Mindfulness
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ORIGINAL PAPER

Acute and Enduring Effects of Mindful Eating on Delay and Probability Discounting for Food and Money in Food-Insecure Women

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Abstract

Objectives Mindful eating (ME) reduces impulsive choice for food, which has implications for obesity. However, its impact on individuals with economic disadvantage and a higher risk for obesity, such as those with food insecurity, has not been evaluated. This study determined the effects of ME in this population.

Methods Women with food insecurity ($n = 117$) were recruited from a community sample. They completed baseline measures of food and money delay discounting (assesses impulsivity) and food and money probability discounting (quantifies sensitivity to risk aversion). In a second session, participants were randomized to one of three groups and exposed to either an acute 50-min ME training, a 50-min DVD on nutrition, or a control condition. Discounting was measured post-session for acute effects of each condition. Participants in the ME group were then instructed to practice ME for 1 week. At the 1-week follow-up, discounting was measured again for all three groups.

Results Results revealed that acute ME and an extended ME practice increased delay discounting for food and money relative to baseline. ME also increased risk aversion for food and money at the 1-week time point. Neither the DVD or control conditions affected food or monetary discounting at any time point.

Conclusions These results suggest that for women with food insecurity, ME's effects shift decision-making processes regarding food and money to a more "survival mode" pattern in which more immediate and risk-averse choices are preferred over larger, less immediate, and uncertain ones

Trial Registration. ClinicalTrials.gov #NCT02930642.

Keywords Delay discounting · Food Choice Questionnaire · Food insecurity · Mindful eating · Mindfulness · Probability discounting

Food insecurity (FI) refers to limited, inconsistent access to nutritious foods that meets dietary needs due to economic or physical barriers (e.g., Martin & Ferris, 2007; Pan et al., 2012). Currently in the USA, about 30 million adults and 12 million children have FI (United States Department of Agriculture, 2021). Households with children report an almost doubling of the likelihood of FI (USDA, 2020), and households headed by single women also are at greater risk for FI (Pan et al., 2012, USDA, 2020).

Food insecurity is associated with obesity and its related health problems; women with FI, especially those of color, are at even greater risk for obesity (Martin & Ferris, 2007; Pan et al., 2012; USDA, 2020). One of the reasons for this has to do with the affordability and consumption of processed foods that are higher in refined carbohydrates, as these foods are less expensive than fresh fruits and vegetables and lean meats (e.g., Darmon & Drewnowski, 2015; Drewnowski, 2004). Experimental studies, though, have shown that food that is high in refined carbohydrates, especially sugars and fats, blunts reward processes which makes it more likely for their consumption to increase (Boomhower et al., 2013; Johnson & Kenny, 2010; Pritchett & Hajnal, 2011).

In addition to diet, FI may also implicate other aspects of food reward. Delay discounting (DD) is a process that is related to decision making for delayed rewards or outcomes

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(Ainslie, 1975; see Madden & Bickel, 2010). Typically with DD studies, individuals are presented with a series of choices between smaller, sooner amounts of money ($100 now) vs. larger, delayed amounts of money ($500 in 3 months). Preferences for the more immediate reward are described as impulsive while preferences for the larger, later outcome are described as self-controlled. Other outcomes, such as food, also have been used to examine delay discounting processes. When given choices between smaller, more immediate vs larger, delayed amounts of food, women with FI tend to show stronger preferences for the smaller, more immediate food outcomes compared to women with food security (Rodriguez et al., 2021). It makes intuitive sense for people with FI to prefer more immediate food rewards as temporal windows may be shorter in these circumstances; i.e., low access to food may activate strategies for survival now as opposed to planning for the future. However, a drawback for a "survival mode" situation is that preferences for immediate outcomes can make one more vulnerable to long-term health problems, such as substance abuse or obesity—conditions in which preferences for immediate outcome such as drugs and unhealthy food, respectively, may outweigh the long-term benefits of good health (see Bickel et al., 2019; DeHart et al., 2020).

Importantly, obesity is also related to delay discounting (see meta-analysis by Amlung et al., 2016). Studies show that obesity status predicts impulsive choice for food (Hendrickson et al., 2015; Rasmussen et al., 2010) and monetary outcomes (e.g., Jarmolowicz et al., 2014; Weller et al., 2008; see also Amlung et al., 2016, for meta analysis). Therefore, delay discounting may also be related to food insecurity by way of obesity—either as a process that is directly associaed with food insecurity or indirectly as a process that is related to obesity, which is also related to food insecurity, or both.

Embedded in waiting for a delayed outcome is the notion that the longer the delay, the less likely that the outcome may be delivered. Studies using probability discounting (PD), in which choices between smaller, more certain, and larger, less certain outcomes are arranged, show that obese individuals are more risk averse (less risky) when it comes to food-related outcomes compared to healthy-weight individuals (Rasmussen et al., 2010). This is not surprising, given that probability (sensitivity to risk of uncertain events) and delay discounting (sensitivity to delayed events), though independent processes (e.g., Green & Myerson, 2010; Green et al., 2014; Richards et al., 1999), may be a joint part of many decisions (see, e.g., Vandervelt et al., 2015). For example, often people consider the choice of less healthy, but inexpensive food (refined carbohydrates) now with a higher chance of weight gain in the future vs. healthy, more expensive food (such as fruits and vegetables) that will lead to a lower chance of weight gain in the future. While little, if any, research to date is published on the relation between FI and risk aversion for food, understanding this process may be useful in understanding health-decision making that occurs under conditions of FI. In addition, targeting discounting processes in a FI female population may have benefits that relate to reducing the risk of obesity.

Mindfulness-based treatments have been shown to effectively manage and treat a variety of behaviors related to mental health, such as stress (e.g., see Kriakous et al., 2021 and Morton et al., 2020 for review and meta-analysis) and depression- and anxiety-related symptoms (e.g., Evans, 2016; Song & Lindquist, 2015; Zhou et al., 2020). Some instructional components of mindfulness-based strategies reduce delay discounting, i.e., shift preferences from the smaller, more immediate reward to the larger, more delayed reward. Indeed, a study by Morrison et al. (2014) found that impulsive choice as assessed by DD for monetary outcomes was reduced by a brief, focused acceptance and commitment therapy (ACT) intervention, which targeted acceptance of internal experiences (a component of mindfulness) compared to control conditions. Another study by Dixon et al. (2019) showed that a 5-min mindfulness-based instructional training reduced monetary discounting compared to baseline and a control group. In addition, mindfulness paired with reality therapy reduced monetary delay discounting in a sample diagnosed with internet gaming disorder (Yao et al., 2017).

Mindful eating (ME) is a mindfulness-based exercise geared specifically toward the act of eating. With ME, individuals are trained to eat slowly while being non-judgmentally attentive to the sensations of tasting, chewing, and swallowing food (Nelson, 2017; Zettle, 2007). This process slows the pace of eating and increases awareness of the amount, quality, and quantity of the food that is eaten, as well as interoceptive stimuli that are related to appetite and satiety, which ultimately may lead to a reduction in food intake (Scisco et al., 2011; Warren et al., 2017).

A 50-min ME training, which includes attentional focus on the act of eating, as well as labeling intereoreceptive and exteroreceptive experiences of eating, reduced DD for food compared to baseline DD levels in adults (Hendrickson & Rasmussen, 2013) and adolescents (Hendrickson & Rasmussen, 2017); those in 12 groups were unaffected. This was the case for two different delay discounting tasks—the computerized adjusting amount procedure (Hendrickson & Rasmussen, 2013) and the Food Choice Questionnaire (Hendrickson & Rasmussen, 2017). Interestingly, in both of these studies with both types of measures of food discounting, ME specifically reduced DD for food-related outcomes, but had no effect on monetary outcomes, as measured by a computerized adjusting amount procedure (Hendrickson & Rasmussen, 2013) and the Money Choice Questionnaire (MCQ). This domain-specific effect (see Holt et al., 2016)

supports that only food-related impulsivity may be affected by ME, as opposed to general levels of impulsive choices.

