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# Effects of mindful eating training on delay and probability discounting for food and money in obese and healthy-weight individuals

Kelsie L. Hendrickson<sup>1</sup>, Erin B. Rasmussen\*

Department of Psychology, Idaho State University, 921 S. 8th Avenue, Stop 8112, Pocatello, ID 83209, United States

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## ABSTRACT

Obese individuals tend to behave more impulsively than healthy weight individuals across a variety of measures, but it is unclear whether this pattern can be altered. The present study examined the effects of a mindful eating behavioral strategy on impulsive and risky choice patterns for hypothetical food and money. In Experiment 1, 304 participants completed computerized delay and probability discounting tasks for food-related and monetary outcomes. High percent body fat (PBF) predicted more impulsive choice for food, but not small-value money, replicating previous work. In Experiment 2, 102 randomly selected participants from Experiment 1 were assigned to participate in a 50-min workshop on mindful eating or to watch an educational video. They then completed the discounting tasks again. Participants who completed the mindful eating session showed more self-controlled and less risk-averse discounting patterns for food compared to baseline; those in the control condition discounted similarly to baseline rates. There were no changes in discounting for money for either group, suggesting stimulus specificity for food for the mindful eating condition.

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## Introduction

*Obesity and mindless eating*

Obese individuals are at greater risk for physical (e.g., type 2 diabetes; Field, Barnoya & Colditz, 2002) and mental health problems (e.g., depression; Sarwer & Thompson, 2002) compared to individuals of normal weight. According to the Centers for Disease Control and Prevention (CDCP; 2012), the prevalence of obesity has increased substantially in the last 30 years and is expected to continue to rise. Currently, over 35% of U.S. adults and 17% of U.S. children are obese. The increased prevalence of obesity across time has been attributed to a number of variables, including an increase in food consumption (Thompson et al., 2004).

Some researchers suggest that *mindless eating* is relevant to increases in food intake across the last several decades (e.g., Wansink, 2006). Mindless eating occurs when the act of eating is not consciously attended to; the cessation of eating is based on salient external environmental food cues (e.g., the bottom of a food

bowl or the end of a television program) rather than internal cues that signal satiety. Other “mindless” environmental cues influence eating, such as larger food container sizes (Wansink & Kim, 2005), a greater number of people present during the meal (de Castro & Brewer, 1992), dimmed lighting (Wansink, 2004), and watching a longer television program while eating (Tuomisto, Tuomisto, Hetherington, & Lappalainen, 1998). Taken together, these factors may contribute to weight gain across time.

Within the past decade, there has been an increase in research and therapy-based interest in *mindfulness*, a term defined as “paying attention in a particular way: on purpose, in the present moment, and non-judgmentally” (Kabat-Zinn, 1994, p. 4). Within the mindfulness training model of acceptance-based treatments (e.g., Acceptance and Commitment Therapy; ACT), individuals learn to examine their behavior in an objective manner. Specifically, different phenomena that come into the individual’s awareness (e.g., thoughts regarding past events) during the training session are observed but not evaluated (Marlatt & Kristeller, 1999).

Some studies have reported on the applicability of mindfulness to obesity. For example, mindfulness, compared to a control condition, has been shown to reduce food cravings in overweight and obese populations (Alberts, Mulken, Smeets, & Thewissen, 2010). Other studies using ACT have improved the quality of life of obese individuals by reducing obesity-related stigma, psychological distress, body mass, and increasing physical activity (Lillis, Hayes,

\* Corresponding author. Tel.: +1 208 282 2462; fax: +1 208 282 4832.

E-mail addresses: [hendkel2@isu.edu](mailto:hendkel2@isu.edu) (K.L. Hendrickson), [rasmerin@isu.edu](mailto:rasmerin@isu.edu) (E.B. Rasmussen).<sup>1</sup> Tel.: +1 208 282 2462; fax: +1 208 282 4832.

Bunting, & Masuda, 2009; Tapper et al., 2009). In one case study, mindfulness strategies were used to manage rapid eating, facilitate labeling of hunger, and eventually reduced the body mass of a morbidly obese individual by over 140 pounds (Singh et al., 2008).

While these studies made important contributions to improve the lives of obese individuals, the utility of mindfulness in the context of making food decisions has not been explored experimentally. One way to address this would be to train an individual to eat slowly while being non-judgmentally attentive to the sensations of tasting, chewing, and swallowing food (Zettle, 2007). This is intended to slow the pace of eating, increase time between bites of food, and increase awareness of the amount, quality, and quantity of the food that is eaten, which ultimately may lead to a reduction in food intake (Andrade, Greene, & Melanson, 2008; Scisco, Muth, Dong, & Hoover, 2011). Creating a context in which deliberate and thoughtful attention is placed on the act of eating may also reduce impulsive choice for food.

### *Impulsivity and obesity*

Impulsive choice patterns may be a behavioral mechanism relevant to obesity (e.g., Davis, Levitan, Smith, Tweed, & Curtis, 2006). Several self-report studies have shown that a positive relation exists between BMI and impulsive choice – a pattern of preference for smaller, immediate rewards over larger, later rewards (Borghans & Golsteyn, 2006; Komlos, Smith, & Bogin, 2004; Smith, Bogin, & Bishai, 2005; Zhang & Rashad, 2008). However, self-report measures can be sensitive to demand characteristics (e.g., experimenter expectancy), and participants may not be aware of their own behavior. Behavioral measures, such as the delay discounting (DD) task, may reduce problems inherent to self-report measures by examining patterns of choice between a smaller reward delivered immediately (e.g., \$100 now) and a larger reward delivered after a delay (e.g., \$1000 in one year). After the participant makes an initial choice, the immediate amount is increased or decreased until the participant switches to the immediate, smaller amount of the reward. The value at which the participant switches is called the indifference point. The process is repeated for a range of delays and indifference points are plotted for each delay value. In general, as the delay increases, the indifference points decrease in a hyperbolic manner (Mazur, 1987).

Research with humans has established that food is more reinforcing and tends to be more steeply discounted than a variety of other outcomes (e.g., money, books, music; Charlton & Fantino, 2008; Odum, Baumann, & Rimington, 2006). Therefore, it is possible to consider environmental conditions that capitalize on the immediacy of food delivery as a condition that would enhance excessive eating. Individuals who prefer more immediate, less healthy food options may be more susceptible to weight gain and later obesity (e.g., Maddock, 2004). Several studies have reported steeper discounting in obese populations compared to healthy-weight individuals for food (Rasmussen, Lawyer, & Reilly, 2010) and monetary rewards (Fields, Sabet, Peal, & Reynolds, 2011; Weller, Cook, Avsar, & Cox, 2008). Another study shows that when obese and overweight women dine out, those who tend to discount money more steeply (i.e., behave more impulsively) tend to consume more calories than those with lower discounting values (Appelhans et al., 2012). Moreover, overweight children who more steeply discount future monetary rewards are also less sensitive to weight-loss treatments when compared to less impulsive children (Best et al., 2012). This trend in the literature, then, may suggest that the degree to which one discounts future rewards may be a behavioral process involved in obesity.

