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EFFECTS OF MATCHING IMAGES OF NATURAL AND BUILT ENVIRONMENTS ON DELAY DISCOUNTING: A SYSTEMATIC REPLICATION OF BERRY ET AL. (2014)

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by

Elizabeth "Ellee" Fillmore

B.S., Southern Illinois University, 2020

A Thesis
Submitted in Partial Fulfillment of the Requirements for the
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THESIS APPROVAL

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in the field of Behavior Analysis and Therapy

Approved by:

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Decision making is heavily influenced by the environment around us. Berry et al. (2014, 2015, 2019) showed that viewing images of natural environments during the delay discounting task resulted in lower impulsive choice, as compared to viewing images of built environments or geometric figures. Berry et al. proposed that attentional factors could explain this effect, however, recent attempts to reproduce Berry et al.’s findings in a different laboratory have been unsuccessful (Johnson 2017, 2018, 2019). The present study tested if manipulating the participants’ observing responses towards different types of images (natural, built, and no images) modulates the effect reported by Berry et al. Eighty-seven college students were exposed to a matching-to-sample task aimed at increasing observation responses to the images (attentional manipulation) throughout the same delay discounting task implemented by Berry et al. (2014). It was expected that increasing the participants interaction with the images via the matching task would increase the magnitude of the effect reported by Berry et al. (2015); namely, further reduction of impulsive responses after being exposed to images of natural environments and increase of impulsive choice when exposed to built environments. Results indicated that participants who engaged in matching images of built environments had a higher rate of discounting than the group that replicated Berry et al. (2014). Matching images of natural environments did not seem to reduce impulsive choice, as predicted based on Berry et al.’s findings. Furthermore, none of the groups of the present study reproduced the rates of delay

discounting originally reported by Berry et al. Participants in Berry et al., (2014) overall discounted less steeply when compared to participants in the present study. This finding resembles the results reported by Johnson et al. (2017, 2018, 2019) in their replica attempts. Lastly, participants' self-reports regarding time spent in natural and built environments did not correlate with rate of discounting. Future research should use the number of correct responses as a measure of procedural integrity. Also, it is possible that perhaps participants failed to match more often in the built condition, and such aversive condition could have increased the impulsive choice for that group (Flora et al. 1992, 2003).

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

Under certain circumstances, individuals tend to choose smaller immediate rewards rather than larger delayed rewards. For example, an individual may prefer 20 dollars now rather than wait one week for 30 dollars. This phenomenon is known as impulsive behavior (Odum, 2011). Impulsive behavior is relevant to the understanding and intervention on several socially relevant issues, including food addiction (Minhas et al. 2021), drug addiction (Cassidy & Kurti, 2018), gambling (Dixon et al., 2006), academic procrastination (Zentall, 2021), climate change (Berry et al., 2019), and risky sexual behavior (Johnson et al., 2021). One approach to understand impulsive behavior, which has captured considerable attention during the last decades, is delay discounting. It overall describes the devaluation of an outcome because it is delayed (Madden & Johnson, 2010).

Delay Discounting

The tendency to devalue delayed consequences or future prospects is another way to describe delay discounting (Rung et. al., 2019). Research has shown that discounting functions tend to be hyperbolic (or approximately so) across both human and nonhuman species (Odum, 2011). The hyperbolic shape could be described as more steep decline in reward valued at short delays and a shallow decline at longer delays. Steeply discounting the value of delayed outcomes usually underlies a pattern of impulsive choice (Rung & Madden, 2018). The extent to which individuals discount the value of rewards correlates with health and disorder-related outcomes. For example, those that are addicted to gambling are more likely to steeply discount (Dixon, 2006). Research has shown that delay discounting could be decreased using behavioral trainings and other manipulations (Scholten et al., 2019). Exposure to antecedent stimulation has been one of those manipulations, and it is the area in which the present study focuses.

