Systematic Replication of the Effects of Environmental Imagery Exposure on Delay Discounting

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Abstract

Delay discounting is a behavioral process describing the manner in which rewards lose their value as a function of time until their receipt. Delay discounting has gained the attention of researchers because it is reliably linked to a variety of impulsive behaviors including substance use, gambling, sexual risk behavior, and failure to engage in preventive health measures. Increasingly, there is interest in identifying environmental variables that decrease the rate at which individuals discount delayed rewards. Recent studies have found that participants who viewed images of natural environments discounted delayed money less steeply compared to participants who viewed images of built environments. The present between-subjects study attempted to reproduce this effect and investigate the generality of the finding with the inclusion of food discounting. In addition, measures of positive/negative affect, connectedness with nature, and space/time perception were included in order to identify possible mechanisms. No differences were observed in the degree of delay discounting between those exposed to natural versus built imagery for either commodity. However, the well-established finding of steeper discounting for food was reproduced. Differences in overall exposure to natural environments between participants in the current study and previous research could account for these divergent findings.

1. Introduction

Humans have long displayed a tendency to make decisions that are convenient in the short term, but detrimental in the long term. For example, an individual may choose to consume a piece of cake when it is immediately available, only to forego their diet and risk poor health in the future. Likewise, a cigarette smoker may choose a cigarette in the moment, only to suffer from devastating health issues in several years. Decision-making of this sort is commonly called impulsive and can have a range of negative consequences for the individual (Odum, 2011) and society as a whole (Hepburn et al., 2010). One reason why individuals may engage in impulsive decision-making such as consuming unhealthy foods or drugs of abuse is if a behavior and its consequences are separated by a large amount of time (Whittle, 1980). Delayed consequences such as diabetes and lung cancer in these examples are less likely to affect one's decision relative to immediate consequences, and this inability for delayed consequences to affect present choices often leads to engagement in risky or impulsive behaviors.

The notion that a reward decreases in value as the delay to its receipt increases is known as delay discounting (Chung & Herrnstein, 1967; Mazur, 1987). Returning to the unsuccessful dieter above, the value of a piece of cake right now may outweigh the value of avoiding a chronic health condition in the future. Similarly, for the smoker, the value of the immediate relief provided by a cigarette may supersede the distant value of avoiding lung cancer. In these examples, the value of a distant reward of having one's health at a later juncture is discounted as a function of delay and therefore is unlikely to effectively compete with an incompatible reward that is immediately available. To illustrate this effect, Figure 1 shows the effect of delay on the value of $100 for two individuals. For the individual who discounts delayed rewards at a low rate (i.e., shallow discounting), the $100 reward loses half of its value in approximately 300 hours

(12 days). Conversely, for the individual who discounts delayed rewards at a high rate (i.e., steep discounting), the $100 reward loses half of its value in approximately 24 hours (1 day).

Steep discounting is most consistent with impulsive decision-making. A meta-analysis of delayed reward discounting in substance-dependent populations revealed steeper discounting than demographically matched control participants (MacKillop et al., 2011). Delay discounting procedures have also revealed that pathological gamblers discount delayed rewards more steeply than control participants (Dixon et al., 2003). Obese women have also been shown to discount delayed money more steeply than control women; however, this effect did not translate to obese men (Weller et al., 2008). Finally, individuals who discount delayed rewards steeply have been shown to participate in preventative health procedures (e.g., dentist visits, vigorous exercise, prostate examinations, mammogram use, cholesterol testing) less often than those who discount at a lower rate (Bradford, 2009). These findings pertaining to steep discounting in at-risk populations are informative and illustrate the need for a therapeutic intervention.

In particular, a therapeutic intervention designed to enhance future-oriented decision-making in those experiencing impulse control issues would have applied significance. Such an intervention would also have broad application in relation to imminent environmental threats (e.g., global climate change, biodiversity loss, ocean acidification) that are linked to human behaviors. It is widely acknowledged by the scientific community that human activity—especially in countries with extensive access to and consumption of natural resources—is principally driving global climate change (Shine, 2014). Like the consumption of unhealthy foods and drugs of abuse, behaviors that have a negative impact on the natural environment such as driving a personal car may result from steep delay discounting. These behaviors result in the dispersal of climate-altering pollutants, further extending the amount of carbon dioxide in the

atmosphere beyond recommended levels by climate scientists (Anderson & Bows, 2011). In short, conservation of the natural world should be a priority, as humans are not immune from the consequences of a degraded environmental system. An intervention that has only slight impacts on the phenomenon of human delay discounting, when considered en masse, could have substantial implications in combating pressing environmental issues.

Recent research has suggested that exposure to natural environments could have a positive impact on impulsive decision-making (i.e., improve self-control). Berry et al. (2014) designed a laboratory procedure in which participants were presented with images depicting natural environments (e.g., mountains, waterways), built environments (e.g., cityscapes), or geometric figures (e.g., triangles) on a computer screen. Stimuli were displayed prior to, and interleaved within, a monetary delay discounting task. Results of the study showed that individuals who were exposed to images of natural environments discounted delayed monetary rewards less steeply than those who saw images of built environments or geometric figures.