While relatively little research has been conducted on mindful eating compared to general mindfulness-based strategies, it might be assumed that mindful eating would be efficacious for most people. However, it should be mentioned that though mindfulness-based strategies in general have a substantial amount of support for efficacy, there are some individuals who do not respond therapeutically to them. For example, individuals who have high self-awareness, especially in response to acute stressors like health challenges, are more likely to respond to mindfulness-based strategies with adverse effects, such as greater depression and anxiety; those with high body awareness (sensitivity to interoreceptive cues) and high threat cue responsiveness may also show similar effects (e.g., Britton et al., 2021; Johnson et al., 2016; Reynolds et al., 2017; Sahdra et al., 2017; see Galante et al., 2021 for meta-analysis). Therefore, for some individuals with specific circumstances, mindfulness-based strategies might be counter-indicated. This too may hold for mindful eating—rather than assuming mindful eating might affect behavior similarly with everyone, it may make sense to test the extent to which it will work on individuals with special circumstances, especially those related to stress.

Though ME has been used as a strategy for weight control and to reduce emotional eating (see Fuentes et al., 2019; Sarto et al., 2019), ME has not yet been applied to decision making, such as delay and probability discounting, in populations that are at risk for obesity, such as those with FI. The current study was designed to test the efficacy of ME as a strategy that may affect DD and PD in women who are FI and therefore at risk for obesity. The current study also expanded on previous studies of ME by attempting to replicate acute (50 min) effects of ME, but also examined more enduring effects of ME by expanding the 50-min ME training to a week-long practice. Based on previous research, we hypothesized that an extended mindful eating strategy would reduce impulsive choice for food, but not money, compared to control conditions. We also hypothesized that ME would decrease risk aversion with food, but not affect money, compared to control conditions, similar to results found in Hendrickson and Rasmussen (2013).

Methods

Participants

Participants were recruited from the greater southeastern Idaho area from local food pantries, community fliers, and social media ads. Interested participants completed a brief pre-screening interview either in person or over the phone to determine eligibility prior to enrollment. A participant was eligible if she identified as a woman, was ≥ 18 years of age, was proficient in English, and met the criteria for food insecurity (score of 3 or more on the 18-item US Household Food Insecurity Survey Module; Bickel et al., 2000; USDA, 2012). Participants were excluded if they endorsed a current or previous eating disorder diagnosis or current pregnancy, as these factors may influence food reward and therefore could influence performance on the food discounting tasks. Those with hemophilia or HIV-positive status were also excluded to reduce risk to participants and researchers during blood sample collection.

To determine sample size, an a priori power analysis assuming a mixed model (3 × 3) was conducted using G*Power. An effect size = 0.15, an alpha = 0.05, and power = 0.85 yielded a sample size of 120 (40 in each group).

Demographic information for the total sample, and by group, is presented in Table 1.

All women who enrolled and participated in the study met the criterion for food insecurity, as defined by a score of 3 or greater on the 18-item USDA Food Security Module. The average score was over 5.5, which is a value between the categories of low food security (3–5) and very low food security (6–10) (Bickel et al., 2000; USDA, 2012). Importantly, 42% of the sample had annual incomes below $10,000. Most of the sample was middle age (*M* age = 45.5 years), white (80%), and of average intelligence (*M* SIS-R3 score = 93.78). Approximately 40% of the participants were not married. Importantly, mean percent body fat and BMI exceeded the thresholds for obesity for women (PBF > 35%; DeLorenzo et al., 2003 and BMI > 30; CDC, 2021). Participant consumption of fruits, vegetables, and fiber per day was in the lowest category (< 4 per day) of the BFFS. Consumption of dietary fat was in the very high category (23.32). Mean scores from the PSS suggest that stress levels were approximately 20, which is within the moderate range (14–26) of the Perceived Stress Scale (Cohen et al., 1983) and consistent with the relation between stress and FI (see meta-analysis by Arenas et al., 2019). Participants also reported low levels of alcohol consumption, smoking, vaping, and drug use.

Across the three treatment conditions, there were no differences across most demographic and health variables. Some exceptions follow. Significant differences in percent body fat were observed between treatment conditions [$F(2,72.42) = 3.82$, $p = 0.03$]. Participants in the mindful eating (ME) group had higher percent body fat than participants in the control groups ($p = 0.03$); there were no differences between the ME and DVD groups or the DVD and control groups. There were also group differences in the consumption of dietary fat [$F(2,112) = 3.03$, $p = 0.05$]. Those in the DVD group reported higher dietary fat compared to those in the ME ($p \leq 0.05$), but not control, group; there were no differences in the ME and control conditions. While the overall

Table 1 Participant demographic and health information

	Total $N=113$ M(S.E.)	Control $n=36$ M(S.E.)	DVD $n=40$ M(S.E.)	Mindful Eating $n=37$ M(S.E.)	p
Age	45.54 (1.31)	45.44 (2.48)	42.18 (2.27)	49.26 (1.94)	0.08
%White[#]	79.6%	86.1%	72.5%	81.1%	0.65
%Single[#]	39.8%	33.3%	30.0%	56.8%	0.11
SIT-R3	93.78 (1.13)	92.78 (2.08)	95.31 (1.85)	93.08 (1.96)	0.60
Food Security Tot	5.53 (0.25)	5.69 (0.37)	5.50 (0.49)	5.41 (0.39)	0.68
Income < $10,000	41.6%	47.2%	30.0%	48.6%	0.17
Paid within past 2 weeks	54.1%	55.9%	62.5%	42.9%	0.23
Weight (kg)	88.31 (1.97)	81.49 (3.07)	90.53 (3.65)	92.53 (3.22)	0.05*
PBF	41.93% (0.88)	39.95% (1.34)	41.09% (1.79)	44.79% (1.21)	0.03*
BMI	33.72 (0.80)	31.05 (1.21)	34.90 (1.54)	35.03 (1.26)	0.07
Fagerstrom total	1.36 (0.19)	1.30 (0.31)	2.09 (0.29)	1.80 (0.36)	0.17
Fagerstrom Vape	0.50 (0.14)	0.45 (0.21)	0.18 (0.13)	0.89 (0.35)	0.08
DAST-10 total	1.87 (0.20)	2.15 (0.42)	1.90 (0.32)	1.56 (0.26)	0.77
AUDIT-10 total	1.40 (0.18)	1.17 (0.25)	1.65 (0.35)	1.37 (0.30)	0.75
Perceived stress	19.63 (0.56)	20.29 (1.07)	19.75 (0.89)	18.87 (0.99)	0.59
BFFS fruit/Veg	11.81 (0.46)	11.83 (0.72)	12.60 (0.84)	10.95 (0.81)	0.34
BFFS dietary fat	23.32 (0.78)	22.64 (1.35)	25.78 (1.44)	21.32 (1.17)	0.05*
Blood glucose (mg/dL)	103.03 (1.34)	101.81 (2.74)	103.27 (1.94)	103.96 (2.33)	0.81
Subj. hunger	33.31 (2.72)	32.39 (4.98)	37.31 (4.26)	29.87 (4.95)	0.52
Baseline FCQ [sqrt]	0.54 (0.02)	0.58 (0.04)	0.54 (0.04)	0.61 (0.04)	0.42
Baseline MCQ [lg10]	0.03 (0.00)	0.04 (0.01)	0.03 (0.01)	0.03 (0.00)	0.32
Baseline PFCQ [lg10]	0.66 (0.05)	0.56 (0.12)	0.79 (0.07)	0.60 (0.09)	0.19
Baseline PMCQ [lg10]	0.48 (0.05)	0.38 (0.09)	0.50 (0.09)	0.55 (0.08)	0.39

*$p \leq 0.05$. [#]Largest group by percentage; *S.E.*, standard error; *PBF*, percent body fat; *BMI*, body mass index; *DAST-10*, Drug Abuse Screening Test—Version 10; *AUDIT-C*, Alcohol Use Disorders Identification Test—Version C; *BFFS*, Block Food Frequency Screener; *FCQ*, Food Choice Questionnaire; *MCQ*, Money Choice Questionnaire; *PFCQ*, Probability Food Choice Questionnaire; Probability Money Choice Questionnaire

ANOVA indicated significant differences in weight between treatment conditions [$F(2,112) = 3.00$, $p = 0.05$], post hoc analyses revealed no significant differences between groups. Because there were group differences across the three groups for weight, PBF, and dietary fat intake, these variables were controlled statistically as potential confounds in analyzing differences in all baseline discounting data; when controlled statistically, none of these variables had an effect on discounting variables.