The way in which we conceptualize impulsive behavior toward food-related outcomes and its relationship with body weight has

important implications for weight management and obesity treatment. Research suggests that there are behaviors (e.g., physical activity, caloric intake), that tend to increase and maintain weight loss when modified (Anton et al., 2009). Acceptance-based strategies promote the willingness of an individual to experience what cannot be controlled (e.g., stress) and support behavioral choices that are based on non-judgmental awareness in the present moment (Zettle, 2007). One component of this, which may be relevant to food-related behavior via decreasing impulsivity, is mindful eating.

### *The current study*

The present study tested the extent to which mindfulness training would affect impulsive choice patterns for food and money in an experimental setting. In Experiment 1, we attempted to systematically replicate a study by Rasmussen et al. (2010), which reported that individuals with high percent body fat (PBF) exhibited steeper discounting patterns for hypothetical bites of food, but not money. Consistent with Rasmussen et al., the present study used smaller values of outcomes (e.g., bites of food) across smaller windows of time (hours) to reflect the everyday food-related decisions that people make across a one-day time period. We improved on limitations of the initial study by controlling for estimated intelligence (IQ) and ensuring participants had no consumption of liquid or food at least 2 h prior to body fat measurements. In Experiment 2, participants were randomly assigned to one of two conditions to examine the extent to which a 50-min mindfulness-based workshop, using eating behavior as the focus, would change discounting patterns compared to a control condition. It was hypothesized for Experiment 1 that obese individuals would exhibit higher measures of impulsive choice for food compared to healthy-weight individuals, and small-value money would be less steeply discounted than food across participants. In Experiment 2, we hypothesized that participants who completed the mindful eating workshop would behave less impulsively with decisions regarding food and money compared to their pre-treatment measurements and that those in the control group would not change.

## **Experiment 1**

### *Method*

#### *Participants*

A total of 304 undergraduate psychology students ( $n = 211$  female) from Idaho State University were recruited for participation in the study and received course credit as compensation for their time. The average age of the participants was 24.58 ( $SD = 7.68$ ) years; 81.9% reported European-American ethnicity. The researchers asked participants to not eat or drink at least two hours before the experimental session.

#### *Materials*

*Demographics questionnaire.* The demographics questionnaire asked questions related to basic demographic variables, smoking behavior, self-identified or reportedly diagnosed eating disorders within the past two years, nutritional choices, and physical activity.

*Subjective hunger questionnaire.* The subjective hunger questionnaire queried the participants to rate their subjective hunger on a scale from 0 to 100 and indicate the time since their last meal and last snack.

*Drug and alcohol screening test (DAST).* The DAST (McCabe, Boyd, Cranford, Morales, & Slayden, 2006; Skinner, 1982), a measure of

drug/alcohol use in undergraduate populations, asked participants to report consequences associated with their drug and/or alcohol consumption, including aspects of occupational, social, and physical dysfunction. This measure was included because discounting has been shown to be steeper in individuals with substance abuse patterns (e.g., Madden, Petry, Badger, & Bickel, 1997). Responses are totaled and scores of 5–9 were considered to be indicative of a possible alcohol and/or drug problem, and scores higher than 10 were considered to be indicative of an alcohol and/or drug use problem based on Skinner (1982).

**Barratt impulsiveness scale (BIS-11).** The BIS-11 (Barratt, 1959; Patton, Stanford, & Barratt, 1995) is a 30-item questionnaire that asks participants how often certain statements about impulsivity apply to them (e.g., “I plan tasks carefully”). Queries are answered based on a 5-point Likert scale (rarely/never, occasionally, often, almost always or always). There are six first-order factors and three second-order factors that are positively correlated with other psychometric impulsivity measures (Patton et al., 1995).

**Shipley Institute of Living Scale (SILS).** The SILS (Zachary, 1986) is a brief and accurate measure of estimated general intellectual functioning (i.e., estimated Full-Scale IQ) that can be given individually or in groups. The self-administered scale includes two subtests, a 40-item vocabulary test and a 20-item test of abstract thinking. This measure was administered to quantify intellectual functioning, as steeper discounting has been shown in individuals with lower estimated IQ (see Shamosh & Gray, 2008).

**Other measurements.** Physical measurements included weight, height, and body fat percentage. A Tanita 2204 Body Fat Scale was used to measure percent body fat (PBF) through bioelectrical impedance analysis. Participants' heights were measured in cm using a standard tape measure and converted to meters. Body mass indices (BMIs) were also determined by dividing a participant's weight in kilograms by his or her height in meters squared ( $\text{kg}/\text{m}^2$ ).

#### Procedure

Participants completed the experiment individually in an office-sized room. First, they were asked to report the last time they ate and drank. If they reported fewer than two hours, they were asked to reschedule their visit and refrain from eating or drinking two hours before the experimental session. If they reported more than two hours, they were asked to read and sign a consent form. Then, to measure weight and percent body fat, participants removed their socks and shoes and stepped backwards on to the Tanita scale for weight and body fat measures. Height also was measured. Participants completed the self-report measures at a desk in the laboratory. The order of self-report, behavioral, and weight measures were counterbalanced across all participants.

**Discounting tasks.** For the discounting tasks, the participant was seated at an adjacent desk with a single desktop computer and presented with a script that described how to complete the discounting tasks. All discounting measures were presented via a PC-compatible computer using a modified version of a well-established discounting program (see Richards, Zhang, Mitchell, & de Wit, 1999) used in several discounting studies (e.g., Lawyer, 2008; Rasmussen et al., 2010). Questions for the delay and probability (to be described) discounting tasks were presented in a pseudo-random fashion using hypothetical food as an outcome and then using hypothetical money as an outcome. The order of the food and money discounting tasks was counterbalanced across participants.