This effect was replicated in a second study in which the researchers attempted to identify possible mechanisms that could account for the differences in decision-making (Berry et al., 2015). As in the original study, participants who viewed images of nature displayed less impulsive decision-making on the monetary discounting task relative to those that viewed images of built environments. (There was no geometric control condition in this study.) Interestingly, those who viewed images of nature reported longer subjective session times compared to those who viewed images of built environments, despite there being no between-group difference in objective session times. Thus, those in the natural condition experienced an alteration in their subjective time perception (i.e., time appeared to slow down). This finding was proposed as a mechanism for the discounting differences displayed between nature and built image conditions.

The results of these studies shed light on an effect that could be expanded upon and developed as a therapy for especially impulsive populations (e.g., immersion in natural environments). However, there is reason to be skeptical when considering a phenomenon that is in its infancy (Pashler & Harris, 2012). While the effect in question has been observed twice, much remains unknown regarding its validity and generality. Replication of psychological research has historically been undervalued, especially when null findings do not support seminal research (Franco, Malhotra, & Simonovits, 2014). Despite this trend, the current study attempted to systematically replicate the findings of Berry et al. (2014) and Berry et al. (2015).

The current study replicates the procedures of Berry et al. (2015) with one deviation: the inclusion of a second commodity (i.e., food). This condition was added to determine whether the positive effect of viewing natural images extended to a non-monetary commodity. Food discounting was also investigated to examine an alternative explanation for the findings of the Berry and colleagues. Specifically, one reason why participants who viewed natural images tended to choose delayed money more frequently than immediate money (i.e., discount delayed money less steeply) could be that their perception that the natural environment was less conducive to the immediate exchange the monetary reward for goods or services. In other words, an immediate monetary amount would have no utility in a natural setting. In essence, this incidental feature of natural environments, as opposed to the natural environments themselves, may account for the observed differences in delay discounting. Compared to money, however, food is a commodity that does not require exchange and would therefore have immediate significance in a natural environment. Thus, if individuals exposed to images depicting natural environments discount both commodities less steeply compared to individuals exposed to images of built environments, then this will lend credence to the explanation offered by Berry and

colleagues. Alternatively, if discounting is affected in only those participants who are asked about money and view natural environments—that is, individuals who are asked about food discount similarly, regardless of the images they view—then this would suggest that the effect observed is limited to monetary rewards.

Although it has been shown on numerous occasions that food is discounted more steeply than money (e.g., Forzano and Logue, 1992; Friedel et al. 2014; Odum et al., 2006; Odum and Baumann 2007; Odum and Rainaud, 2003), it is unknown why this is the case. One possible explanation is that money, unlike food, is scaled in units that are agreed upon within a given population. Another possibility is that food, unlike money, is perishable. Thus, a second goal of the present study was to investigate differences in food and money discounting. To this end, we created a novel food discounting procedure that allowed participants to select a preferred food item from a list of 10 items commonly found in a vending machine.

The creation of a new food discounting procedure served two purposes. First, we wanted to closely align the value of food rewards with the value of monetary rewards. Specifically, most items in a vending machine cost approximately $1. Thus, a choice between 50 candy bars now or 100 candy bars in 1 week is close in relative value to a choice between $50 now or $100 in 1 week. Second, we wanted to investigate food items that were minimally perishable. Because the discounting tasks used by Berry et al. (2014) and Berry et al. (2015) had delays spanning vast amounts of time (e.g., 25 years until receipt of the larger, delayed reward), it was important that the food items in our novel task could conceivably hold their value for extended durations. If aligning the value of the food items with the value of monetary outcomes and minimizing food perishability results in similar discounting between the two commodities, then this might explain why food has been discounted more steeply in previous studies. Alternatively, if food is still

discounted more steeply than monetary outcomes, despite the features of the new procedure, then this would confirm that food and money are, in fact, uniquely discounted commodities.

2. Method

2.1 Participants

Individuals enrolled in psychology coursework were recruited as participants. The study was advertised on the Psychology Department's cloud based participant pool software, Sona Systems®. An online screening questionnaire introduced students to the study and provided information pertaining to participation eligibility.

2.2 Ethics Statement

Prior to participating in the study, individuals viewed the informed consent online and agreed to participate. By agreeing to participate, the individual confirmed that he/she was at least 18 years of age. Participants were compensated with possible extra credit toward their psychology coursework. The California State University, Chico Institutional Review Board approved the study.

2.3 Setting and Apparatus

Sessions were conducted in a windowless room in the Psychology department that was 9' x 6.5' x 8'. Participants were seated at a workstation featuring a Dell® PC with a 19" monitor and a screen resolution of 1280 x 1024. A 4' x 5.5' partition separated the participant workstation from a desk at which a research assistant was seated. For most of the session, the participant used a mouse to interact with the online survey, while the keyboard was used to answer a single question pertaining to time perception at the end of the survey. Survey data and demographic information were collected via Qualtrics® online survey software (Provo, UT)

2.4 Procedure

2.4.1 Screening Questionnaire

Individuals interested in participating in the survey study completed a brief screening questionnaire advertised on the department's Sona website (https://csuchico.sona-systems.com/) and hosted by Qualtrics®. Upon reading and agreeing to the informed consent, participants provided demographic information (e.g., age, sex, race, ethnicity). To ensure all potential participants would prefer to consume one of the pre-selected items used in the food discounting task, individuals were presented with several hypothetical food items that are commonly found in a vending machine (e.g., chips, fruit snacks, beef jerky) and were asked to choose the food item that they most preferred. Individuals who were 18 years of age or older and who selected one of the food items were deemed eligible to participate in the in-person experimental session.