History and Development of Delay Discounting Research

Delay discounting has a deep and rich history in the field of behavior analysis dating back to the 1950's. The research is flourishing and steadily growing with implications for socially important issues, like drug abuse (Carroll et al., 2010) marriage infidelity (Reimer, 2009) grades (Reimer, 2009), gambling (Dixon, 2003), and obesity (Tang, 2019). The number of articles published is rapidly growing, especially with an applied focus. For instance, using PubMed Central (National Library of Medicine) to locate articles published in the *Journal of Applied Behavior Analysis* using the keyword 'Delay Discounting' shows a total of 49 articles published. Using the same keywords to search in the *Journal of Experimental Analysis of Behavior* showed that a total of 53 articles have been published just in the last ten years (2012-2022).

The origins of the research on delay discounting in behavior analysis started in animal laboratories studying patterns of choice in operant conditioning chambers (Skinner, 1950). Animal choice procedures were first used by Logan (1965), to quantitatively describe how reinforcer value declines with increasing delays. Not long after, several researchers proposed that the shape of the discounting curve was a hyperbola or hyperbolic (Rachlin et al., 1991; Johnson & Bickel, 2002).

Implementing a delay discounting procedure with hypothetical money was first attempted by Rachlin et al., (1991). These data strongly supported a hyperbolic discounting equation over other formulations, in both animals and humans. A subsequent study that supported these findings was published by Johnson and Bickel (2002), which not only showed similar patterns of discounting, but also similarities across hypothetical and real rewards. Currently, the self-report methodology used for delay discounting research is known to be accurate. This is because there is not a right or wrong answer, the individual is making a choice in the present, and the individual is not comparing themselves to others (Odum, 2011).

The degree of discounting in reward type is not due to addiction (Odum & Rainaud, 2003). Food and alcohol were found to be discounted the same, which was also always steeper than money. Studies on the degree of discounting in relation to reward amount indicate that the more self-controlled we are, the less steeply we discount (Green et al. 1997). Finally, research on the degree of discounting across different ages indicates that children discount more steeply than young adults (Oden & Rainaud, 2003).

Models of Delay Discounting

Researchers have been trying to find the functions of delay discounting by using quantitative models (Odum, 2011). Quantitative models have been of interest because they allow to identify higher order dependent variables, describe processes in a precise way, describe structures/functions that may or may not exist, and stimulate research with clear predictions (Nevin, 1984; Shull, 1991).

Rachlin (1974) provided supporting data to conclude that the hyperbolic model is the best function for delay discounting. Rachlin showed that the hyperbolic model predicts well preference reversals during high discounting. The hyperbolic model shows that it is initially preferred to have a larger more delayed reward. However, preference changes to the smaller immediate reward as time progresses. For example, when the delay is one week an individual is more likely to choose the larger later reward but as the delay increases, an individual is more likely to choose the smaller sooner reward (choice of a smaller, more immediate reward over a larger more delayed reward).

Another assessment of delay discounting was conducted by Mazur (1987) via generating indifference points between smaller more immediate rewards and larger later rewards at a variety of delays. This is the equation to generate the indifference points $V= A/ 1 + kD$ (V=present value; A=amount; D= delay; k= degree of discounting). This showed to also fit best with the function of a hyperbolic model. A more complex model has been $V=A/1 + kD^s$ where the “s” has been interpreted by Rodriquez and Logue (1988) as sensitivity to delay. This model accounts more variance than the equation without “s”. Another model that was proposed was $V= A/ (1+kD)^s$ where the “s” has been interpreted by Myerson and Green (1995) as nonlinear scaling of amount and time. This latter equation often accounts for just as much variance as the previous one (Odum, 2011).

When considering the different types of functions for delay discounting and how the present value is related to the delay, a linear function has been found to be too simple and has not worked (Odum, 2011). Another function that has been tested is exponential. This function will change by a certain proportion for each unit of time. The exponential function also was limited in describing delay discounting data, mostly due to the inability to work without making assumptions (Odum, 2011).

Altogether, the option that has received more attention is the hyperbolic function, which initially seemed fitting, but researchers wanted to confirm with further tests (Odum, 2011). Aligned with that effort, Akaike Information Criterion (AIC; Akaike, 1974) has been used to compare exponential and hyperbolic functions. AIC measures the relative goodness of a fit of a model. It also, describes the tradeoff between accuracy and complexity by penalizing models for a greater number of free parameters (Akaike, 1974).