The Delay Discounting (DD) task for hypothetical money required participants to choose between 10 dollars after 1 of several different delays (1, 2, 30, 180, and 365 days) or a smaller amount of money available immediately. After each choice, the immediate amount was increased or decreased by the program until the participant switched to the immediate and smaller amount of money (indifference point). The DD task for hypothetical food was identical to the DD money task except it used bites of hypothetical food instead of money as the outcome (for more detail, see Rasmussen et al., 2010). Visualization of a standardized hypothetical food bite was accomplished by presenting a 5/8" cube to the participant and asking him or her to imagine the cube as one bite of his or her favorite food (Rasmussen et al., 2010). Then, using the computer task, participants chose between a certain number of standardized bites of their favorite hypothetical food (e.g., 10 bites) after one of several different delays (1, 2, 5, 10, and 20 h) or a smaller number of standardized bites (e.g., 2) available immediately. The smaller amount was increased or decreased until the lowest value (one standardized bite) was presented.

One variant of discounting is probability discounting (PD), which measures the degree to which the value of the reward decreases as the odds against obtaining it increases. PD provides an index of risk towards uncertainty, which is inherent to delay discounting, since as delay toward an outcome increases, the odds against receiving it also increases (Rachlin, Raineri, & Cross, 1991). We included a PD measure for hypothetical money using a procedure similar to the delay discounting money task, except indifference points were determined for five different probability values: 0.9, 0.75, 0.5, 0.25, and 0.1. Questions for establishing PD required subjects to choose between a particular probability of receiving \$10 (e.g., 0.25 chance) or a smaller amount to be received for certain. The computer program increased or decreased the smaller amount of money ( $\pm\$0.50$ ) until an indifference point was determined for each of the probabilities. Probability Discounting (PD) for hypothetical food also used the same procedure except that participants chose between a particular probability of receiving standardized units of food (e.g., 0.25 chance) or a smaller amount to be received for certain.

After completing the tasks, participants received a debriefing form, and were asked if they had any questions or concerns regarding the experimental session. Each participant then received course credit and a list of healthy lifestyle tips to take home.

#### Analyses

Data were analyzed using SPSS 18.0 and GraphPad Prism<sup>®</sup> statistical software. Equation (1), the delay discounting hyperbolic function, was fit to individual and group data (using median indifference points) for the DD task.

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

Here,  $V$  (value) represents the indifference point,  $A$  is the amount of the delayed reward, and  $D$  is the length of the delay to its deliver. The decay of the curve is described by the free parameter  $k$ , which is a measure of discounting. Higher  $k$  values represent higher sensitivity to delay or a greater tendency to choose impulsively.

Equation (2), was fit to the indifference points generated for the PD task:

$$V = A/(1 + hO) \quad (2)$$

Here,  $O$  represents the odds against receiving the larger reward  $[(1/p) - 1]$ , where  $p$  is the probability of receiving the large outcome. The free parameter  $h$  is the rate of discounting in which higher values represent a preference for more certain outcomes over less

certain ones. That is, steeper discounting of probabilistic rewards implies greater risk aversion while shallow discounting of probabilistic rewards suggests less risk aversion.

Analyses were conducted for each individual, and free parameter values for rates of discounting ( $k$  for delay discounting and  $h$  for probability discounting) were determined. Because outliers used in the  $k$  and  $h$  parameters typically generate highly skewed distributions, the non-parametric Mann–Whitney  $U$  test was used to compare  $k$  and  $h$  values by ranking scores for each participant and then comparing the ranking between groups. Area under the curve (AUC; Myerson, Green, & Warusawitharana, 2001) was also determined as an atheoretical measure of discounting for each outcome type for each participant.

Though the data we present in this paper is based on all respondents (i.e., all participants except those excluded for self-reported eating disorders), we also conducted analyses using only systematic responders. Johnson and Bickel (2008) presented an algorithm that is used for identifying non-systematic discounting data for a participant. This helps to identify participants who are careless responders or respond randomly to the choice questions. Because results were similar whether we used all responders or systematic responders only, we presented the data with all responders. However, we simply note that between 81 and 89% of our sample (depending on the discounting task) qualified as systematic responders.

Results

A total of 304 participants completed each discounting task. Seventeen participants endorsed one or more possible eating disorders within the past two years and were excluded from all analyses.

Fig. 1 shows median indifference points as a function of delay (left) and odds against receiving (right) for money (top) and food (bottom) for all responders. The curve provided a good fit to group median data across all discounting tasks as indicated by  $R^2$  values, which were all above 0.94. All  $R^2$  values were above 0.90 for group median data for systematic responders. There were strong, positive correlations among all discounting measures for both food and

**Table 1**  
Correlations between discounting measures using all responders.

Measure	1	2	3	4
1. AUC delay money	–			
2. AUC probability money	0.29***	–		
3. AUC delay food	0.23***	0.17**	–	
4. AUC probability food	0.14*	0.49***	0.27***	–

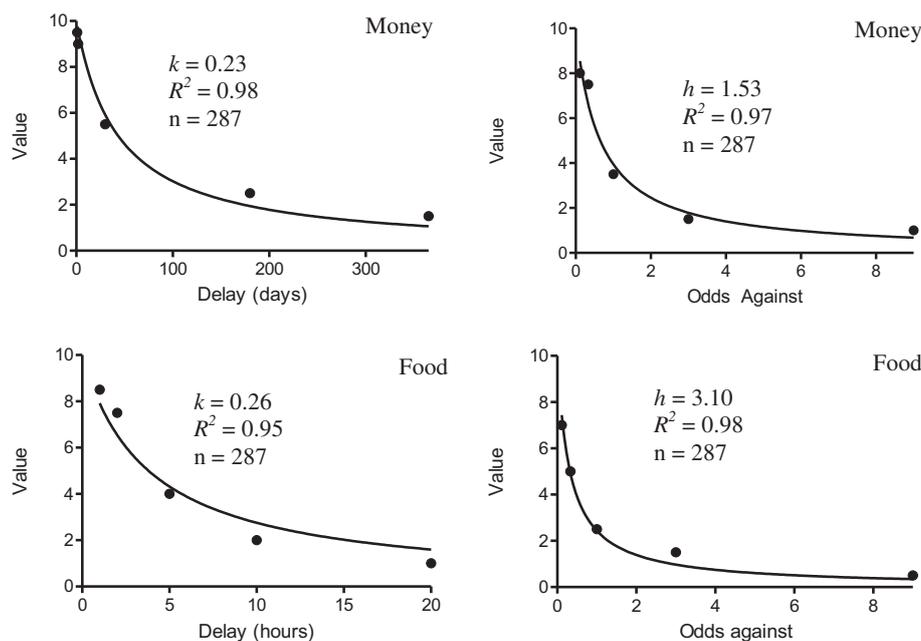
Note. \* $p < 0.05$ . \*\* $p < 0.01$ . \*\*\* $p < 0.001$ .

money ( $ps < 0.01$ ; see Table 1). Subjective hunger was also positively correlated with self-reported deprivation (i.e., hours since last snack,  $r = 0.19$ ,  $p < 0.01$ ; hours since last meal,  $r = 0.16$ ,  $p < 0.01$ ).