2.4.2 Experimental Session

Upon completion of the screening questionnaire and being deemed eligible for the study, participants were scheduled to visit the laboratory for an experimental session lasting approximately 45 minutes. Upon arrival, the participant was provided with a copy of the informed consent and was instructed to review it and ask questions. Each participant was asked to stow cell phones and watches in a personal bag. This eliminated any time cues available to the participant. At this time, the research assistant started a stopwatch to determine the objective session duration (see Space/Time Perception below). The participant was then randomly assigned by the survey (block randomization) to one of four imagery-commodity conditions: nature-money, nature-food, built-money, or built-food. Prior to the data collection session, the research assistant had prepared the online survey and activated "full screen" mode, thereby obscuring a digital clock located in the Windows® taskbar. The participant was seated at the computer workstation, instructed to ask questions during the experimental session, and was given

verbal instruction on how to interact with the survey. The research assistant then returned to their desk behind the partition to ensure he remained blinded to the imagery-commodity condition to which the participant had been assigned.

Once seated, the participant completed, in order, a Positive and Negative Affect Schedule pre-test (PANAS; Watson et al., 1988), imagery exposure, the delay discounting task, a PANAS (post-test), the Nature Relatedness Scale (Nisbet et al., 2009), and a series of time and space perception questions. The only difference in participant experience across the four groups was the experimental manipulations to which the participant was exposed (imagery exposure and discounted commodity).

2.4.2.1 Positive and Negative Affect Schedule (PANAS)

All participants were initially presented with the PANAS. The scale consisted of ten positive (positive affect scale: PA) and ten negative (negative affect scale: NA) descriptors. The instructions asked participants to report the extent to which each descriptor applied to their current emotional state. The PANAS features a 5-point scale ranging from 1 (very slightly or not at all) to 5 (extremely). All descriptors and response options were presented on one screen. Participants were not required to respond to all statements. In addition to being administered at the beginning of the survey, the PANAS was also administered following the delay discounting task.

Upon the creation of the PANAS, Watson et al. (1988) reported high internal consistency for the PANAS for the PA scale (Chronbach's α ranging from .86 to .90) and the NA scale (Chronbach's α ranging from .84 to .87). In addition, evidence for factorial validity (two-factor model supported accounting for 75.4% and 73.3% of the variance for PA and NA respectively), convergent validity ($r > .90$), and discriminant validity was provided.

2.4.2.2 Imagery Exposure

Depending on group assignment, participants next viewed a slideshow consisting of images of either natural or built environments. These images have been used previously in studies focusing on attentional differences (Berto, 2005) and decision-making (Berry et. al. 2014; Berry et al. 2015). Each imagery set consisted of 25 photographs of built (e.g., cityscapes, roadways, industry) or natural (e.g., lakes, mountains, coastlines) environments. Each image was presented at a resolution of 1280 x 960 for 10 seconds in a randomized order prior to the start of the delay discounting task (following completion of practice trials as described below). Additionally, 5 randomly selected images from the original set of 25 images were displayed for 10 seconds each between each delay block in the delay discounting task.

2.4.2.3 Delay Discounting Task

Prior to beginning the delay discounting task, the research assistant read instructions that would subsequently be presented on the computer screen regarding how choices would be presented and how to choose a preferred option. Participants were also informed of the hypothetical nature of the task, and that there were no "right" or "wrong" answers.

During 10 practice trials, participants were presented with a choice between two alternatives differing in amount and delay to receipt ("Would you rather have (amount) now or (amount) in (delay)?"). The practice trials began by presenting the participant with the choice between $10 now or $100 in 1 week. Each practice trial began with the "smaller-sooner" (hereafter, SS) and "larger-later" (hereafter, LL) options on the left and right sides of the screen, respectively. The participant moved the cursor over their preferred option and clicked the mouse to indicate their choice. The SS and LL strictly alternated sides after each trial. Upon completion of the practice trials, participants experienced the initial imagery exposure.

Experimental trials began after the initial imagery exposure. Each delay block consisted of 10 trials. The task consisted of seven delay blocks (i.e., 1 day, 1 week, 1 month, 6 months, 1 year, 5 years, 25 years). The delay blocks proceeded in ascending order, beginning with 1 day and concluding with 25 years. The delay discounting tasks were programmed in Qualtrics® using JavaScript®.

2.4.2.3.1 Money Discounting

The monetary discounting procedures were identical to those used in the study by Berry et al. (2014) and the study by Berry et al. (2015). In the monetary condition, the first trial within each delay block began by presenting the choice between $50 now or $100 after 1 day. Based on the participant's decision, a titrating procedure adjusted the amount of the SS option for the subsequent trial. For instance, if the SS option was selected, then the SS option would decrease in size on the next trial. If the LL option was selected, the SS option would increase in size on the next trial. After the first trial, the SS option would be adjusted by increasing or decreasing the value by $25 depending on the participant's previous choice. Thus, the second trial for all participants presented either $25 now or $100 in 1 day, or $75 now or $100 in one day. The value of adjustment to the SS was halved on each subsequent trial. This process continued for 10 trials to determine the indifference point, or the present subjective value of the delayed reward for the participant (Borges et al., 2016).