Methodologies for the Study of Delay Discounting

Delay discounting procedures are mainly about "finding the point at which two rewards, one relatively immediate and one delayed, have approximately the same value" (Odum, 2011, pg. 249). Among different methods that can be used, one frequently implemented entails using the duration of the delay to the larger later reward to create a dependent variable known as an indifference point, which represents the value of the delayed outcome (Odum, 2011).

Another method that can be used to assess how delay affects the value of an option is to adjust the delay to one of the choices to the amount of the choice can be adjusted across trials while the delay is held constant. Both methods mentioned above (adjusting the delay option and duration of the delay), produce similar estimates of the degree of discounting for humans (Odum, 2011). However, a procedure developed by Evenden and Ryan (1996), may be the most prevalent way to determine how delay affects value in nonhumans (Odum, 2011). The delay to the larger later reward option increases across blocks within the experimental session making it very efficient. This procedure does not generate indifference points; instead, results in calculation of percent of choices for the larger later option as the dependent variable.

For humans, how the delay affects the value of outcomes is very similar to nonhumans. The example above described for nonhumans (delay to the larger later reward option increases across blocks within the experimental session) can also be used to measure delay discounting in humans. However, one main difference is using hypothetical resources for the delays and rewards. Currently, most publications in the area of human delay discounting are based on purely hypothetical outcomes (Odum, 2011).

Interventions on Delay Discounting

One of the manipulations that has shown changes in delay discounting is delay fading. It is a training procedure that has shown to produce relatively long, lasting reductions in impulsive choice. It was first described by Mazur and Logue (1978) via establishing pigeons' preference for a large over a small food reward when both rewards were delayed. After many subsequent sessions, the delay to the smaller reward was gradually reduced. During this time, they were careful to maintain a strong preference for the larger later reward by giving the pigeons a small amount. The delay to the smaller sooner reward was eventually faded out and the outcome showed the pigeons continued to prefer the larger later reward far more than the control group that received no delayed fading (Mazur & Logue, 1978).

Another demonstration of effective changes in delay discounting consisted of manipulating money management in cocaine addicts (Black & Rosen, 2011). In this study, there were two groups, one control, and one that received money management. The outcome showed that the money management training influences the likelihood to relapse. In other words, the more time spent in money management training, the less likely one is to relapse. In this case, the control group was much more likely to relapse since they did not receive any training. In the present study, visual exposure to natural environments was used as an intervention on delay discounting.

Other interventions have been shown to also produce changes when there is exposure to natural environments (Berry et al., 2015, 2019)

Visual Exposure to Natural Environments and Impulsive Responses

Several studies have shown that seeing a natural environment causes less impulsive responses (Berry et al., 2014, 2015, 2019). By using images of natural environments projected on a computer screen, Berry et al. (2014) were able to decrease impulsive response during a delay discounting task. The same findings were reported by van der Wal et al. (2013) using a different discounting task and different images of natural environments. Van der wal et al. were able to explain the gain in self-control by suggesting that it is because of an evolutionary process: "Pictures of natural environments signal resource abundance therefore individuals discount future outcomes less" (Berry et al., 2015, p. 3).

Berry et al.'s (2014) first report on the effects of images of nature on delay discounting was followed by a systematic replication by Berry et al. (2015), which aimed at exploring the role of time perception. Additional to reproducing the effect on impulsive choice, Berry et al. (2015) found that images of natural environments also affected time perception. They proposed that time perception may be a potentially complimentary mechanism by which natural environments might increase self-control. For the authors it was "possible that restorative natural environments are tranquil-reducing general arousal, and/or increasing attentional capacity- and that viewing them lengthens the perception of time." (Berry et al. 2015).

In a third study, Berry et al. (2019) again presented images of natural environments to their participants, but their aim was to test if the effect could be reproduced with discounting of air quality. As predicted, they were able to demonstrate, for the first time, that other outcomes different than monetary discounting could be influenced by exposure to pictures of natural versus built environments.