Procedures

All procedures were conducted under the auspices of the Idaho State University Institutional Review Board. Participants that met inclusion criteria completed three sessions. They were invited individually to an office-size room at a local university or at one of two local food pantries. Participants were asked to not eat or drink at least 2 h before each session to control for immediate hunger. The methods for sessions 1 and 2 were conducted in a manner identical to those described in Hendrickson and Rasmussen (2017), except for the addition of measures of food insecurity and diet quality.

Session 1: Baseline

After participants were consented, a research assistant conducted an additional brief interview to confirm eligibility status, and then the Subjective Hunger Questionnaire (SHQ) was administered. If the participant reported eating food or drinking any liquid within the 2-h window before the session, she was rescheduled. In addition, blood glucose samples were obtained to ensure the participant had not eaten before the session. If a participant had a high blood-glucose session after re-scheduling it was noted and they were asked to seek a medical consultation in case blood glucose-insulin regulation was disrupted, but were allowed to continue in the study. Across the three conditions, four individuals met this set of conditions (1 in 12, 2 in DVD, and 1 in mindful eating), but their data for discounting were not statistically

different from those whose blood glucose was within the normal range. In addition, mean blood glucose rates across each group did not differ (see Table 1).

After blood glucose was determined, the Slossen Intelligence Test (SIT-R3) was administered. Then, the participant completed the four baseline discounting measures in random order on a laptop: Probability Food Choice Questionnaire (PFCQ), Probability Monetary Choice Questionnaire (PMCQ), Food Choice Questionnaire (FCQ), and Monetary Choice Questionnaire (MCQ). Then, she completed the substance use measures, Perceived Stress Survey, Block Food Frequency Screener (BFFS), and additional demographic information was obtained. Finally, biometric information was collected. Each participant who completed this session received $15 immediate cash for compensation and was rescheduled within 14 days for the second session. She was reminded to not eat or drink anything 2 h before the next session. Each participant was then randomized to one of three groups: mindful eating, nutrition DVD control, or a no-intervention control condition. Randomization was determined at the level of study (not site). Participants were not told to which group they were assigned.

Session 2: Treatment

At the beginning of session 2, researchers administered the SHQ. Then, a blood glucose test was given to the participants to ensure food deprivation. After blood glucose was determined, depending on group assignment, participants completed the following procedures:

Mindful Eating (ME) To examine acute effects of ME, participants assigned to this condition first individually completed a ME workshop that was similar to that described in Hendrickson and Rasmussen (2013) and Hendrickson and Rasmussen (2017). Briefly, they chose one small amount of food from four food categories (a total of four foods): a fruit (e.g., strawberry), a small vegetable (e.g., carrot), a cracker, and a sweet (e.g., Hershey's® chocolate square). Then, a researcher led them in a 50-min mindful eating procedure, a modification of the "raisin exercise" (Kabat-Zinn, 1994). Here, the participants were instructed to eat each food individually and while doing so, deliberately attend to physical features of the food (sights, smells, tastes, texture, etc.) and their physiological responses (e.g., salivation, feeling fuller) to them in an objective manner. Participants wrote down their observations to ensure the researchers that the exercise was followed. Each food took approximately 10 min to eat (40 min total). The final 10 min was used to discuss what the participant noticed during the exercise and how this differed from their usual eating behavior. More detail on the ME exercise can be found in Hendrickson and Rasmussen (2013). After the ME exercise, participants completed the four discounting tasks in random order (FCQ, MCQ, PFCQ, and PMCQ) as acute post-treatment measures. They were compensated for their time ($15), given instructions for the week-long subsequent part of the study, and scheduled for their last session.

Extended ME After the second session was complete, participants in this group practiced the ME strategy twice per day for 1 week to determine the extent to which a daily ME practice may affect discounting. A text message was sent to participants twice a day around times in which the participants reported typically eating, reminding them to mindfully eat. Participants were asked to text back a description of their mindful eating observations; at least 2–3 statements had to be written that were objective descriptions of their eating experience ("I noticed the red color of the food," "The smell of the food made my mouth water," "I had the thought 'I want to eat quicker'"). Participants were also provided with a handout to remind them of the tenets of mindful eating as examples of objective eating statements. Text descriptions that met these criteria were rewarded with cash monetary compensation ($3/text), which would be collected at the last session. Participants received feedback of their monetary compensation per text (i.e., "You have earned $3 for this text message.") within 60 min of being received by the research associate. A participant could earn up $6 per day for 7 days, so a total of $42/week.

DVD Control Condition (DVD) Participants assigned to this condition were given the four foods (similar to the ME condition) in the second session, except they were free to eat them however they wished during the session. They were also asked to view a 50-min segment of the DVD "Learn Nutrition" (Standard Deviants, 2004), which describes healthy eating content, such as nutrients, the food pyramid, calories, and metabolism. This condition controlled for the presentation on food-related content and was a passive exercise, compared to the activity required in the ME condition. After the DVD session was complete, participants completed the FCQ, MCQ, PFCQ, and PMCQ in random order as acute post-treatment measures. They were compensated for their time ($15), given instructions for the week-long next part of the study, and scheduled for their last session.

Extended Condition for DVD Group After the second session was complete, participants in this group were asked to respond to text messages that were sent by the researchers twice a day around the times in which they would be most likely to eat, in which a statement about the content from the Learn Nutrition DVD was presented. Participants were asked to text back a single word or letter choice (True or False; A, B, or C) to these texts. For example, "How many basic nutrients are there? 3? 6? 10?" or "Lipids are a chemical class

name for fat and fat-related compounds. True or false?" Each text, regardless of whether it was correct, was rewarded with cash monetary compensation ($3/text), which would be collected at the last session. Participants received feedback of their monetary compensation per text (i.e., "You have earned $3 for this text message.") within 60 min of being received by the research associate. A participant could earn up $6 per day for 7 days, so a total of $42/week. This condition controlled for food-related texts, contact with researchers, and money that occurred.

Control Participants assigned to a no-treatment control condition also received the four foods during session 2, but no treatment. The purpose of this condition was to enhance the internal validity of the study by determining the consistency of discounting across sessions without any treatment. After they ate the foods, they completed the four discounting tasks in random order. They were compensated for their time ($15) and scheduled for their last session 1 week later. They did not engage in any study-related procedures during the week, but each participant received money in the third session that was yoked to a participant in the ME condition. This yoked compensation was to control for money received as a potentially confounding variable.

Session 3: 1-Week Follow-up

One week after session 2, participants completed the final session. They were again asked not to eat or drink anything for 2 h before the session. Upon arrival, the SHQ was administered, and a blood glucose test was given to the participants to ensure food deprivation. Participants completed a third set of discounting tasks in random order. They were compensated another $15 and any money they had earned during the 1-week extended treatment. Each participant that completed all three sessions was given an additional $10 and placed into a lottery for an additional $100 cash prize.