2.4.2.3.2 Food Discounting

Upon completing the PANAS pre-test, participants assigned to the food conditions selected the item they would most prefer to receive from a hypothetical vending machine. Participants were not required to select the food item they had previously preferred during the online screening questionnaire. There were 10 food items from which to choose: granola bars,

bags of chips, packages of crackers, bags of cookies, bags of pretzels, bags of fruit snacks, bags of peanuts, candy bars, bags of beef jerky, or bags of popcorn. The food condition used the same numeric values as in the monetary conditions for the amount of food being compared (e.g., 50 candy bars now or 100 candy bars after a delay). The food delay discounting task operated identically to the monetary task with the exception of the type of commodity.

2.4.2.4 Nature Relatedness Scale (NRS)

Upon completing the delay discounting task, participants completed the PANAS post-test prior to completing the NRS (Nisbet et al., 2009). For the NRS, participants were presented with statements like, “I take notice of wildlife wherever I am” and “I am not separate from nature, but a part of nature.” The directions asked participants to rate the extent to which they agreed with each statement. The NRS consisted of 21 statements to be rated on a 5-point Likert scale, with respondent options ranging from 1 (strongly disagree) to 5 (strongly agree). All statements were listed on a single screen with a reminder of the response options after every sixth statement.

The Nature Relatedness construct was developed to assess the affective, cognitive, and experiential aspects of an individual’s connection to nature. Support was presented for the internal consistency of the overall measure (Chronbach’s $\alpha = .87$), test retest reliability over a two-month period ($r = .85$), and convergent and discriminant validity (Nisbet et al., 2009).

2.4.2.5 Demographics

Participants answered several demographic questions. The questions were viewed individually and required a response to proceed; however, each question had a “prefer not to respond” option. The first question asked the participant to indicate their age by selecting a number (ranging from 18 to 60) from a drop-down list. The second question asked the participant to indicate their sex by choosing the appropriate option in a multiple-choice format. The fourth

and fifth questions concerned ethnic and racial identification. The sixth question asked about cigarette smoking status. The seventh question only appeared if the participant answered, “yes” to the preceding question and requested information on cigarette consumption (i.e., cigarettes smoked per day). Participants respond by selecting the appropriate number on a drop-down list (ranging from 0 to over 30 cigarettes a day).

2.4.2.6 Space/Time Perception

Lastly, participants answered four questions relating to space and time perception. Each question was viewed individually. There were two space perception questions. The first asked, “How does space feel around you when you close your eyes?” The second question presented the same question with the additional prompt, “Picture yourself immersed in the images you saw on the screen throughout the study.” Participants responded on a 10-point Likert scale with responses ranging from 1 (space feels constricted) to 10 (space feels expansive).

There were two time perception questions. The first asked, “How quickly has time seemed to pass since you first arrived and viewed the informed consent?” Participants responded on a 5-point Likert scale with options ranging from 1 (time flew) to 5 (time dragged). The second question asked the participant to estimate how many minutes had passed since they viewed the informed consent. Participants responded by clicking in a text entry box and entering a valid number with the keyboard. This was the last question viewed by participants, and signaled the end of the data collection session. At this time, the stopwatch the participant had started at the beginning of the session; this value represented the objective session duration.

2.5 Data Analysis

Nonsystematic discounting was assessed using a validated criterion (Johnson and Bickel, 2008). Specifically, data were examined for instances in which an indifference point exceeded

the value of the immediately preceding indifference point by more than 20% (e.g., an $80 indifference point for the 1 year delay immediately preceded by a $50 indifference point for the 1 month delay).

Goodness-of-fit of the discounting data was established using the following two-parameter hyperbolic discounting equation (Myerson and Green, 1995):

$$V = 100/(1 + kD)^s \quad (1)$$

Equation 1 was fit to the mean indifference points for the four conditions (nature-food, nature-money, built-food, built-money) using nonlinear regression (GraphPad Prism®) to provide visual representation of the degree of discounting for each condition.

Area under the curve (AUC) was used to determine the level of impulsivity exhibited in the delay discounting task. AUC values were used for the dependent measure as they are a more precise representation of discounting as compared to *k* values (see Eq. 1), which are an approximation of discounting based on the model fit to the indifference points. AUC values correspond to the proportion of the graphical area beneath the discounting curve, and thus range from 0 to 1, with smaller numbers indicating higher degrees of impulsive decision-making (Myerson et al., 2001). AUC values were calculated using GraphPad Prism 7 (La Jolla, CA).

The study employed a 2 (imagery) x 2 (commodity) between-subjects factorial design. Eight dependent measures were examined for group differences in an exploratory fashion. AUC values, the primary dependent measure, were normally distributed, allowing for the use of a parametric statistical test. Consequently, a 2 x 2 factorial multivariate analysis of variance (MANOVA) was used to investigate group differences. The use of a MANOVA test allowed for a higher threshold for significance and reduced alpha inflation in comparison to examining each

dependent measure individually. Bivariate correlations were examined in an exploratory fashion to determine within-group relations between dependent measures.