Although not tested yet, Berry et al. (2014) proposed that attention is a factor that could be responsible for the effects of images of natural environments on discounting. They argue that… "viewing natural scenes could increase baseline levels of attention leaving additional attentional resources to devote to consequences of decisions… Differences in attention could contribute to decreased impulsive decision-making when viewing natural scenes." (Berry et al., 2014 p. 5). The present study explored further this hypothesis.

Recent Replication Attempts of Berry et al. (2014, 2015)

Recent replication attempts of Berry et al.'s (2014, 2015) studies in a different laboratory (Patrick Johnson's, California State University, Chico) have been unsuccessful on reproducing the same effect of images of natural environments on delay discounting.

Johnson and Hodes (2017) systematically replicated Berry et al.'s (2014, 2015) procedure and tested both monetary and food discounting. They hypothesized that one potential reason why money was discounted less steeply for participants who viewed the natural imagery was that the vast, empty landscapes shown on the pictures served as Delta Stimulus (S^{Δ}) for monetary exchange. In other words, there was nothing depicted on the images for the participants to spend their money on. In contrast, the urban landscapes might have signaled exchange opportunities. Johnson and Hodes (2017) predicted that by using a non-monetary commodity they were able to tease out the conditioned vs. unconditioned reinforcer discrepancy that might have explained the initial findings by Berry et al. However, Johnson and Hodes (2017) were not successful in reproducing the original effect reported by Berry et al. (2014, 2015).

Two more replication attempts have been conducted by Johnson and their graduate students. Johnson and Boullion (2018) only tested the monetary discounting effect, and Johnson and Boullion (2019) directly replicated all Berry et al.'s (2014) procedures to the best of the authors' ability. However, on both cases, results were inconclusive, and overall did not reproduce the effects reported by Berry et al. related to exposure to images of built and natural environment on delay discounting.

The Present Study

The present study aimed to continue exploring variables that moderate the effect reported by Berry et al. (2014, 2015) regarding the role of images of natural environments on delay discounting. The experiment focused on a factor Berry et al. (2015) proposed as responsible for such effect; namely, attention. In doing so, the present systematic replication tried to extend Johnson et al. (2017, 2018, 2019) inconclusive efforts to reproduce such effect in a different laboratory.

The procedure reported by Berry et al. (2014) was directly replicated (e.g., same delay-discounting task, dependent variables, data analysis, etc.). In addition, a matching-to-sample task designed and developed by Henao, Clavijo, and Hurtado-Parrado (under review) was added at the beginning of the experiment to manipulate the attention of participants, hereon understood as observing responses (i.e., operant behavior that functions to produce a discriminative stimulus or extinction stimulus; Pierce & Cheney, 2017).

Two groups of participants replicated directly the design reported by Berry et al. (2014) in terms of being differently exposed to 25 images of only one type (Replica Berry et al. Natural and Replica Berry et al. Built). Two groups were exposed to matching-to-sample trials (Matching Natural and Matching Built) in which participants interacted with those same images using a computerized task. An additional control group (No Images), which did not observe or match images at all was also included to explore the effect of the delay discounting task separately. It was expected that participants assigned to groups that were required to match images of nature (i.e., increasing observing behavior) would overall show less impulsive behavior, as compared to the other conditions. Similarly, it was expected that increasing observing responses to the images of built environments would have the opposite effect (i.e., increments on impulsive responses).

CHAPTER 2

METHODOLOGY

Participants

Eighty-seven undergraduate students were recruited via SIUC's Psychology Research Participant Pool. Each participant was assigned to only one condition ("Matching Natural," "Matching Built," "Replica Berry et al. Natural" "Replica Berry et al. Built)", or "No Image" groups - see Procedure and Design sections below). To be included in the present study, each participant must have been 18 years or older, signed a consent form and a release form allowing the researchers to use all data collected during the time of the experiment. Participants that could not come to campus for data collection were not included in the study. All procedures were approved by the Institutional Review Board (IRB) at Southern Illinois University Carbondale prior to the start of the study. Participants received one credit for SIUC Psychology 102 course as compensation for participating in the experiment.