Table 2 presents the means and ranges for variables across the low and high quartiles for percent body fat for all responders. Participants in the low quartile group were significantly younger than those in the higher quartile group,  $t(174) = -4.71$ ,  $p < 0.01$ . There were also significantly more women in the highest quartile for percent body fat (91.6%;  $n = 66$ ) than those in the lowest quartile (31.9%,  $n = 23$ ),  $\chi^2(1) = 54.39$ ,  $p < 0.01$ . Participants in the low quartile also had a significantly higher estimated IQ than those in the high quartile,  $t(173) = 4.25$ ,  $p < 0.01$ . No other differences were found between groups.

Mann–Whitney  $U$  nonparametric tests confirmed that mean ranks of  $k$  values in the high quartile (PBF) was significantly greater than those in the lower quartile PBF for delay discounting for food ( $U = 1890.0$ ,  $p = .005$ ; high quartile PBF = 71.28, low quartile PBF = 52.57,  $U = 1315.50$ ,  $p = 0.04$ ). For probability discounting ( $h$  values) for food, the difference between high (78.40) and low (66.60) quartile body fat was not significant ( $p = 0.09$ ). For monetary outcomes, there were no PBF differences for  $k$  or  $h$  values.

Fig. 2 shows mean AUC values for money (left) and food (right) in the lowest and highest quartiles for PBF. Individuals in the high quartile for PBF had significantly steeper delay discounting for food compared to the low quartile,  $t(174) = 2.12$ ,  $p < 0.05$ . There were no significant differences with the food probability task. For monetary outcomes, there were no PBF differences for delay or probability AUC estimates.



**Fig. 1.** Median indifference values for delay (left) and probability (right) discounting for monetary (upper two figures) and food (lower two figures) outcomes. Best fit lines from the hyperbolic discounting function are included. Includes all responders.

**Table 2**  
Means (SEM) and ranges for variables across low and high quartiles for percent body fat for all responders.

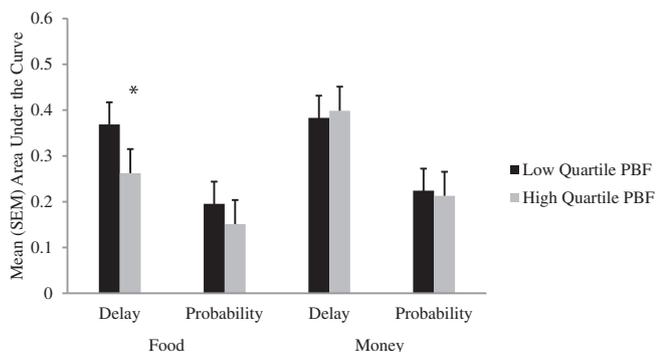
	Low quartile (bottom 25%)			High quartile (top 25%)		
	n	Mean (SEM)	Range	n	Mean (SEM)	Range
PBF	72	16.23(0.44)	4.3–21.0	72	41.66(0.43)	36.5–50.3
BMI	72	22.53(0.32)	17.1–28.8	72	32.50(0.58)	21.9–44.4
Current subjective hunger	72	54.24(2.78)	0–100	72	51.42(3.67)	0–100
Hours since last meal	72	8.77(1.21)	2–80	72	7.85(0.64)	2–20
Hours since last snack	72	5.75(0.52)	2–19	72	5.41(0.47)	2–16
Age	72	21.54(0.47)	18–34	72	27.11(0.99)	18–57
Estimated IQ	71	103.87(0.90)	85–120	72	98.28(1.00)	74–117
Smokers	5	–	–	12	–	–
Substance users	14	–	–	19	–	–
Females	23	–	–	66	–	–

Note. PBF = percent body fat; BMI = body mass index; IQ = intelligence quotient.

Because of a potential gender effect, we examined differences between men and women. Women had significantly higher percent body fat (PBF;  $M = 32.02$ ,  $SEM = 0.61$ ) than males ( $M = 21.18$ ,  $SEM = 0.86$ ), and males had a statistically higher (though, not clinically significant) estimated IQ. All other variables were similar across gender. A series of independent samples *t*-tests were also used to test differences of AUC estimates between men and women. There were no significant gender differences for either money or food in the delay and probability tasks. There were no significant differences in AUC estimates when BMI categories, specifically normal ( $BMI = 18.5–24.9$ ) vs. obese ( $BMI \geq 30$ ), were compared.

To further explore the relationship between gender and PBF in relation to discounting, AUC values for discounting tasks were compared in a series of independent sample *t*-tests using only women. Results indicated that there was a trend for delay discounting for food, such that women in the high PBF quartile group ( $M = 0.42$ ,  $SD = 0.28$ ) discounted food more steeply than women in the low PBF quartile group ( $M = 0.31$ ,  $SD = 0.25$ ),  $t(87) = 1.88$ ,  $p = 0.063$ . No other differences in discounting existed. There were no significant differences across time since last meal, time since last snack, or subjective hunger between the high and low quartile groups. Another series of independent sample *t*-tests were performed using only men. There were no AUC differences between males in the high and low PBF quartiles.

To determine if delay and probability discounting rates for food and money were orderly across the entire sample of participants (rather than just the upper and lower quartiles of PBF), a series of



**Fig. 2.** Mean ( $\pm$ SEM) area under the curve (AUC) estimates for food (left) and money (right) across tasks for participants in the low (black) and high (gray) quartiles for body fat percentage. Participants include all responders. \* $p < 0.05$ .

hierarchical multiple linear regression analyses were conducted. This established the unique variability that PBF and BMI contributed to the discounting rate. Due to significant co-linearity between PBF and BMI ( $r = 0.68$ ,  $p < 0.01$ ), PBF and BMI were placed in separate blocks. In the first regression, subjective hunger and estimated IQ were entered in the first step, since these variables were significantly correlated with discounting for food, along with PBF. BMI was entered in the second step. When delay discounting for food was the dependent variable, PBF was a significant predictor ( $b = -0.005$ ,  $p = 0.05$ ), BMI was not associated, and the entire model was significant,  $F(1, 281) = 10.93$ ,  $p < .0001$ . When probability discounting was used as the dependent variable, neither the model nor the variables were significant. In the second regression when BMI was entered in the first step and PBF was entered in the second step, results were similar. Next, monetary outcomes were examined, and only estimated IQ was a predictor of delay discounting, ( $b = 0.005$ ,  $p < .05$ ),  $F(1, 285) = 4.62$ ,  $p < .05$ .