3. Results

3.1 Sample Size and Orderliness of Delay Discounting Data

364 (95%) of 382 individuals who completed the screening questionnaire were eligible for the in-person experimental session. One hundred and eighteen eligible participants signed up for an in-person experimental session; 107 (91%) of these individuals completed the experimental session.

Of the 107 individuals that completed the experimental session (749 individual indifference points from the discounting tasks), 19 (2.5%) indifference points were flagged due to nonsystematic discounting.

3.2 Demographic Information

Table 1 presents demographic information. The mean age was 23.6 years (*SD* = 6.8). A one-way ANOVA found no differences in age across the four conditions, $F(3, 103) = 2.6$, $p = .06$. Of the 107 participants, 19 identified as male and 88 identified as female. Chi-square analyses revealed no differences between the observed and expected frequencies between groups for sex, $X^2(3) = 1.4$, $p = .70$, race, $X^2(18) = 23.5$, $p = .17$, ethnicity, $X^2(6) = 5.7$, $p = .46$, or smoking status, $X^2(6) = 7.3$, $p = .29$.

3.3 Delay Discounting

Figure 2 displays the mean indifference points across the four conditions. Eq. 1 provided good fits to the mean indifference points for nature-food ($R^2 = .97$), nature-money ($R^2 = .99$), built-food ($R^2 = .95$), and built-money ($R^2 = .99$).

Significant multivariate effects were found for imagery (nature vs. built), $\lambda = .44$, $F(8, 96) = 15.1$, $p < .001$, $\eta_p^2 = .56$, and commodity (food vs. money), $\lambda = .74$, $F(8, 96) = 4.2$, $p < .001$, $\eta_p^2 = .26$. These effects were examined further using 2 x 2 factorial ANOVAs. There were no differences in discounting (AUC) between natural and built imagery conditions ($p = .08$). There was a small significant main effect for commodity ($\eta_p^2 = .06$), in that food was discounted more steeply than money, $F(1, 103) = 6.1$, $p = .02$. There was no significant interaction between image and commodity conditions on discounting ($p = .30$).

3.4 Pre-test vs. Post-test PANAS

A pair of positive affect and negative affect scores was generated for each participant (i.e., PANAS pre-test and post-test). Subtracting the pre-test score from the post-test score generated difference scores for the positive and negative scales. This new dependent measure represented a change in positive or negative affect as a result of stimulus exposure.

There were no differences between the four groups in terms of positive affective change, $p = .62$, or negative affective change, $p = .23$. There was no main effect for image condition, in that there were no differences in positive affective change, $p = .77$, or negative affective change, $p = .61$, as a result of viewing images of either natural or built environments.

3.5 Nature Relatedness

There were no between-group differences in nature relatedness, $p = .66$. In addition, there was no significant main effect for image condition; thus, no differences were found in connectedness with nature as a result of being exposed to images of natural or built environments, $p = .21$.

3.6 Space/Time Perception

There were no significant differences between groups in regards to how space felt around participants upon closing their eyes, p = .92. However, there was a moderate main effect of imagery condition (η_p^2 = .53) for the question that asked participants to imagine that they were immersed in the environments from the session. Participants who viewed images of natural environments reported that space felt expanded to a greater degree compared to those who viewed images of built environments, $F(1, 103) = 118.16$, $p < .01$.

In terms of objective session duration, there was a small main effect for commodity (η_p^2 = .04), in that the sessions for those participants who completed the food discounting task were, on average, longer than the sessions for those participants who completed the money discounting task (26.1 min. vs. 24.7 min.), $F(1,103) = 4.72$, p = .03. This difference resulted from one additional question in the food commodity condition (i.e., hypothetical vending machine question). Due to this difference in objective session duration, a new measure was created to account for this difference by calculating the difference between participants' estimated session duration and the objective session duration. There were no differences between groups in terms of the difference between subjective and objective session times, p = .50.

For time perception, there was a small main effect for commodity condition (η_p^2 = .18), in that participants in the food conditions (M = 3.7, SD = 0.8) reported that time dragged more compared to those in the monetary conditions (M = 2.9, SD = 0.9), $F(1, 103) = 22.58$, $p < .01$.

3.7 Correlational Analyses

Four bivariate correlations were examined to determine within-group relations between dependent measures.

Within the nature-food group, there was a significant negative correlation between session duration differential in the nature-food condition and positive affective change (i.e.,

overestimation of session time was associated with decreased positive affect, $r = -.57$, $p = .002$) and NRS scores (i.e., overestimation of session time was associated with decreased nature relatedness, $r = -.50$, $p < .01$).

Within the nature-money group, there was a significant positive correlation between session duration differential and time perception (i.e., overestimation of session time was associated with increased time perception; $r = .44$, $p = .02$). There was also a significant negative correlation between space perception and time perception (i.e., increased expansiveness of space was associated with time "dragging"; $r = -.42$, $p = .03$).

Within the built-food group, there was a significant negative correlation between time perception and positive affective change (i.e., time "dragging" was associated with a decrease in positive affect, $r = -.41$, $p = .04$) and AUC (i.e., time "dragging" was associated with steep discounting, $r = -.46$, $p = .02$).