Instruments/Materials

Data collection took place in a computer room of Life Science II at SIUC. Demographic data were collected using Qualtrics, it included gender (male, female, other), age (in ranges, including "under 18," "18-24," "25-34," "35-44," "45-54," "55-64," "65-74," "75-8"4, and "85 & older") and employment status ("employed full time (40 or more hours per week)," " employed part time (up to 39 hours per week)," "unemployed and currently looking for work," "unemployed not currently looking for work," "student," "retired," "homemaker," "self-employed," and "unable to work"). The following questions were also collected: "How many hours approximately you spent during the last week directly exposed to natural environments, including lakes, rivers, hills, woods, orchards, forests, etc.?" "How many hours approximately you spent during the last week directly exposed to built environments, including city streets, industrial zones, housing porches, urban areas, and skyscrapers, etc.?" "How many hours approximately you spent during the last week indoors at home?" "How many hours approximately you spent during the last week indoors at work (if you did not work last week, please choose N/A)?" All questions had the choices of 0 - 3 hours and continued in increments of 3 hours until 15+ hours.

The delay discounting task was programmed in Qualtrics and replicated Berry et al.' (2015) task. When applicable (see Conditions and Design sections below), it included images reported in Berry et al. (2014), which consisted of 25 photographs of natural and built environments from Berto (2005). Screenshots of the demographics and delay discounting task are provided in Appendix C and D. Samples of the images from Berto (2005) are provided in Appendix A and B.

Ten choice trials were programmed and arranged in blocks based on delays between an immediate reward and a delayed reward in 1 day, 1 week, 1 month, 6 months, 1 year, 5 years, and 25 years (see more details in Procedure section). For the matching-to-sample trials, a maximum of 25 trials, one for each image of each type (natural and built), were programmed.

Consent forms were signed before participants started the experiment, and then placed safely in a locked storage unit in the building Life Science II on SIUC's campus.

Design

Participants were randomly assigned to one of five groups, which varied in terms of the type of images (No Images, Natural, and Built environments) and matching-to-sample trials. Table 1 shows the details on distribution of the participants across groups. For instance, fifteen participants were randomly assigned to the "Natural Matching" group, in which participants matched images depicting natural environments,. Please note on Table 1 that only one group of "No Image" was configured (N = 15) to test the effect of not observing or matching any image.

Table 1

Distribution and number (N) of participants across the different groups, which was configured in terms of image type (natural, built, no image) and matching-to-sample trials.

	Image type		
Matching or no matching	*No Image*	*Natural Environment*	*Built Environment*
No Matching (Replica Berry et al., 2014)	*N = 13*	*N = 13*	*N = 13*
Matching		*N = 15*	*N = 13*

Procedure

Participants were invited to attend a single session in a computer room of the Life Science II building of Southern Illinois University Carbondale. Prior to arriving, each was randomly assigned to one of the groups described in the Design (see also Table 1).

Participants that were in groups that viewed images (Replica Berry et al. Natural, Replica Berry et al. Built, Matching Natural, and Matching Built groups) went through 3 steps during the experiment - (see Figure 1) namely, (1) images (images without matching, images with matching trials); (2) Delay discounting task broken into 7 blocks (1 day, 1 week, 1 month, 6 months, 1 year, 5 years, and 25 years) that consisted of 10 larger later reward questions. Interspersed between each block were 5 randomly presented images. Matching groups found the small image within the larger image during each of the interspersed images and non-matching groups, or

Replica groups, were instructed to view; and (3) Demographics survey. Participants in the No Images group experienced a similar session; however, no images were viewed prior to the delay discounting task or interspersed between each delay block. Sessions were expected to last approximately 30 minutes. Figure 1 shows a description of each step.