When AUC estimates of discounting were correlated with the BIS self-report measure of impulsivity, no significant results were found.

## Discussion

### BMI, PBF, gender, and discounting

In the current experiment, participants completed delay and probability discounting tasks for hypothetical food and money. Consistent with previous discounting literature, choice patterns for money (e.g., Green, Fristoe, & Myerson, 1994; Green, Myerson, & McFadden, 1997; Kirby, 1997; Madden, Bickel, & Jacobs, 1999) and for food (e.g., Epstein, Dearing, Temple, & Cavanaugh, 2008; Odum et al., 2006; Rasmussen et al., 2010) were described well by the hyperbolic discounting function. Positive correlations among discounting measures were strong, which replicates other studies (e.g., Richards et al., 1999).

Overall, findings replicated and extended previous research regarding percent body fat (PBF) and its relationship to delay discounting for food in humans (Rasmussen et al., 2010). High-PBF participants had steeper discounting curves (higher  $k$  values) and lower area under the curve (AUC) estimates than did low-PBF participants for the delay discounting for food task. Rasmussen et al. (2010) reported stronger impulsive food discounting rates in individuals with high PBF with both delay and probability discounting tasks with 43 systematic responders; therefore we replicated this effect with a larger sample, and also controlled for other possible confounding variables, such as estimated IQ and previous liquid and food consumption. In the present study, PBF did not predict discounting patterns for money, which was also reported by Rasmussen et al. (2010). While we did not find PBF differences in the food probability discounting task in the present study using all responders, we did replicate it when we used systematic responders only,  $t(110) = 2.16$ ,  $p < 0.05$ . However, because  $k$  values did not differ between the two groups for the food probability task, we question the strength of this particular effect.

Gender differences were related somewhat to steeper discounting for food. There were more women in the higher PBF quartile than in the lower quartile, and women had higher PBF than men. However, no differences in discounting were found when men and women were compared. When women and men were analyzed separately to predict discounting patterns using a regression model, women with high PBF predicted a trend for steeper delay discounting for food than women with low PBF. Men did not show PBF effects, though that may be due to the low number of males in the study, and the very few in the high PBF category. As such, it is difficult to make a definitive conclusion about the role that gender plays, independent of the notion that women tend to have a higher percent body fat, which

may relate to their discounting rates for food. Some studies (e.g., Rasmussen et al., 2010; Weller et al., 2008) found that obese women had steeper discounting patterns than healthy-weight women; although, it appears that at least one of these studies included more proportionate gender samples in weight categories than the current study.

The present study, along with Rasmussen et al. (2010), found that weight status measures did not predict discounting for money. This contrasts with other studies that report monetary discounting differences in obese populations compared to healthy-weight population (Fields et al., 2011; Weller et al., 2008). Methodological differences may play a role in the different findings. For example, the amount and delay from the aforementioned studies (e.g., \$50,000 with up to 3600 days) differed from the current study (\$10 and a maximum of 365 days). The current study used PBF, while the other two used BMI and BMI percentiles. The current study did not find significant differences in terms of discounting patterns based upon BMI categories. However, the use of BMI rather than PBF has been criticized (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 (CDCP, 2011). PBF, on the other hand, accounts for these limitations by dividing an individual's total body fat by their total mass and is a more valid measure of body fat (Pi-Sunyer, 2002). When comparing the methodological differences among the present study, Rasmussen et al. (2010), Fields et al. (2011) and Weller et al. (2008), it may be the case that these procedural variants, in particular money amounts, played a role in the differences in results that were reported in each study, and these variants should be addressed in future studies. Regardless of this, across the four studies, impulsive choice in obese individuals was the common finding and is therefore suggested as a common process of decision making with obese humans.

#### *Other factors related to discounting*

Several other findings are worthy of mention. First, the low PBF quartile group comprised significantly younger participants than the high PBF quartile group, which is not surprising given that muscle mass (i.e., fat-free mass) generally declines, while percent body fat and fat mass tend to increase with age (Janz, 2004; Malina et al., 1996). Age, though, did not predict discounting patterns in the current study, as other studies have shown across the adult lifespan (Green, Myerson, Lichtman, Rosen, & Fry, 1996; Whelan & McHugh, 2009). This may be due to a restricted age distribution given the study population (i.e., undergraduate students). Second, subjective hunger, but not hours since time last meal or snack, significantly predicted delay and probability discounting for food. This is somewhat consistent with previous literature, which suggests that the rate of discounting changes in response to deprivation (e.g., Kirk & Logue, 1997; Ostaszewski, Karzel, & Bialaszek, 2004). While we did not induce deprivation for a standardized amount of time, it may be important to look at both standardized deprivation and current subjective hunger, and to explore the relationship between these variables and discounting patterns. Discounting tasks for money did not change based upon subjective hunger, hours since last meal, or hours since last snack. Taken together, it appears that increased subjective hunger may be associated with impulsive choices for food-related, but not monetary, outcomes. Third, estimated IQ as measured by the Shipley Institute of Living Scale (SILS), was a significant predictor of delay discounting for hypothetical food and money outcomes, but not probability outcomes. The latter finding is consistent with a meta-analysis by Shamosh and Gray (2008).

Taken together, the findings from Experiment 1 suggest that impulsive discounting patterns for food may be associated with obese weight status (i.e., PBF), which may implicate physical and

mental health consequences. It is important to address these behavioral problems and attempt to find behavioral strategies that may shift an individual's choice of a smaller, sooner reward to a larger, later reward. We experimentally tested a potential strategy that may change impulsive discounting patterns for food. Experiment 2 tested the extent to which a mindful eating strategy compared to a control condition would affect baseline discounting patterns for food and money.

## **Experiment 2**

### *Method*

#### *Participants*

One hundred two randomly selected participants ( $n = 73$  female) from Experiment 1 participated in the second experiment by returning to the laboratory within 21 days of their first session. The average interval between Session 1 and Session 2 was nine days. Each received course credit as compensation for their time. The average age of the participants was 25.46 ( $SD = 8.59$ ) years; 80.4% reported European–American ethnicity. All participants were asked to not eat or drink at least two hours before the experimental session to ensure consistency across experiments.

#### *Materials*

The “Learn Nutrition” (Standard Deviants, 2004) DVD was used in the control condition. The DVD describes the food pyramid and nutrition over the course of a 50-min segment and is typically used for high school and college fitness, health, and nutrition classes. Food items used for experimental and control groups included a choice of one item from each of the following four categories: fruit (blackberry or red grape), sweet (Hershey's<sup>®</sup> milk chocolate square or Reese's<sup>®</sup> Pieces), cracker (triscuit or wheat thin), and vegetable (baby carrot or piece of broccoli).