Within the built-money group, there was a significant positive correlation between AUC and NRS scores (i.e., higher AUC values [less discounting] was associated with greater nature relatedness, $r = .42$, $p = .03$). There was also a significant positive correlation between session duration differential and time perception (i.e., overestimation of session time was associated with time "dragging," $r = .49$, $p = .01$).

4. *Discussion*

The purpose of the current study was to systematically replicate the research by Berry et al. (2014) and Berry et al. (2015) in the attempt to reproduce the effect that exposure to natural imagery results in less discounting (i.e., greater self-control). Despite the use of the same imagery exposure and delay discounting procedures, this effect was not reproduced. In other words, there were no differences in the degree of delay discounting between individuals who

viewed images of natural or built environments. Moreover, because there were no significant differences in delay discounting between imagery conditions, it was impossible to identify potential mechanisms for this effect in terms of affective change, nature relatedness, or space and time perception.

One explanation for this null finding involves differences in the geographic locations of the populations from which these experiments sampled. Specifically, the study by Berry et al. (2014) was conducted at Utah State University, which is located in a mountain valley in northern Utah. Likewise, the study by Berry et al. (2015) was conducted at Montana State University, another campus surrounded by mountains, forests, and wilderness in central Montana. In addition, these universities advertise that their close proximity to nature is their foremost attraction. It is possible that the students attending these two institutions have an elevated affinity for nature. By comparison, California State University (CSU), Chico is located in a small town surrounded by agricultural land. While there are locations that offer a retreat into nature, they are not as remote as those located near the previously mentioned institutions. As a result, engagement in outdoors opportunities (e.g., skiing, camping, wildlife observation) is likely greater at Utah and Montana State Universities. Thus, the samples for the previous studies may have been prone to discounting excessively steep in the presence of built environments, and/or discounting excessively shallow in the presence of natural environments. If so, this may limit the external validity of the previous research. More research is therefore needed to fully understand the impact of viewing nature on impulsivity in diverse populations living in various locations.

Although the present study did not reproduce the positive effect of natural imagery on discounting, it did reproduce the well-established finding that food is discounted more steeply than money. This is consistent with the literature, that consumable commodities (e.g., food) are

discounted more steeply than money (e.g., Estle et al., 2007; Forzano and Logue, 1992; Friedel et al. 2014; Odum et al., 2006; Odum and Baumann 2007; Odum and Rainaud, 2006). This finding was important for two reasons. First, reproducing a well-established outcome from the delay discounting literature suggests that the present study had some degree of internal validity despite the presence of some nonsystematic responding. Second, despite the use of a novel food discounting procedure that more closely approximated the money discounting procedure and incorporated less perishable food items, discounting was still steeper for food than it was for money. Thus, it appears that food and money may be discounted differently, regardless of how the former commodity is conceptualized.

In addition to findings from the delay discounting tasks, there were differences in space perception between participants that viewed images of natural environments and those that viewed images of built environments. Although there were no differences between groups on the first question regarding space perception, differences emerged for the second question, which asked participants to imagine they were immersed in the environment they saw throughout the session. In particular, those in the natural imagery conditions reported that space felt more expansive relative to those in the built imagery condition. While this finding may seem somewhat intuitive, this is the first time such an observation has been made using this set of natural and built images and, to this author's knowledge, reported in the general literature. Such a finding could have applied significance for those experiencing anxiety disorders or phobias involving confined spaces. Specifically, by exposing individuals with claustrophobia to images of nature and subsequently practicing visualizing those expansive environments, such a therapy may alleviate feelings of anxiety. This treatment would effectively teach a safety behavior for these individuals, the appropriate use of which has led to improvements in measures of

claustrophobic fear (e.g., Deacon et al., 2010; Rachman et al., 2008). Further research is necessary to investigate the viability of this technique in the realm of anxiety disorders.

There are several limitations to be considered from the present study. First, it is possible that participants in the food conditions discounted more steeply than participants in the money condition because the number of food items was potentially burdensome. For example, receiving $100 requires fewer resources to store and "consume" compared to receiving 100 candy bars. Thus, although a food reward may be comparable in value to a monetary reward, the handling cost required for a consumable commodity may lead to further discounting of its subjective value (Madden et al., 2000). Second, although the number of participants in each group was comparable to that of previous research (Berry et al.2014; Berry et al. 2015), it would have been ideal to include more participants given the addition of a second commodity. In addition to size, a more diverse sample would have been preferable given that the sample consisted primarily of white college-aged female participants. Third, future research should attempt to replicate the effect of viewing natural imagery on delay discounting in a location that is less rural than the locations used in the previous research and the present study. It is possible that students enrolled at an urban institution would discount less steeply upon exposure to images depicting built environments. Fourth, the objective session duration differences between food and monetary commodity conditions should have been considered and accounted for prior to data collection. Future research should equate objective session durations to best compare measures such as space and time perception. Finally, the delays and outcomes presented to participants were entirely hypothetical. Furthermore, the present study did not specify what could happen during the delay to the reward (e.g., whether participants could or could not continue to pursue other

rewards in the interim), which could have impacted the degree of discounting (Johnson et al., 2015).