Images/ Matching to Sample →	**Delay Discounting Task** →	**Demographics** →	**End**
Participants viewed 25 images. Matching groups will complete the matching to sample task, replica groups will not. No images group skips this step.	Participants saw 10 trials of larger later, smaller sooner for each delay period. (1 day, 1 week, 1 month, 6 months, 1 year, 5 years, and 25 years). Five randomly-selected images were interspersed between each delay block.	Participants completed a form informing researcher of age, ethnicity, questions pertaining to time spent outdoors and around built environments and occupation	Experiment was over.

Figure 1. Flow Diagram of the 3 steps of the experiment. Images/Matching to Sample, Delay Discounting Task, Demographics, End of experiment.

Image Presentation

Depending on random group assignment, each participant was exposed to only one of the following conditions:

No-Matching Berry et al. Replica. Similar to Berry et al.'s (2014) manipulations, participants were exposed to 25 images presented in random order for 10-s each. Depending on configuration, participants would experience either Natural or Built images (see Design section above). There were 7 delay blocks (1 day, 1 week, 1 month, 6 months, 1 year, 5 years, and 25 years) and 10 larger later reward questions were asked in each block. Participants viewed 5 random images (natural images for natural groups and built images for built groups) interspersed between each of the seven delay blocks.

Matching to sample. Presentation of the stimuli, number of images, trials and variables was the same than in the No-matching condition, except a message with the sample stimuli on the top section of the page said "Find the following image in the picture." A green box signaled correct matching when clicked. See Figure 2 and detailed description of matching trials below.

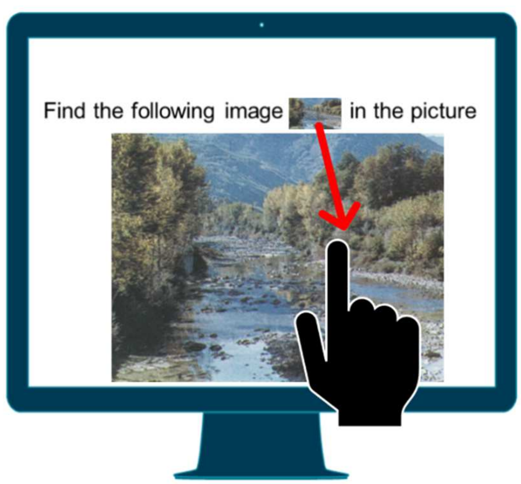

Figure 2. Screenshot illustrating the arrangement of the matching-to-sample trial. An instruction, a sample stimulus (small section of the full image), and the comparison stimulus (full image) appeared simultaneously on the screen and will remain for up to 10 s.

No Images. Instead of being exposed to the images, as in the other groups, participants were exposed to 250-s of a waiting period with a message on the computer screen that said "please wait.".

Matching to Sample Trials

The matching-to-sample procedure that was implemented was based on Henao et al. (under review). On each trial, a single image (natural or built) appeared on the center of the computer screen. On top, a section of the image (2 cm x 2 cm) appeared with the instruction "Find the following image in the picture." The sample (small section of the image), comparison (full image), and instruction remained on the computer screen for 10 sec. The participant was then able to click on any area of the image during this time. If the participant found the "hidden" section, the image was highlighted in a green box. If after 10 sec the participant had not found the sample image, the trial ended (no highlighted image). The software tracked the location of each click, if the participant matched the indicated sample, and a click count per image. Depending on the condition, no matching trials were randomly interspersed with the presentation of the 25 images (Replicas of Berry et al.), or 25 matching trials were presented to the participant (Matching condition). Five images were also randomly interspersed between each delay block. Participants in the No Image condition did not experience any part of this step. Rather, they began with the delay discounting task after viewing a blank page for 250 seconds.

Delay Discounting Task

Participants were exposed to a replication of the delay discounting task developed and implemented by Berry et al. (2014). Instructions were provided on the computer screen, which lead the participants through the task, and noted that they should choose whichever options they preferred. Participants used the mouse to progress through instructional screens and to make their choices. After the instructions, 10 practice trials were presented, which were designed to familiarize the participant with the immediate and delayed tradeoff options. Following the 10 practice trials and depending on condition-specific stimuli exposure, all participants experienced the titrating amount discounting procedure described below. Delays tested were l day, 1 week, 1 month, 6 months, 1 year, 5 years, and 25 years specifically in that order. Participants could not miss any trials because the software prohibited them from continuing until a choice was made.