Measures

Delay Discounting for Money and Food

The Monetary Choice Questionnaire ($\alpha = 0.92$; MCQ; Kirby & Marakovic, 1996; Kirby et al., 1999) is a 27-item of delay discounting for hypothetical monetary outcomes across small ($25–$35), medium ($50–$60), and large ($75–$85) magnitudes. Individuals are presented with choices between a smaller, immediately available amount of money (e.g., $54 now) and a larger, delay amount of money (e.g., $77 in 117 days), though the money values and delay range are manipulated (1–360 days).

The Food Choice Questionnaire ($\alpha = 0.92$; FCQ; Hendrickson et al., 2015) is a similar 27-item measure of delay discounting that is similar to the MCQ, except presents choices between two hypothetical food outcomes in which one of the food outcomes is available immediately (e.g., 4 bites now) and the other is available after a delay (e.g., 8 bites in 1 h). Delays range from 30 min to 24 h and food outcome amount ranges across small (8–13 bites), medium (25–35 bites), and large (40–50 bites) magnitudes (9 questions per magnitude). Before answering questions, a 5/8-in white cube is placed in front of the participant and she is asked to imagine it is a bite of her favorite food. The higher the discounting value for both the MCQ and the FCQ, the stronger the preference for the smaller, immediate outcome.

Probability Discounting for Money and Food

The Probabilistic Money Choice Questionnaire ($\alpha = 0.94$; PMCQ; Madden et al., 2009) is a 30-item measure of probability discounting for hypothetical monetary outcomes that estimates discounting rates across small ($20 vs. $80), medium ($40 vs. $60), and large ($40 vs. $100) magnitudes. An individual makes choices between smaller, certain amounts of money (e.g., $40 for sure) versus larger, less certain amounts of money (e.g., A 6-in-11 chance [55%] of receiving $60). The Probabilistic Food Choice Questionnaire ($\alpha = 0.94$; PFCQ; Rodriguez et al., 2018) is a 39-item measure of probability discounting for hypothetical food outcomes that was adapted from the FCQ (Hendrickson et al., 2015) and the PMCQ (Madden et al., 2009). The measure estimates food probability discounting across small (8–14 bites), medium (26–36 bites), and large (40–50 bites) magnitudes. A 5/8-in white cube is first presented to the participant and she is asked to imagine the cube as a bite of her favorite food. Within each magnitude, individuals make choices between smaller, certain amounts of food (e.g., 15 bites for sure) versus larger, less certain amounts (e.g., 75% chance of receiving 30 bites). Higher scores on the PMCQ and PFCQ indicate risk aversion or preference for smaller, more certain outcomes over larger, less likely outcomes (the latter reflects preference for more risky choice).

US Household Food Security Survey Module (HFSSM)

The US Household Food Security Survey Module (HFSSM; Bickel et al., 2000; USDA, 2012) is an 18-item measure that assesses the food security level of a household within the past 12 months. To capture current food security concerns, we reduced the timeline of the measure from the past 12 to the past 3 months. The HFSSM consists of questions designed to assess an individual's circumstances regarding concerns about food budget and the ability to meet nutritional needs for their household. Each affirmative response to items is added across the measure to determine a single numerical value of a household's food security status, which

includes the number of people (including children) in the household. Scores < 3 indicate a food-secure household; scores > 3 are considered FI with higher scores indicating greater severity. Individuals who scored a 3 or more were included in the study.

Substance Use

A large literature documents the relation between alcohol and illicit substance use on DD. Therefore, the Alcohol Use Disorders Identification Test ($\alpha = 0.71$; AUDIT-C; Bush et al., 1998) and the Drug Abuse Screening Test ($\alpha = 0.74$; DAST-10; Skinner, 1982) were administered to assess alcohol and drug use, respectively, as potential confounding variables. A score of 3 or higher on the AUDIT-C indicates potential alcohol abuse. For the DAST-10 a score of 3 or higher indicates greater drug-related dysfunction, with 9–10 as a severe level. In addition, participants who endorsed smoking or nicotine vaporizer use were administered the Fagerstrom Test for Nicotine Dependence ($\alpha = 0.99$; FTND; Heatherton et al., 1991) and a version of the FTND with questions focused on vaping behaviors (see Robertson & Rasmussen, 2018), which was scored similarly. Scores between 1 and 2 were low dependence, 3 and 4 low to moderate dependence, and 5 and 7 were moderate dependence, and 8 + were high dependence.

Current Hunger

To control for current levels of hunger at the time of testing, the Subjective Hunger Questionnaire (SHQ) was administered at the beginning of each session. This 3-item self-report measure asks participants to report the time since their last full meal and snack and rate their current hunger level on a scale of 0 to 100. To validate the self-report, blood glucose samples were taken using sterile techniques. A research assistant drew 1–2 drops of blood from the participant's finger and placed it on an Accu-Chek® Compact Plus glucometer strip. If a participant's BMI < 25 (i.e., normal or underweight range), blood glucose levels were expected to fall at or below 110 mg/dL; if a participant's BMI was > 25 (overweight or obese), blood glucose levels were expected to be at or below 140 mg/dL based on cut-off criteria on guidelines set by the American College of Endocrinology (Hendrickson & Rasmussen, 2017; Hendrickson et al., 2015; Rodriguez et al., 2021).

Intellectual Functioning

Previous studies have suggested a negative association between delay discounting and intellectual functioning (Shamosh & Gray, 2007), so to control for this potential confounding variable, we administered the Slosson Intelligence Test-Revised for Children and Adults (SIT-R3; Slosson et al., 2002). The Slossen is a brief measure of intellectual function that estimates general verbal cognitive ability ($M = 100$).

Diet Quality

The Block Food Frequency Screener (BFFS; Block et al., 2000) was used to measure diet quality. This 27-item self-report assesses an individual's daily intake of dietary fats and fruit, vegetable, and fiber consumption within the last 30 days. Responses are summed to create two scores. For dietary fats, categories include the following: very low in fat (0–7), moderate fat (8–14), high fat (15–22), and very high fat (23 +). Vegetable and fruit consumption scores are categorized as ≤ 3 servings per day (0–10), ≤ 4 servings per day (11–12), ≤ 5 servings per day (13–15), and 5 ≤ servings per day (16 +).

Perceived Stress

The Perceived Stress Survey (PSS) ($\alpha = 0.90$; Cohen et al., 1983) is a 10-item scale that assesses an individual's perception of their feelings of stress and ability to cope with different life stressors over the past month. Responses are summed with higher scores indicating higher amounts of stress.

Demographic Information

Demographic information, such as age, income, date since last paycheck, which may indicate immediate financial solvency in individuals with food insecurity (see, e.g., Ford & Beaumier, 2011), and marital status, was assessed with this measure.

Biometric Information

To collect data on height, researchers used a 2-m portable ruler. Weight and percent body fat (PBF), and body mass index (BMI) were gathered and calculated using the Tanita C-300® scale and Tanita Health Ware™ software. This software measures PBF via bioelectric impudence. BMI was calculated by dividing weight (kg) by height (m^2).

Data Analyses

The data were analyzed using IBM SPSS Statistics v25. Four participants were removed from analysis due to ineligibility bringing the total sample to 113. For participants who dropped out before sessions 2 or 3, their last observed values on the discounting, blood glucose, and subjective hunger measures were carried forward and they were considered treatment noncompliant.

Discounting values for the three magnitudes of the FCQ, MCQ, PMCQ, and PFCQ were calculated using procedures described in Hendrickson et al. (2015), Kirby et al. (1999), Madden et al. (2009), and Rodriguez et al. (2018), respectively. The geometric mean of the three magnitudes for each measure was calculated to make a single omnibus score for each of the time points measured. Due to substantial skewness, which is common in research with discounting, values were transformed to help achieve normality so that parametric statistics could be performed. MCQ, PFCQ, and PMCQ scores were transformed using log10 transformation. FCQ scores were transformed using square root transformation across all three time points as log10 transformation still resulted in skewness. Similarly, because of skewness, total scores from the HFSSM, AUDIT-C, DAST-10, FTND, and the adapted vaping Fagerstrom were all transformed using log 10 transformation. Time date since last pay check was a categorical variable that was dichotomized to paid within past 2 weeks (=0) and paid within past 3 + weeks (=1) due to a limited numbers per cell.