#### *Procedure*

Participants again completed the Subjective Hunger Questionnaire and were randomly assigned to either one of two experimental conditions: mindful eating or control. Participants assigned to the mindful eating condition completed a 50-min workshop on how to eat mindfully. In this group, three to four participants were placed in a 50-min workshop that used a modified exercise from Kabat-Zinn (1994)'s “Raisin Exercise”, which targets mindful eating. Participants learned about mindfulness as applied to eating behaviors (e.g., chewing slowly, examining the food carefully) by practicing exercises that include the following: Participants were asked to choose one type of cracker, one type of fruit, one type of vegetable, and one type of sweet that the experimenter set up at the beginning of the session. Next, one experimenter (Hendrickson) read a standardized script, which was presented in a slow, but deliberate pace. The script was timed for speed, such that each food sample received the same amount of time. During this mindful eating exercise, participants were instructed to attend to and record how the food felt in their mouths and how it smelled and tasted during the exercise, moment-by-moment. When observations (internal or external) arose, they were asked to observe them non-judgmentally, and if they noticed their attention drifting to thoughts other than the present moment, they were asked to return their attention to the present activity. Participants recorded their observations on a sheet of paper provided by the experimenter; however, the experimenter told the participants that there were no correct or incorrect answers. This exercise lasted approximately ten minutes for the first food sample, and was repeated for the other three food samples, totaling 40 min for the entire exercise. For the remaining ten minutes of the mindful eating

workshop, the experimenter led a discussion about the observations that the group made during their mindful eating, including the exercise's benefits (e.g., decreased caloric intake when eating slowly). The mindful eating workshop did not contain strategies for losing weight and no weight loss goals or strategies were set up. It was presented to participants as "having a more pleasant eating experience with your own decisions".

Participants in the control condition viewed a pre-selected, 50-min segment of the comprehensive nutrition DVD titled "Learn Nutrition". Participants chose food samples from the four food groups, similar to the mindful eating condition, except they were not given instructions on how to eat mindfully; they ate the food at their own pace. The food was given to control for food consumption during the treatment. The movie was not interactive, did not contain strategies for losing weight, and did not set up weight loss goals or strategies. The workshop was presented to participants as "everyday healthy eating and fulfilling the nutrition pyramid".

After completing one of the two workshops, participants completed the four discounting tasks again. These served as post-treatment measurements of delay and probability discounting.

### Analyses

Data were compared between groups (mindful eating vs. control) and within subjects (pre- and post-session) using mixed model ANOVAs on discounting AUC estimates for hypothetical food and money. The Wilcoxon signed-rank test, a non-parametric test for repeated samples, was conducted to examine median  $k$  and  $h$  values for pre- and post-sessions due to non-normal distributions.

### Results

Data were analyzed using eligible systematic and nonsystematic responders within each task. However, seven participants in total (5 from the mindful eating group; 2 from the control group), indicated having one or more possible eating disorders within the past two years and therefore were excluded from all analyses. Therefore,

data were analyzed using the remaining responders (total  $n = 95$ ; mindful eating  $n = 47$ ; educational video  $n = 48$ ).

A series of independent  $t$ -tests revealed that body mass status (PBF, BMI) demographic (age, gender, estimated IQ, smoking and substance use status) and dietary (e.g., current subjective hunger, hours since last snack or meal) data between mindful eating and control groups were not significantly different from each other. This was expected due to the random assignment to the two conditions. Across all participants, those in the mindful eating group averaged 8.92 ( $SEM = 0.71$ ) days between Session 1 and Session 2, while those in the control group averaged 9.45 ( $SEM = 0.82$ ), which was a non-significant difference.

Fig. 3 shows pre- and post-discounting curves for the control condition (left) vs. mindful eating (right) conditions for food discounting only. The curves fit the data well as  $R^2$  values were  $>0.95$ . For the delay discounting curves (top graphs), the Wilcoxon signed-rank test suggested that the median  $k$  values in the mindful eating group were significantly lower during the post-session (0.14) than the pre-session (0.25),  $Z = -2.94$ ,  $p = 0.003$ , suggesting less impulsive choice in the post-session. There was no median difference between pre- (0.25) and post- (0.30) session  $k$  values for the control group,  $Z = -0.98$ ,  $p = 0.34$ . For probability discounting for food (bottom graphs) median  $h$  values in the mindful eating group were significantly lower during the post-session (1.30) than the pre-session (2.53),  $Z = -3.86$ ,  $p < 0.001$ . There was no median difference between pre- (3.09) and post- (3.10) session  $h$  values for the control group,  $Z = -0.87$ ,  $p = 0.39$ . There were no pre- and post-treatment differences or mindfulness vs. control differences for the money conditions.

Fig. 4 shows mean AUC values for pre- and post-session delay discounting for food (upper left) and money (lower left) and probability discounting for food (upper right) and money (lower right) by condition. For delay discounting for food, results showed no main effects of session (pre- vs. post-) or condition (mindfulness vs. control), but a statistically significant interaction was found between session and condition,  $F(1, 93) = 5.71$ ,  $p = 0.02$ ,  $\eta_p^2 = 0.06$ . A series of paired samples  $t$ -tests showed that the difference

