-topics/topics/obe/> (accessed 2.5.14).

Odum, A. L., Baumann, A. A. L., & Rimington, D. D. (2006). Discounting of delayed hypothetical money and food. Effects of amount. *Behavioural Processes*, *73*(3), 278–284. doi:10.1016/j.beproc.2006.06.008.

Odum, A. L., & Rainaud, C. P. (2003). Discounting of delayed hypothetical money, alcohol, and food. *Behavioural Processes*, *64*(3), 305. doi:10.1016/S0376-6357(03)00145-1.

Ogden, C., Carroll, M., Kit, B., & Flegal, K. (2014). Prevalence of childhood and adult obesity in the United States, 2011–2012. *Journal of the American Medical Association*, *311*(8), 806–814. doi:10.1001/jama.2014.732.

Oliveira, L., Green, L., & Myerson, J. (2014). Pigeons' delay discounting functions established using a concurrent-chains procedure. *Journal of the Experimental Analysis of Behavior*, *102*, 151–161. doi:10.1002/jeab.97.

Petry, N. M. (2001). Delay discounting of money and alcohol in actively using alcoholics, currently abstinent alcoholics, and controls. *Psychopharmacology*, *154*(3), 243–250. doi:10.1007/s002130000638.

Pi-Sunyer, F. X. (2002). The obesity epidemic. Pathophysiology and consequences of obesity. *Obesity Research*, *10*(Suppl. 2), 97S–104S.

Rachlin, H. (1974). Self-control. *Behaviorism*, *2*, 94–107.

Rachlin, H. (1989). *Judgment, decision, and choice. A cognitive/behavioral synthesis*. New York: Freeman.

Rachlin, H., Raineri, A., & Cross, D. (1991). Subjective probability and delay. *Journal of the Experimental Analysis of Behavior*, *55*(2), 233–244. doi:10.1901/jeab.1991.55-233.

Rasmussen, E. B., Lawyer, S. R., & Reilly, W. (2010). Percent body fat is related to delay and probability discounting for food in humans. *Behavioural Processes*, *83*(1), 23–30. doi:10.1016/j.beproc.2009.09.001.

Reynolds, B., & Fields, S. (2012). Delay discounting by adolescents experimenting with cigarette smoking. *Addiction (Abingdon, England)*, *107*(2), 417–424. doi:10.1111/j.1360-0443.2011.03644.x.

Richards, J. B., Mitchell, S. H., de Wit, H., & Seiden, L. S. (1997). Determination of discount functions in rats with an adjusting-amount procedure. *Journal of the Experimental Analysis of Behavior*, *67*(3), 353–366. doi:10.1901/jeab.1997.67-353.

Richards, J. B., Sabol, K. E., & de Wit, H. H. (1999). Effects of methamphetamine on the adjusting amount procedure, a model of impulsive behavior in rats. *Psychopharmacology*, *146*(4), 432.

Richards, J. B., Zhang, L., Mitchell, S. H., & de Wit, H. (1999). Delay or probability discounting in a model of impulsive behavior. Effect of alcohol. *Journal of the Experimental Analysis of Behavior*, *71*(2), 121–143. doi:10.1901/jeab.1999.71-121.

Rollins, B. Y., Dearing, K. K., & Epstein, L. H. (2010). Delay discounting moderates the effect of food reinforcement on energy intake among non-obese women. *Appetite*, *55*(3), 420–425. doi:10.1016/j.appet.2010.07.014.

ten Hacken, N. (2009). Physical inactivity and obesity. Relation to asthma and chronic obstructive pulmonary disease? *Proceedings of the American Thoracic Society*, *6*(8), 663–667. doi:10.1513/pats.200907-070DP.

U.S. Department of Health and Human Services. (2001). *The surgeon general's call to action to prevent and decrease overweight and obesity*. Rockville, MD: U.S. Department of Health and Human Services, Public Health Service, Office of the Surgeon General.

Vuchinich, R. E., & Simpson, C. A. (1998). Hyperbolic temporal discounting in social drinkers and problem drinkers. *Experimental and Clinical Psychopharmacology*, *6*(3), 292–305. doi:10.1037/1064-1297.6.3.292.

Weller, R. E., Cook, E. W., III, Avsar, K. B., & Cox, J. E. (2008). Obese women show greater delay discounting than healthy-weight women. *Appetite*, *51*(3), 563–569. doi:10.1016/j.appet.2008.04.010.

Whelan, R., & McHugh, L. A. (2009). Temporal discounting of hypothetical monetary rewards by adolescents, adults, and older adults. *The Psychological Record*, *59*(2), 247–258.

Wilhelm, C. J., & Mitchell, S. H. (2008). Rats bred for high alcohol drinking are more sensitive to delayed and probabilistic outcomes. *Genes, Brain, and Behavior*, *7*(7), 705–713. doi:10.1111/j.1601-183X.2008.00406.x.

Woolverton, W. L., Myerson, J., & Green, L. (2007). Delay discounting of cocaine by rhesus monkeys. *Experimental and Clinical Psychopharmacology*, *15*(3), 238–244. doi:10.1037/1064-1297.15.3.238.

Zachary, R. A. (1986). *Shipley institute of living scale. Revised manual*. Los Angeles, CA: Western Psychological Services.