Chi-square analyses and one-way ANOVAs were used to assess for differences in demographic and health-related variables among treatment groups. Previous research has shown that alcohol, nicotine, and illicit substance use, in addition to BMI and PBF, have been significantly associated with discounting (Bickel & Marsch, 2001; Jarmolowicz et al., 2014; Madden et al., 1997; Rasmussen et al., 2010). To determine if these variables needed to be included as covariates, Pearson's *r* correlations were conducted to see if suspected covariates significantly correlated with any of the delay or probability discounting tasks for food or money. Variables that demonstrated significant correlations, or those that were significantly different across group (see Table 1) were included in the main analyses. Main analyses consisted of 3 × 3 mixed design ANOVA/ANCOVAs with treatment condition (mindful eating training, DVD, and control) as the between-subjects factor and time point (baseline, post-treatment, 1-week follow-up) as the within-subjects factors. In addition, analyses were conducted to determine if there were site differences.

Results

Enrollment, Treatment Adherence, Retention, and Site

Figure 1 shows a flow chart of the number of subjects from screening to study completion. About 48% of the participants (120/252) screened were eligible and interested in the study and therefore enrolled. An additional 7 participants were deemed ineligible *after* enrollment in the study (did not meet 18-item criterion for FI). Of the eligible 113, all (100%) enrolled participants completed session 1. Approximately 97%, 90%, and 97% of the control, DVD, and ME groups, respectively, completed session 2. For session 3, 94%, 90%, and 95% of each group completed the sessions. There were no group differences. Therefore, at least 90% of the participants completed all three sessions.

In addition to retention as a variable related to treatment fidelity, the percentage of compliant texts (which were coded by a single researcher) received out of a possible 14 during the 1-week time period between sessions 2 and 3 was compared in the DVD control and ME groups. (No texts

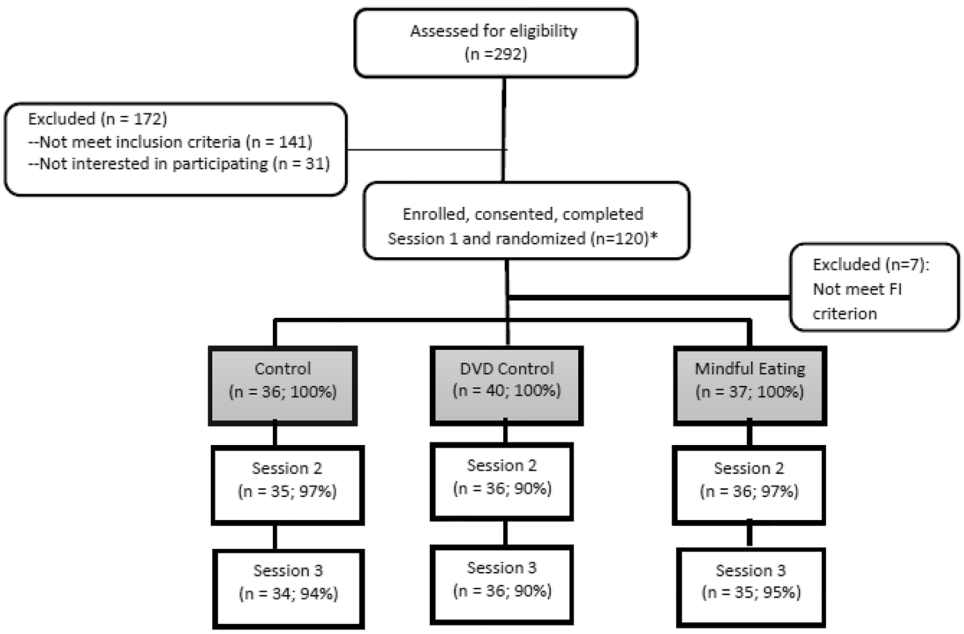

Fig. 1 Flow chart of participant eligibility assessment to study completion

were required for control group.) The DVD group completed 93.9% of the texts; the ME group completed 82.3% of the texts; these were significantly different [$t(70) = -2.74$, $p = 0.008$, $d = 0.64$]. Importantly, of the ME texts, 93% met the criteria for mindful eating. Those that did not meet the criteria were either too short (less than 2–3 sentences), were not objective descriptions of eating, or were omitted (did not text).

Differences across site also were tested to ensure that the place of testing did not introduce a confounding variable. Of the 113 participants, 60% (68/113) completed the first session of the study at a campus office, 10% at Food Pantry A (11/113), and 30% (34/113) at Food Pantry B. Individuals from Food Pantry A who initially completed session 1 at the food pantry had to complete sessions 2 and 3 at the campus office due to issues of space at Food Pantry A. Participants from Food Pantry B completed all three sessions at Food Pantry B. Approximately 70% (26/37) of participants completed the mindful eating condition at the campus office and 30% (11/37) at Food Pantry B. For the DVD condition, 65% (26/40) of participants completed it at the campus office, and 35% completed it at Food Pantry B. For the control condition, 75% (27/36) completed it at the campus office and 25% (8/36) completed it at Food Pantry B. At session 3, 70% (79/113) completed it at the campus office and 30% (34/113) at Food Pantry B.

Six percent (4/68) of participants who completed the full duration of the study at the on-campus office dropped out after session 1 (3/4) or after session 2 (1/4). Nine percent (1/11) who completed the first session at Food Pantry B and sessions 2 and 3 at the campus office dropped out after session 2. Nine percent (3/34) who completed the duration of the study at Food Pantry B dropped out after session 1.

We statistically examined food insecurity scores, retention, discounting across site and session (baseline, treatment, and follow-up). Demographic data were also examined across site (same vs. different across session). There were no statistically significant site-related differences in these data.

Table 2 Correlations between baseline delay and probability discounting tasks

Variable	1	2	3
Baseline FCQ [sqrt]	-		
Baseline MCQ [lg10]	0.27**	-	
Baseline PFCQ [lg10]	0.05	0.06	-
Baseline PMCQ [lg10]	0.19*	0.24*	0.31**

*$p < 0.05$; **$p < 0.01$; *FCQ*, Food Choice Questionnaire; *MCQ*, Money Choice Questionnaire; *PFCQ*, Probabilistic Food Choice Questionnaire; *PMCQ*, Probabilistic Money Choice Questionnaire

Baseline Measures of Probability and Delay Discounting and Co-variates

Table 2 shows Pearson's *r* correlations between baseline delay and probability discounting measures. The FCQ was significantly, positively correlated with the MCQ and PMCQ. The MCQ showed significant positive associations with the PMCQ. The PFCQ showed no significant associations with any of the discounting tasks. In addition, Pearson's *r* correlations were conducted to determine potential covariates for analyses. Neither baseline food delay discounting nor food probability discounting was significantly correlated with any health and demographic variables across the total sample. Baseline money delay discounting (Table 3) was positively correlated with AUDIT-C scores and time since last full meal and negatively correlated with IQ and income; these variables were controlled in the analyses. In addition, baseline money probability (Table 4) showed a negative relation with income and dietary fat; these variables were also controlled in the mixed ANCOVA analyses. Because weight, PBF, and dietary fat were statistically different across groups, they were entered as covariates to test baseline discounting differences across group despite not being significantly correlated across all baseline discounting measure. When controlling for these variables, ANCOVAs revealed no group differences on any of the baseline delay and probability discounting for both food and money.