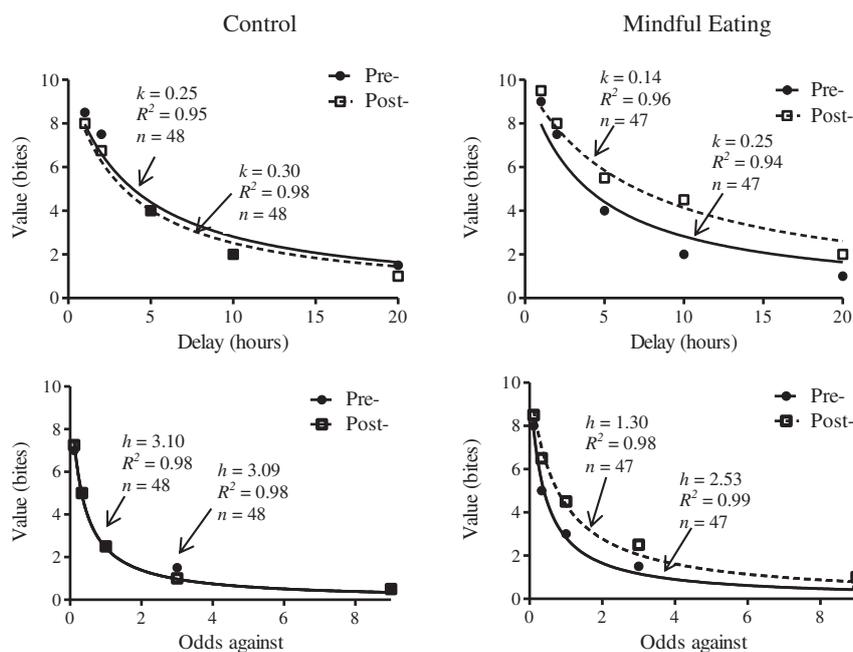
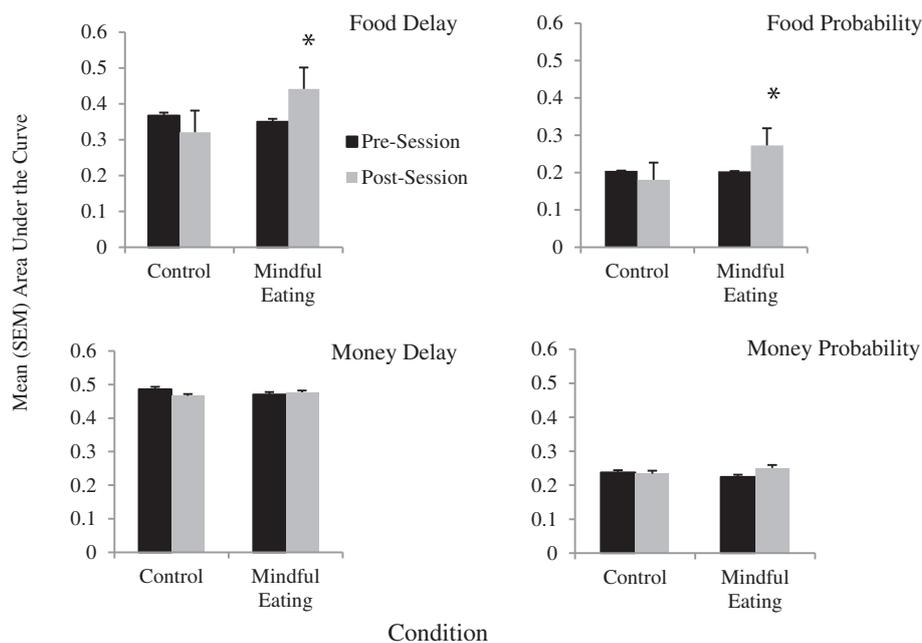


Fig. 3. Median indifference values as a function of delay (upper figure) and odds against receiving (lower figure) for food outcomes for control (left column) and pre- and post-mindful eating training (right column) conditions. Fit lines represent best fit of hyperbolic discounting function. Includes all responders.



**Fig. 4.** AUC estimates for delay discounting for food (upper left) and money (lower left) and probability discounting for food (upper right) and money (lower right) by condition. Participants in the control condition are depicted in black; participants in the mindful eating condition are in grey. Includes all responders. \* $p < 0.05$ .

between AUC values in the pre- and post-test was significant for those in the mindful eating group,  $t(34) = -2.12, p < 0.05$ , but there was no change in the control condition. For probability discounting for food, a significant interaction was also found between pre- and post-test and condition,  $F(1, 93) = 5.10, p < 0.05, \eta^2 = 0.05$ . A series of paired samples  $t$ -tests confirmed that the difference between pre- and post-test AUC probability discounting values for food was significant for those in the mindful eating group,  $t(34) = -2.88, p < 0.01$ , but there was no change in the control condition. There were no differences between groups for AUC estimates for money under delay discounting. There were also no changes in pre- and post-treatment phases when money was used.

Given that discounting patterns for food changed in the mindful eating condition and not the control condition, we investigated whether PBF or BMI status played a role in this shift. We conducted a series of mixed model ANOVAs, and results indicated main effects for condition (mindfulness vs. control) regardless of PBF quartiles for delay,  $F(1, 87) = 5.96, p < 0.05$ , and probability tasks,  $F(1, 87) = 4.64, p < 0.05$ . A similar pattern was found despite BMI status for delay,  $F(1, 88) = 3.56, p = 0.06$ , and probability,  $F(1, 88) = 3.69, p = 0.058$ . This suggests that only mindful eating training influenced changes in discounting patterns, regardless of PBF or BMI status.

### Discussion

In this experiment, we examined the extent to which a brief mindfulness-based eating training session would alter discounting patterns for hypothetical food and money. Participants completed a mindful eating training session or watched a segment from an educational DVD about nutrition and the food pyramid within a timespan that was within three weeks (but, on average, nine days) of their baseline discounting patterns. Both conditions were equal in duration and participants in each group were given an equivalent amount of food to eat during their sessions. The only factor that differed between groups was whether they participated in the mindfulness exercise or whether they watched a DVD on nutrition.

Individuals who participated in the mindful eating session discounted delayed food-related outcomes less steeply (i.e., had lower  $k$  values) and had higher AUC values compared to their baseline rates, suggesting a more self-controlled pattern of responding after the training. They also exhibited less risk-averse probability discounting (i.e., lower  $h$  values) and higher AUC values for food, suggesting preference for less certain food outcomes. The control group did not exhibit differences in discounting in any of the tasks. This novel finding is the first to show that mindfulness can affect discounting patterns, at least temporarily, for food in a laboratory setting.

There was no change in discounting patterns for either group with regard to monetary outcomes, suggesting that mindfulness training for food specifically affected food-related decisions and not a more global impulsive choice pattern that extended to money. One interpretation of this effect is that mindful eating strategies change discounting patterns that are specific to food stimuli. Previous research has also demonstrated stimulus-specific results with other populations, including steeper discounting of heroin among individuals with opioid dependence (Madden et al., 1997; Odum, Madden, Badger, & Bickel, 2000), cigarettes among individuals who smoke cigarettes (Bickel, Odum, & Madden, 1999; Mitchell, 1999), alcohol among individuals who drink heavily (Petry, 2001), and erotica among those who regularly view erotica material (Lawyer, 2008). This is consistent with the notion that more experience with an outcome may influence its value.