This study failed to reproduce the effect seen in previous research (Berry et al., 2014; Berry et al., 2015) that viewing images of nature produces shallow discounting relative to viewing images of built environments. This occurred despite the use of identical money discounting procedures and identical environmental images. Future research should attempt a direct replication of the previous research (Berry et al. 2014; Berry et al. 2015) in a similar, mostly rural location before including additional commodities to investigate the generality of the effect. If unaffiliated research groups are able to reproduce the effect under strict conditions, then this may set the stage for further research to elaborate on the existing findings. A logical extension of the current research would be to expose participants to actual natural and built environments to investigate how complete immersion in these surroundings would impact discounting. Such research could set the stage for treatments designed to promote self-control in vulnerable populations (e.g., drug-dependent populations). Findings that immersion in natural environments lessens discounting could also be used to promote conservation efforts and inform environmental policy (Hepburn et al., 2010). Applications such as these, however, remain contingent upon further laboratory evidence supporting the positive effect of natural imagery on delay discounting and related processes.

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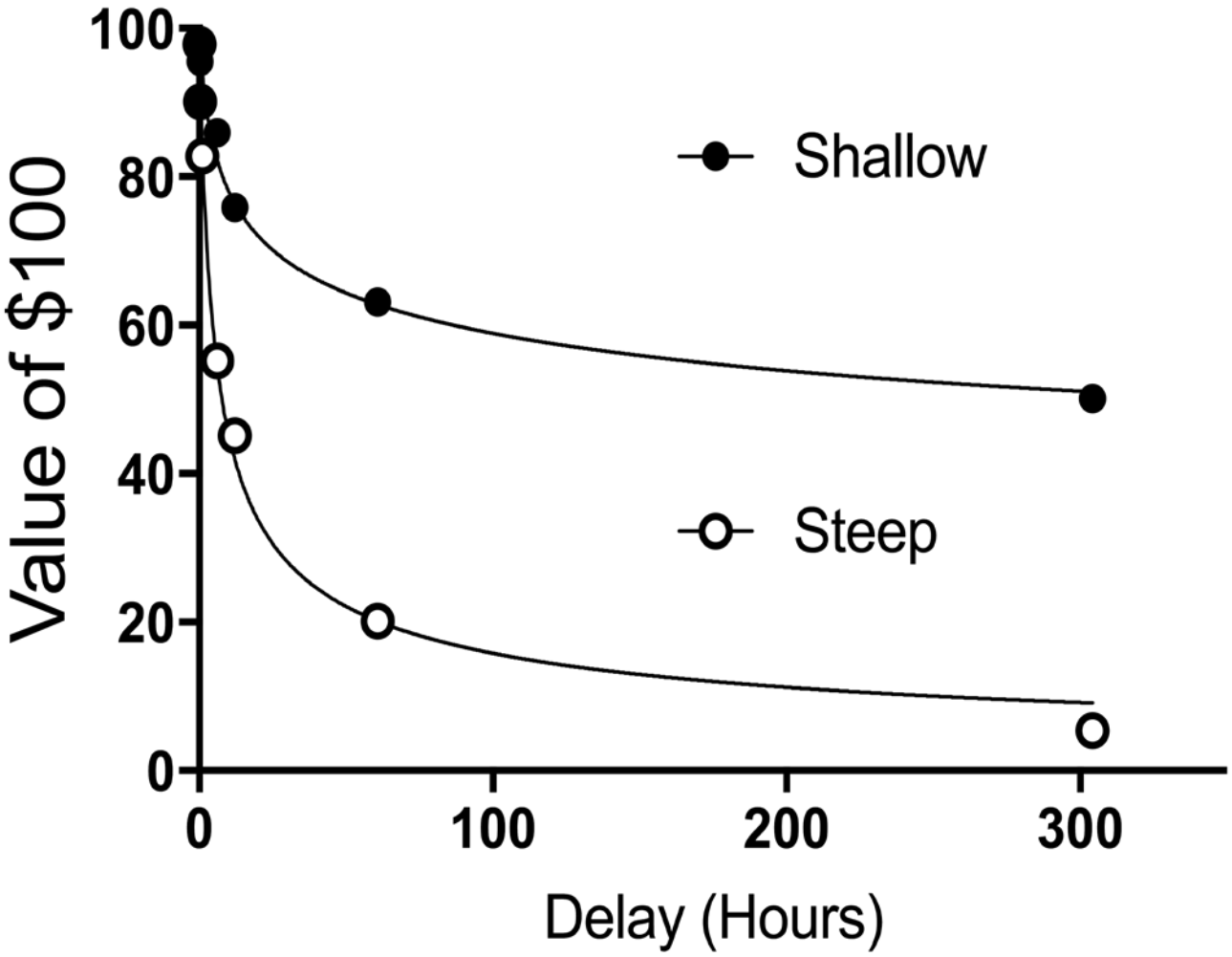

Figure 1: Hypothetical delay discounting curves displaying an example of shallow discounting (filled circles) and steep discounting (open circle).