Mindful Eating and Delay Discounting

Food Mean values for food delay discounting (transformed) are presented in the top of Fig. 2. A 3 × 3 mixed ANOVA, with treatment condition (control, DVD, and ME) as the between-subject factor, time as the within-subject factor (baseline, post-treatment, 1-week follow-up), revealed a significant main effect of time [$F(2,220) = 3.48$, $p = 0.03$, $\eta_p^2 = 0.03$]. Simple contrast analyses showed that when controlling for the main effect of treatment, and the interaction, food delay discounting at post-treatment [$F(1,110) = 3.78$, $p = 0.05$, $\eta_p^2 = 0.03$] and 1-week follow-up was significantly higher compared to baseline [$F(1,110) = 5.64$, $p = 0.02$, $\eta_p^2 = 0.05$]. When examining each group individually with dependent samples *t*-tests to determine which group appeared to drive this effect, the ME group had significantly higher discounting between baseline vs. post-treatment conditions [$t(36) = -2.79$, $p = 0.008$, $d = 0.31$], but not significant discounting at baseline vs. 1-week follow-up [$t(36) = -1.89$, $p = 0.07$, $d = 0.29$]. The control group and DVD group did not exhibit differences between these conditions ($ps > 0.15$). There was no significant main effect of treatment condition nor was there a significant interaction. When running an ANCOVA that controlled for the effects of PBF, weight, and dietary fat, there still remained a significant

Table 3 Pearson's *r* correlation between baseline money delay discounting and relevant demographic and health-related variables

	Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1.	Baseline MCQ [lg10]	-														
2.	HFSSM [lg10]	.16	-													
3.	BMI	.11	−.02	-												
4.	PBF	.08	.04	.77**	-											
5.	AUDIT-C [lg10]	.24*	−.03	.07	−.01	-										
6.	DAST-10 [lg10]	.05	.004	−.15	−.21*	.40**	-									
7.	FTND [lg10]	.13	.04	−.19*	−.27**	.25**	.48**	-								
8.	Vape FTND [lg10]	.14	.15	.03	.04	.20*	.32**	.39**	-							
9.	Time Since Last Meal	.22*	.22*	−.07	−.07	−.06	−.01	−.11	−.07	-						
10.	Time Since Last Snack	.17	.20*	−.05	−.01	−.04	.03	.04	.10	.57**	-					
11.	Subjective Hunger	−.11	.06	−.07	−.14	.02	.19*	.11	.12	−.003	.04	-				
12.	Intellectual Functioning	−.24*	.13	−.04	−.003	−.03	.08	−.04	−.11	−.11	−.04	.14	-			
13.	Income	−.19*	−.03	−.14	−.06	.03	.002	−.05	.13	−.17	−.02	.23*	.27**	-		
14.	Baseline Blood Glucose	.13	.16	.01	.09	−.05	−.03	.01	−.04	−.15	−.02	−.21*	−.11	−.26**	-	
15.	Dietary Fat	.01	−.08	−.08	−.12	.25**	.39**	.31**	.11	−.10	.01	.13	.14	.24*	−.04	-
16.	Perceived Stress Survey	−.002	.19*	−.01	−.14	.22*	.23*	.01	.004	.02	−.23*	.05	.01	−.10	−.001	.11

*$p < 0.05$; **$p < 0.01$; *MCQ*, Money Choice Questionnaire; *HFSSM*, Household Food Security Survey Module; *PBF*, percent body fat; *BMI*, body mass index; *AUDIT-C*, Alcohol Use Disorders Identification Test—Version C; *DAST-10*, Drug Abuse Screening Test—Version 10

Table 4 Pearson's *r* correlation between baseline money probability discounting and relevant demographic and health-related variables

	Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1.	Baseline PMCQ [lg10]	-														
2.	HFSSM [lg10]	.05	-													
3.	BMI	.16	−.02	-												
4.	PBF	.16	.04	.77**	-											
5.	AUDIT-C [lg10]	−.02	−.03	.07	−.01	-										
6.	DAST-10 [lg10]	−.18	.004	−.15	−.21*	.40**	-									
7.	FTND [lg10]	−.11	.04	−.19*	−.27**	.25**	.48**	-								
8.	Vape FTND [lg10]	−.03	.15	.03	.04	.20*	.32**	.39**	-							
9.	Time Since Last Meal	.02	.22*	−.07	−.07	−.06	−.01	−.11	−.07	-						
10.	Time Since Last Snack	.04	.20*	−.05	−.01	−.04	.03	.04	.10	.57**	-					
11.	Subjective Hunger	−.03	.06	−.07	−.14	.02	.19*	.11	.12	−.003	.04	-				
12.	Intellectual Functioning	−.09	.13	−.04	−.003	−.03	.08	−.04	−.11	−.11	−.04	.14	-			
13.	Income	−.19*	−.03	−.15	−.06	.03	.002	−.05	.13	−.17	−.02	.23*	.27**	-		
14.	Baseline Blood Glucose	.18	.16	.01	.09	−.05	−.03	.01	−.04	−.15	−.02	−.22*	−.11	−.26**	-	
15.	Dietary Fat	−.23*	−.08	−.08	−.12	.26**	.39**	.31**	.11	−.10	.01	.13	.14	.24	−.04	-
16.	Perceived Stress Survey	−.06	.19*	−.01	−.14	.22*	.23*	.01	.004	.02	−.23*	.05	.01	−.10	−.001	.11

*$p < 0.05$; **$p < 0.01$; *PMCQ*, Probabilistic Money Choice Questionnaire; *HFFSM*, US Household Food Security Survey Module; *BMI*, body mass index; *PBF*, percent body fat; *AUDIT-C*, Alcohol Use Disorders Identification Test-Version C; *DAST-10*, Drug Abuse Screening test—Version; *FTND*, Fagerstrom Test for Nicotine Dependence

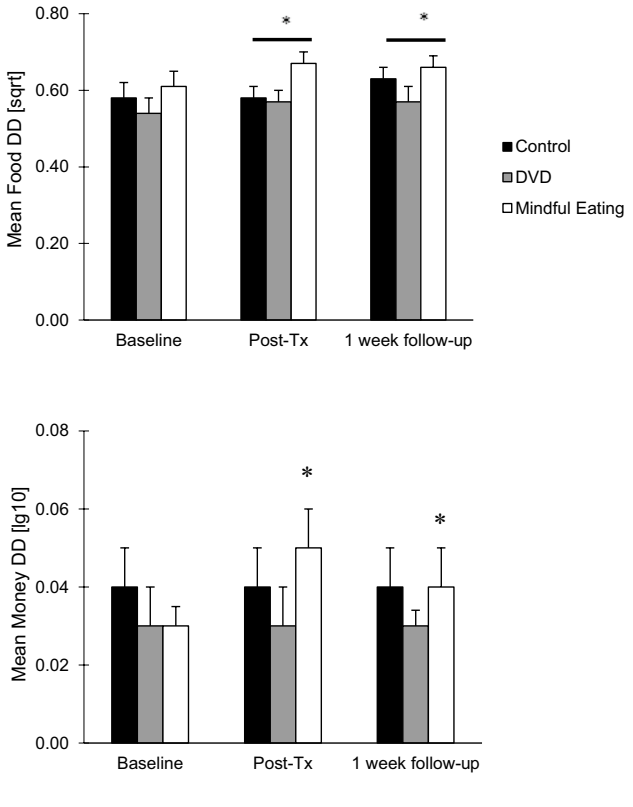

Fig. 2 Mean food (top) and money (bottom) delay discounting values. *Note* $*p \leq 0.05$; analyses revealed a main effect of time on food delay discounting (top) at the post-treatment and 1-week follow-up; both effects were driven by ME. There was a significant treatment X time interaction on money delay discounting (bottom). ME significantly increased money PD at the post-treatment and 1-week follow-up compared to baseline. Higher values indicate greater discounting or greater preferences for the smaller, sooner option. Error bars = 1 SEM