Importantly, individuals who watched the educational DVD on the food pyramid and nutrition did not exhibit changes in discounting compared to their baselines in the food- or money-related tasks. This type of control group was chosen because it related to food and information about food was conveyed through verbalization, which is similar to the mindfulness training. It did not, however, provide instruction on eating and attending to cues inside the body, as the mindfulness training did. While we did not include a third group that did not receive any treatment at all to compare to our other two groups, the control group may add support to the test-retest nature of discounting. A number of studies show that

money discounting is a relatively stable pattern of behavior in humans (Baker, Johnson, & Bickel, 2003; Lagorio & Madden, 2005; Simpson & Vuchinich, 2000). In our control group, pre-test discounting predicted post-test discounting significantly for delay ( $r = 0.77$ ) and probability ( $r = 0.45$ ) money tasks, while also across the two food tasks for delay ( $r = 0.41$ ) and probability ( $r = 0.35$ ;  $ps < 0.05$ ). This suggests that test-retest reliability of discounting in our study was at least moderately stable in the control group, though we cannot be certain, as the educational training video may have assisted in stabilizing the data in some manner. Although practice effects may have influenced the data in some manner, the lack of difference in the pre- and post-test data of the control group suggest that it would be minimal. Future research may want to examine test-retest discounting patterns with hypothetical food without any additional components (such as the educational DVD or mindfulness), since no prior studies have demonstrated reliability of delay discounting food-related outcomes.

Interestingly, percent body fat (PBF) and body mass index (BMI) did not predict the mindfulness-induced change in discounting patterns. Therefore, mindful eating training may be helpful as a preventative measure and as an intervention strategy to help decrease impulsive food choice behavior in individuals across a variety of weight statuses. Most interventions target overweight and obese individuals, but it seems that teaching even healthy-weight individuals about mindful eating and having them practice strategies may be advantageous.

These results add to other studies focused on using mindfulness-based strategies for obese populations (Alberts et al., 2010; Forman, Butryn, Hoffman, & Herbert, 2009; Lillis et al., 2009; Singh et al., 2008). The current study was different from these, however. Most of these studies, for example, were conducted as treatment studies with different goals; the current study was a laboratory study with no treatment goals. Also, in the other studies, mindfulness training took place for weeks to years; the current study used a 50-min training session. Nonetheless, the current study demonstrates that mindfulness does indeed play a role in changing impulsive food choice patterns at least temporarily, such that individuals tend to be less impulsive and less risk averse after a brief mindful eating training.

## General discussion

The current study extended and replicated previous research by showing that percent body fat (PBF) predicted discounting patterns for hypothetical food, but not lower-value (i.e., \$1 to \$10) money. It also made a novel contribution to obesity and discounting literatures by demonstrating that with mindfulness training, discounting patterns could be changed at least momentarily for food, but not money, across individuals of various body fat percentages.

The current study contains limitations that should be addressed in future research. Hours since last meal and snack and subjective hunger were self-reported. Future research could attempt to incorporate more objective methods, such as blood glucose analysis, instead of relying on participants to estimate the time since their last meal and snack. In addition to this, while our body fat measure by bioelectrical impedance analysis (BIA) is a valid and noninvasive measure of body composition, there has been a reported trend for larger error in larger-mass obese individuals. Specifically, BIA tends to overestimate fat-free mass in individuals whose body fat is greater than 42%, as compared to underwater weighing (Duren et al., 2008; Gray, Bray, Gemayel, & Kaplan, 1989). A hydrostatic (underwater) method may be more accurate, because it measures an individual's entire body density by determining body volume.

For food choice outcomes, the current studies used hypothetical outcomes. However, differences between the utilization of hypothetical, potentially-real (where the participant receives one or more randomly selected choices), and real food rewards should be examined. Literature on money rewards suggests that these three methodologies do not differ with respect to discounting patterns (e.g., Bickel, Pitcock, Yi, & Angtuaco, 2009; Johnson & Bickel, 2002; Lawyer, Schoepflin, Green, & Jenks, 2011), but this has yet to be explored using food rewards. Similarly, magnitude effects may also be important to examine, as the current study only used small magnitude ranges (1–10 bites). Lastly, although the current food discounting paradigm may not have incorporated all aspects of food decisions, it models important types of food choices made daily. For example, individuals may choose between a quick, ready-to-eat snack when arriving home from work or waiting for a larger, prepared meal (i.e., dinner) later. This paradigm incorporates food choices that may be more realistic than larger rewards (e.g., dozens of slices of pizza) and larger time frames (e.g., months) used in other discounting paradigms (e.g., Odum & Rainaud, 2003), which may be more relevant to large-scale menu plans versus moment-to-moment food choices that people make daily (see Wansink, 2006).

In terms of follow-up data, the current study did not measure discounting patterns after Session 2 when the mindful eating training was completed. Although we saw at least temporary changes in discounting patterns for food, it would be useful for researchers and clinicians to determine how many mindful eating training sessions are necessary to exhibit longer lasting results and how long those results last. It appears that research incorporating mindfulness with special populations (e.g., cardiac patients, individuals with eating disorders) with a focus on eating or containing a mindful eating component typically lasts at least 6 h (e.g., Lillis et al., 2009), but utilizes between 4 and 12 treatment sessions (90–120 min per session; e.g., Goodwin, Forman, Herbert, Butryn, & Ledley, 2012; Tapper et al., 2009). It may be beneficial to conduct and compare various lengths of treatment using mindful eating behavioral strategies and with various populations, as this study was based on an undergraduate population that may not be generalizable.

Because of the strong test-retest effects observed across a variety of settings (Baker et al., 2003; Lagorio & Madden, 2005; Simpson & Vuchinich, 2000) and the strong correlations observed among discounting tasks, discounting may reflect a stable pattern of responding, or even a personality trait (see Odum, 2011 for review). However, the present data suggest that food discounting patterns can be shifted, at least temporarily, with mindfulness training. Previous scientific work has also suggested that discounting patterns can be changed using neurocognitive methods, e.g., working memory training (Bickel, Yi, Landes, Hill, & Baxter, 2011). It may be the case that future research should focus more on implementing independent variables that may influence discounting.

Using discounting as an outcome measure of eating behavior may shed light on possible intervention and prevention strategies for those with maladaptive behaviors, such as impulsive eating, which may lead to obesity. It also brings about questions regarding causality about impulsive food choice behavior – do individuals become overweight or obese due to discounting patterns of impulsive food choice or does being overweight or obese affect this pattern, or both? Whatever the case may be, it appears that behavioral strategies to decrease an individual's sensitivity to delay and risk-aversion may be advantageous to one's health.

While being aware of food stimuli and eating behaviors may be a behavioral treatment for obesity, it is important for future research to examine what mechanisms of mindful eating are most effective at creating changes in behavior. It may be that individuals are able to better accept their feelings (e.g., urges) for the more immediate

food rewards in order to receive the larger, later one. It also may be that eating slowly and noticing physical sensations (e.g., a small increase in satiety) decreases impulsive decision making for food. Although the current study represents a first attempt to use an explicit and brief mindful-eating training session to change impulsive food choice decisions, an experimental analysis of mindful eating will allow scientists and clinicians to utilize this technique in a more effective manner.

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