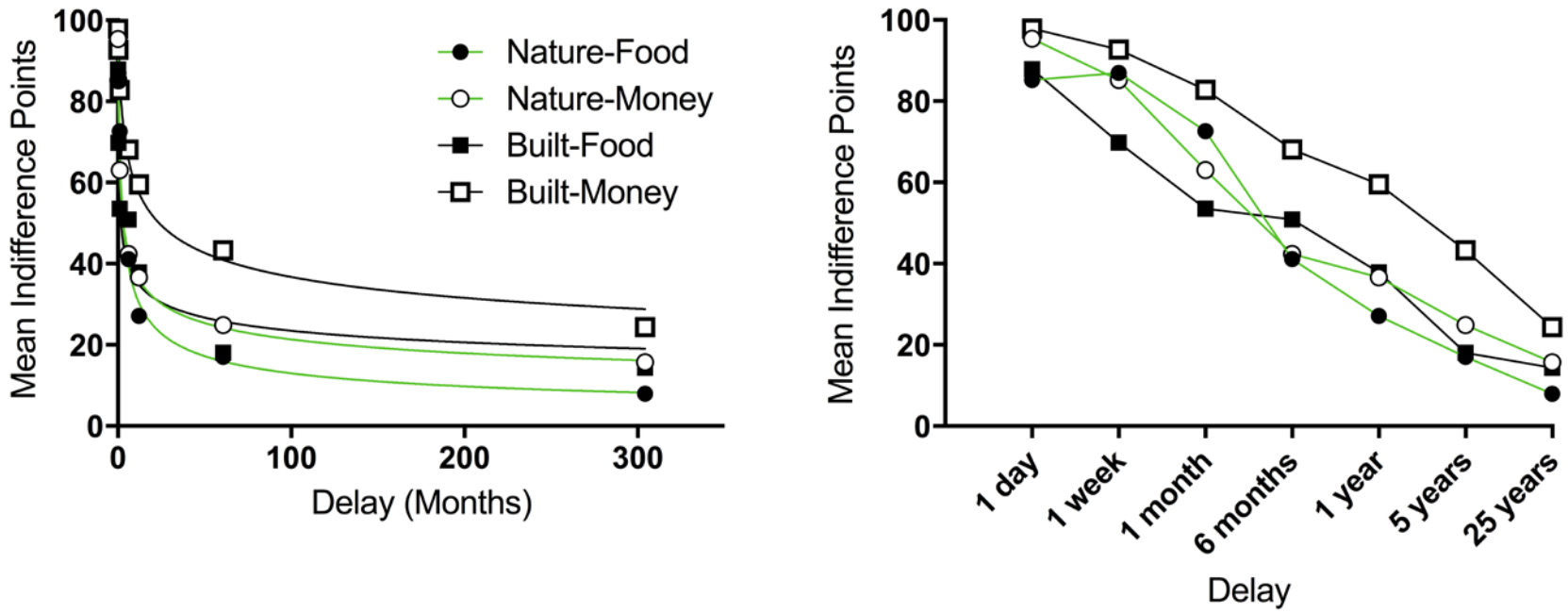

Figure 2: Mean indifference points as a function of delay (months) for nature-food (filled circles, green line), nature-money (open circles, green line), built-food (filled square, black line), and built-money (open square, black line) conditions. Discounting curves shown in the left panel are the best-fitting curves (Equation 1) to the mean indifference points. The right panel shows the same data as in the left panel with delays expressed ordinally (i.e., not continuously).

Table 1: Demographic information.

	Condition					
Demographic	Nature-Food	Nature-Money	Built-Food	Built-Money	Test statistic	*P* value
Age in years, mean (SD)	23.3 (5.7)	23.6 (6.9)	21.2 (2.0)	26.3 (9.5)	$F(3,103) = 2.6$	$p = .06$
Sex, count (%)						
Male	6 (22.2)	6 (21.4)	4 (15.4)	3 (11.5)	$X^2(3) = 1.4$	$p = .70$
Female	21 (77.8)	22 (78.6)	22 (84.6)	23 (88.5)		
Race, count (%)						
Caucasian/White	16 (59.3)	18 (64.3)	19 (73.1)	19 (73.1)	$X^2(18) = 23.5$	$p = .17$
African-American/Black	1 (3.7)	0 (0)	0 (0)	1 (3.9)		
Asian	5 (18.5)	1 (3.6)	2 (7.7)	1 (3.9)		
Native Hawaiian/Pacific Islander	0 (0)	0 (0)	1 (3.9)	0 (0)		
American Indian/Alaskan Native	0 (0)	1 (3.6)	0 (0)	0 (0)		
More than one race	0 (0)	5 (17.9)	0 (0)	2 (7.7)		
Prefer not to respond	5 (18.5)	3 (10.7)	4 (15.4)	2 (7.7)		
Ethnicity, count (%)						
Hispanic or Latino	12 (44.4)	11 (40.7)	6 (23.1)	9 (34.6)	X^2 (6) = 5.7	$p = .46$
Not Hispanic or Latino	15 (55.6)	17 (60.7)	19 (73.1)	17 (65.4)		
Prefer not to respond	0 (0)	0 (0)	1 (3.9)	0 (0)		
Cigarette smoking status, count (%)						
Smoker	2 (7.4)	3 (10.7)	0 (0)	0 (0)	X^2 (6) = 7.3	$p = .29$
Non-smoker	25 (92.6)	24 (85.7)	25 (96.2)	26 (100)		
Prefer not to respond	0 (0)	1 (3.6)	1 (3.9)	0 (0)		

Note: SD = standard deviation.