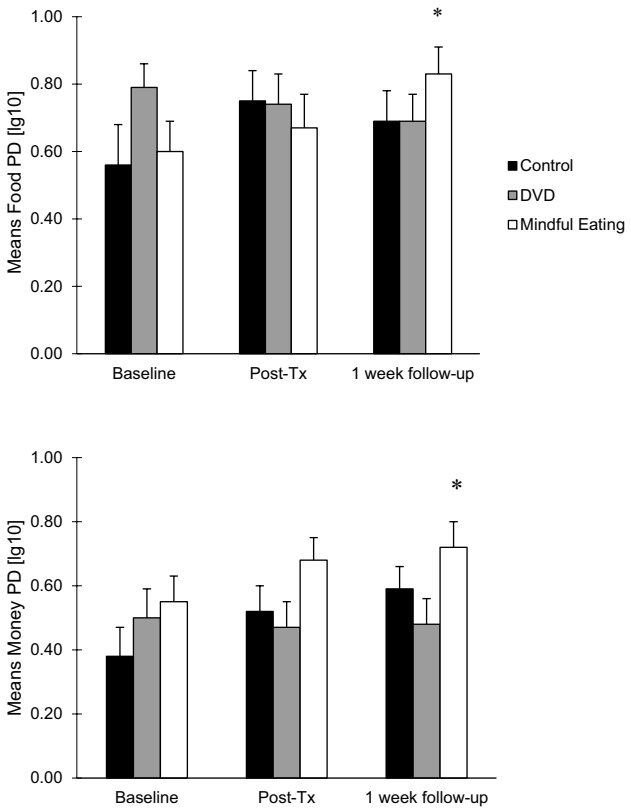

Fig. 3 Mean food (top) and money (bottom) probability discounting values. *Note* $*p \leq 0.05$; analyses revealed a significant interaction of treatment and time on food probability discounting (top) and money probability discounting. ME significantly increased food PD and money PD at the 1-week follow-up compared to baseline. Higher PD values indicate greater risk aversion or stronger preferences for the smaller, more certain outcome. Error bars = 1 SEM

effect of time [$F(2,214) = 3.48$, $p = 0.03$, $\eta_p^2 = 0.03$]. Additionally, there was a significant interaction between session and PBF [$F(2,214) = 4.46$, $p = 0.01$, $\eta_p^2 = 0.04$].

Money Means for money delay discounting (transformed) are presented in the bottom of Fig. 2. A 3 × 3 mixed ANCOVA, with treatment condition (between-subject factors), time of measurement (within-subject factor), and covariates (AUDIT-C, time since last full meal, intellectual functioning, and income) showed a significant interaction [$F(4,212) = 3.20$, $p = 0.01$, $\eta_p^2 = 0.06$] between treatment condition and time of measurement. When controlling for main effects and covariates, women who participated in the mindful eating training showed significantly higher money delay discounting at post-treatment [$F(2,106) = 4.43$, $p = 0.01$, $\eta_p^2 = 0.08$] and 1-week follow-up compared to baseline [$F(2,106) = 3.43$, $p = 0.04$, $\eta_p^2 = 0.06$]. No effects were observed in either the DVD or control conditions. In addition, there were no significant main effects of treatment or time. When the model was conducted with PBF, weight, and dietary fat included as covariates, the results were similar.

Mindful Eating and Probability Discounting

Food Mean values (transformed) for food probability discounting are presented in the top panel of Fig. 3. While there was no main effect of treatment or time, a significant treatment X time interaction was found [$F(4,220) = 2.38$, $p = 0.05$, $\eta_p^2 = 0.04$]. Women in the ME training condition showed significantly higher food probability discounting from baseline to 1-wk follow-up [$F(2,110) = 3.41$, $p = 0.04$, $\eta_p^2 = 0.06$]; the DVD and control groups did not show these differences. When including covariates of PBF, weight, and dietary fat in the model, the significant interaction was no longer significant ($p = 0.17$; $\eta_p^2 = 0.03$). PBF, weight, nor dietary fat showed a significant interaction with time.

Money Mean values for money probability discounting (transformed) are presented in the bottom of Fig. 3. Results

from a 3×3 mixed ANCOVA revealed that when controlling for income and dietary fat there was a significant interaction between treatment condition and time [$F(4,216) = 2.70$, $p = 0.03$, $\eta_p^2 = 0.05$]. Women in the mindful eating condition demonstrated a significant increase in money probability discounting from baseline to 1-week follow-up [$F(2,108) = 3.81$, $p = 0.03$, $\eta_p^2 = 0.07$], but this effect was not observed in either the DVD or control conditions. There were no significant main effects of treatment or time. Income showed a significant interaction with time [$F(2, 216) = 4.74$, $p = 0.01$, $\eta_p^2 = 0.04$)]. When including PBF and weight in the model, the significant interaction between treatment and time was no longer significant ($p = 0.08$, $\eta_p^2 = 0.04$). Income continued to demonstrate a significant interaction ($p = 0.02$, $\eta_p^2 = 0.04$).

Discussion

Food and Money Delay Discounting Mindful eating had both acute and chronic effects on monetary delay discounting. The 50 min post-treatment and the extended practice of the ME condition *increased* delay discounting for money. In addition, there was a main effect of time at the post-treatment and 1-week follow-up on food discounting. The ME group (but not the control or DVD groups) showed an increase in discounting for food that drove both of the effects for the acute post-treatment and 1-week time points.

Importantly, the extended practice of ME increased delay discounting for money and contributed to the effects on delay discounting for food. In other words, ME shifted preferences toward the smaller, sooner food outcomes and the smaller, sooner, monetary outcomes over the larger, delayed ones. This effect is the opposite of what has been shown in the literature, in which ME reduced delay discounting for food (i.e., shifts preferences toward larger, delayed outcomes) in adults and adolescents (Hendrickson & Rasmussen, 2013, 2017). It is important to state that the same mixed design with control groups was employed in the present study as the other two previous studies of ME's effects on discounting. Baseline and acute effects of ME were characterized in the exact same manner as the Hendrickson and Rasmussen (2017) study. Indeed, the same measures of delay discounting (the MCQ and FCQ) were used in the Hendrickson and Rasmussen (2017) study; different measures of discounting were used in the Hendrickson and Rasmussen (2013) study. The only differences in the current study from the previous were (1) the FI population sampled, and (2) the addition of an extended ME condition.

The findings on DD in the present study suggest for women with FI, a focused exercise on food may activate strategies that enhance general preferences for immediate food and money. In other words, for food-insecure women, ME may activate "survival mode" strategies for immediate food and money. It is unclear what the mechanisms for this finding may be. For example, focused attention on eating may have caused worry or concern about food or money during the ME. This has been shown in studies with individuals who have high attention to body awareness and threat cue sensitivity (e.g., Johnson et al., 2016; Lindahl et al., 2017; Reynolds et al., 2017; Sahdra et al., 2017; see Galante et al., 2021 for meta-analysis). However, neither the ME observations during session 2 nor the texts sent during the extended ME condition show evidence of this. Future studies could attempt to isolate what some of these mechanisms may be with the possibility that heightened anxiety or worry may be one possible mechanism for those with FI.

Food and Money Probability Discounting Chronic effects of the extended ME condition were found with both probability discounting for food and for money—the extended ME condition in particular increased PD discounting values for both food and money. Therefore, the extended ME shifted preferences choices from the larger, more risky food and money options under baseline to the smaller and less risky choice.

When comparing these results to those from Hendrickson and Rasmussen (2013), in which the effects of a 50-min ME strategy on discounting were examined in college students, there were no acute effects of ME on monetary probability discounting, but there were acute effects on food probability discounting in the opposite direction from the current study. In addition to this novel finding, we found this ME effect extend to a longer time frame. Like Hendrickson and Rasmussen (2013) and Hendrikson and Rasmussen (2017), the DVD control and standard control groups were not affected at any time point, suggesting that ME was the condition that caused these shifts.

The observation that ME's extended effects on probability discounting were consistent across two outcomes suggests that, for women who are food insecure, ME may shift behavior to less risky options in a general manner regardless of outcome type. However, it may be the case that, for those with food insecurity, processes that occur during mindful eating (e.g., focusing on food) may shift preferences only for outcomes that are related to food insecurity—that is, ME may only affect outcomes that are related to food and income (money). Examining risk aversion with other types of outcomes, such as decisions related to sexual health, may help determine whether extended ME effects are more general in nature or the extent to which they are more specific to the conditions of food insecurity (e.g., concern over money and food). Moreover, directly comparing these processes with other populations that vary in their food security status may also shed light on the scope of risk-aversion processes related to mindful eating.

In this study, mindful eating had consistent effects on decision making processes that are relevant to the Competing Neurobehavioral Decision Systems (CNDS) theory (e.g., Bickel et al., 2014, 2019). The CNDS suggests that there are two neurobehavioral systems that are in competition when humans make decisions: one, the evolutionary "older" system, which is primarily comprised of the limbic system and paralimbic system and is primarily concerned with the valuation of immediate rewards. Two, there is also the more recently developed executive system, which is primarily prefrontal cortices, and is involved in future planning and self-control. These competing systems parallel the choices involved in discounting. In situations like food scarcity, it is likely that the more evolutionary brain may be activated ("survival mode"), which create shifts toward smaller, more immediately available outcomes. This indeed has been demonstrated recently with food-insecure women (vs. food-secure women) with delay discounting for food (Rodriguez et al, 2021).

Mindful eating with individuals without FI likely activates the newer, prefrontal brain, which results in more self-controlled choice patterns that involve long-term planning (Hendrickson & Rasmussen, 2013, 2017). Individuals who are food insecure, though, may respond differently to ME. The data suggest that ME, though promoting of objective and non-judgmental processes, may activate the more immediate decision-making systems in these individuals, shifting preferences toward more immediate and certain food and money, increasing the odds for immediate survival. However, given that high-fat and high-sugar food is more affordable and therefore is more likely to be consumed in this population, there is some question about whether ME may be an appropriate strategy for managing choices related to food that impact obesity. Future studies should examine how FI status interacts with ME strategies to determine what other factors may play a role in decision making for this population. Moreover, while the current study did not examine neural substrates or activity in areas of the brain, future studies might examine neural endpoints, especially those related to reward and prefrontal processing, to determine the extent to which activation in these areas is related to mindful eating in FI samples.

It should also be mentioned that in this sample, the influence of obesity or subjective hunger on food discounting was not observed, as other research has shown (e.g., Hendrickson et al., 2015; Rasmussen et al., 2010). One possibility that may explain this is that the BMI and age of the sample were in the higher range and there was a restriction of range in these compared to other studies with food discounting (e.g., Rasmussen et al., 2010). Therefore, the ability to detect an obesity effect or an effect of subjective hunger would be smaller.

Limitations and Future Research

One limitation to the study is that during the extended mindful eating period, texts were used to enhance confidence that ME was being practiced away from the laboratory; however, there was no direct observation of the participants from others and no other way to be certain that individuals were indeed practicing ME. The data in the extended ME condition, however, generally replicate those from the acute ME session, in which participant behavior indeed was directly observed by a researcher. Therefore, this enhances confidence that ME was being practiced away from the laboratory. Future studies that employ an extended ME practice could benefit from direct observation of ME from others in the home, such as family members or friends, or have participants return to the laboratory twice a day and complete their ME in the presence of a researcher. This latter suggestion, however, may be labor and time intensive for participants, especially for vulnerable populations, such as those with FI, and therefore not practical.

A second limitation also concerns group differences in text completion rates. Those in the DVD group completed more (93%) of the texts than the ME group (82%), presumably because sending a one-word text had less of a response cost than sending the ME texts. The DVD condition was meant to control some of the potentially confounding conditions of ME, such as contact with the experimenters and receiving money. Though both groups completed > 80% of the texts, it could be argued that those in the DVD condition received more contact with the experimenter and more money than those in the ME condition. Despite this, the extended DVD condition did not change DD or PD for food or money. Therefore, these differences in experimenter contact and money did not play a role in treatment.

A third limitation concerns the self-report nature of some of the measures used, such as those for diet quality, intellectual functioning, substance use, and perceived stress. The responses generated from these self-report measures are based on participant perception and can be affected by social desirability, priming effects from instructions or previously completed items, or introspective ability (Posdakoff et al., 2012). Therefore, the data from these measures may be potentially biased and should be interpreted with caution.

A final limitation to the present study refers to sample sizes and effect sizes. The final sample size was lower than what the power analysis suggested ($N = 113$ vs. 120). This was due to subject attrition (2–3 per group) across the three sessions. Nonetheless, our analyses still detected statistically significant differences. A related question to these differences, though, is in regard to the strength of the effect sizes. Effect sizes for mindful eating effects were between 0.03 and 0.07 across the four discounting tasks. These small effect sizes could be related to an underpowered sample;

however, there is another possibility. A discussion of discounting as a trait vs. state is relevant. Odum (2011a, 2011b) characterized delay discounting as a trait in terms of high test–retest variability, in which testing for discounting at two or more time points predicts relatively robust effect sizes. Moreover, cross-commodity discounting (e.g., money vs. food) is strongly correlated within individuals (see Odum et al., 2020), also supporting trait-like behavior. Nonetheless, according to a recent meta-analysis (Rung & Madden, 2018), there are variables that can significantly alter human discounting, such as framing and priming. Though experimentally induced changes in discounting were reported in these studies, the effect sizes tended to be generally smaller, and within the range of the current effects. Indeed, the ME effects from Hendrickson and Rasmussen (2013) and Hendrickson and Rasmussen (2017) were also in this range. In other words, most of the variability in discounting seems to be trait-like, though it can be altered on a smaller scale with variables such as mindfulness.

One question that remains is the extent to which small shifts in discounting that are influenced by external variables impact real life choices, such as those for food and money. In some individuals with FI, a minor shift may not cause much of a change in patterns of preferences. But for others, they may be highly influential. One can imagine, for example, that if someone with FI has recent access to a paycheck or food benefits, a small influence by something external, such as mindful eating, could potentially lead to consumption of what is immediately available and certain. Repeated situations like this may in the long run be potentially harmful in terms of health for some people who may be especially sensitive to the effects of ME. More research is needed on the impact of these types of choices and how people with FI may be more or less impacted by such variables.

The current data suggest that for women who are food insecure, a mindful eating strategy induces a preference for immediately available and more certain food and money outcomes. In other words, ME activates strategies that are appropriate for short-term survival, but perhaps not relevant for long-term planning and health. On one hand, mindfulness strategies can be useful for economically disadvantaged populations, as they have been shown to reduce perceived stress, for example, in pregnant women (Epel et al., 2019). ME may be an appropriate strategy for food-insecure individuals, in the short run, which may enhance sensitivity to choices related to immediate survival, but it may also lead to long-term health problems, such as obesity. The potential role of distress that may be activated by ME in this population should be understood before this strategy is supported as a potential treatment. Therefore, at this point, we would be hesitant to recommend its use for a FI population. More research is needed on mindfulness strategies for individuals with FI to examine both long-term and short-term effects on decision making and health.

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Author Contribution EBR designed, supervised, and procured funding for the study, write the paper and assisted with data analyses. LRR assisted with data collection, data analysis, and writing of the paper. SP assisted with data collection in the writing and editing of the final manuscript.

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Data Availability All data are available at the Open Science Framework. https://osf.io/6n4d3/?view_only=c282bb414397442ba9f163297ad8b58c

Declarations

Ethics Approval and Consent to Participate This study was approved and conducted under the auspices of the Idaho State University Institutional Review Board and monitored for safety annually by an independent entity (Westat), as required by clinical trials studies by the NCCIH. Therefore, this study was performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments. All persons gave their informed consent prior to their inclusion in the study.

Conflict of Interest The authors declare no competing interests.

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