The delay discounting task used hypothetical monetary outcomes. All trials alternatives were presented as "Would you rather have [amount] now or [amount] in [delay]?”. For each trial in the titrating amount delay discounting procedure, participants chose between immediate and delayed options. The first trial at each delay began with the choice of $50 now or $100 after a delay, and the immediate amount will be increased or decreased based on the participant’s response with each subsequent trial. If the immediate outcome was selected, the amount of the next immediate outcome would have decreased; if the delayed outcome was selected, the amount of the next immediate outcome would have increased.

Before the start of the delay discounting task, and between each delay block, participants experienced either natural or built images (unless they were apart of the No Images group). Images were displayed for 10-s each. Participants viewed 25 images on each block, but depending on the group, those images were presented for passive observation (as in Berry et al., 2014) or via the matching-to-sample procedure (i.e., attentional manipulation, see *Design, Image Presentation, and Matching to Sample Trials* sections above for details). Five randomly selected images were presented in between each delay block for either passive observation (no matching/replica groups) or included the matching to sample task for matching groups. All aspects were identical to Berry et al. (2014) across conditions, with the exception of the matching to sample trials (no matching and matching trials- see Design section) as well as different demographic questions.

Demographics

Before concluding the study, participants completed a demographic survey in Qualtrics that included the following information: age, gender, ethnicity, socioeconomic status, and occupation(s). Participants were also asked to report the number of hours, on average, they spend outdoors and around built environments each week. Detailed questions and response options were provided in section Instruments above. Screenshots of these questions can be found in Appendix D.

Interobserver Agreement and Procedural Integrity

Data was automatically collected via the computer software, which was pilot tested prior to beginning of the experiment to ensure data was being collected correctly and accurately. To ensure procedural integrity, the researcher tested that the computer program was running as it should. In other words, the researcher systematically pilot tested the software before participants begin the task.

Data Analysis

Of the 87 individuals that participated, data for 20 were excluded due to nonsystematic discounting. Delay discounting data were considered systematic and used if (a) participants discounted more than $5 across any delay (which assumes delay decreases the value of a reward), and (b) indifference points did not increase across consecutive delays by more than 20% of the larger later reward. Substantial increases in the value of a reward across delays would have suggested that the value of a reward was enhanced with increased delay. These criteria were the same implemented by Berry et al. (2014). They were based on the expectation of a monotonically decreasing discounting function and are similar to the algorithm used by Johnson and Bickel (2008).

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

The equation above (Equation 1) was fit to the median indifference points for each condition and individual participants using nonlinear regression (GraphPad Prism®). The resulting *k* values were analyzed to compare degrees of discounting across conditions. To explore an overall effect on *k* values (degree of discounting), a Kruskal-Wallis one way analysis of variance (ANOVA) was conducted (nonparametric analysis since *k* values do not follow a normal distribution). To further compare *k* values, a Mann-Whitney independent two-tailed *t*-tests was performed to assess the impact of natural versus built conditions on *k* values (nonparametric analysis). Effect sizes for non-normal distributions (eta squared – η^2) was also used to compare *k* values across conditions (Olejnik & Algina, 2003).

CHAPTER 3

RESULTS

Of the total participants included in the study, 39% were males, 6% was other, and 55% were females. The mean age range was 18-22 years old.

***k* Values**

Figure 3 shows the median indifference points at each delay for each group of the study. Original data corresponding to Berry et al.'s (2014) Natural group was included for comparison purposes (grey dots and dashed line). All participants' indifference points decreased as delay increased, regardless of condition. However, participants viewing scenes of natural environments (Replica Berry et al. Natural and Matching Natural) exhibited less impulsive choice (higher indifference points) relative to participants who viewed built environments, viewed, and matched built environments, or who were not exposed to images at all. The rate of discount of all the groups of the present study was considerably higher when compared to the rate of discount in the original Natural group reported by Berry et al. (2014).

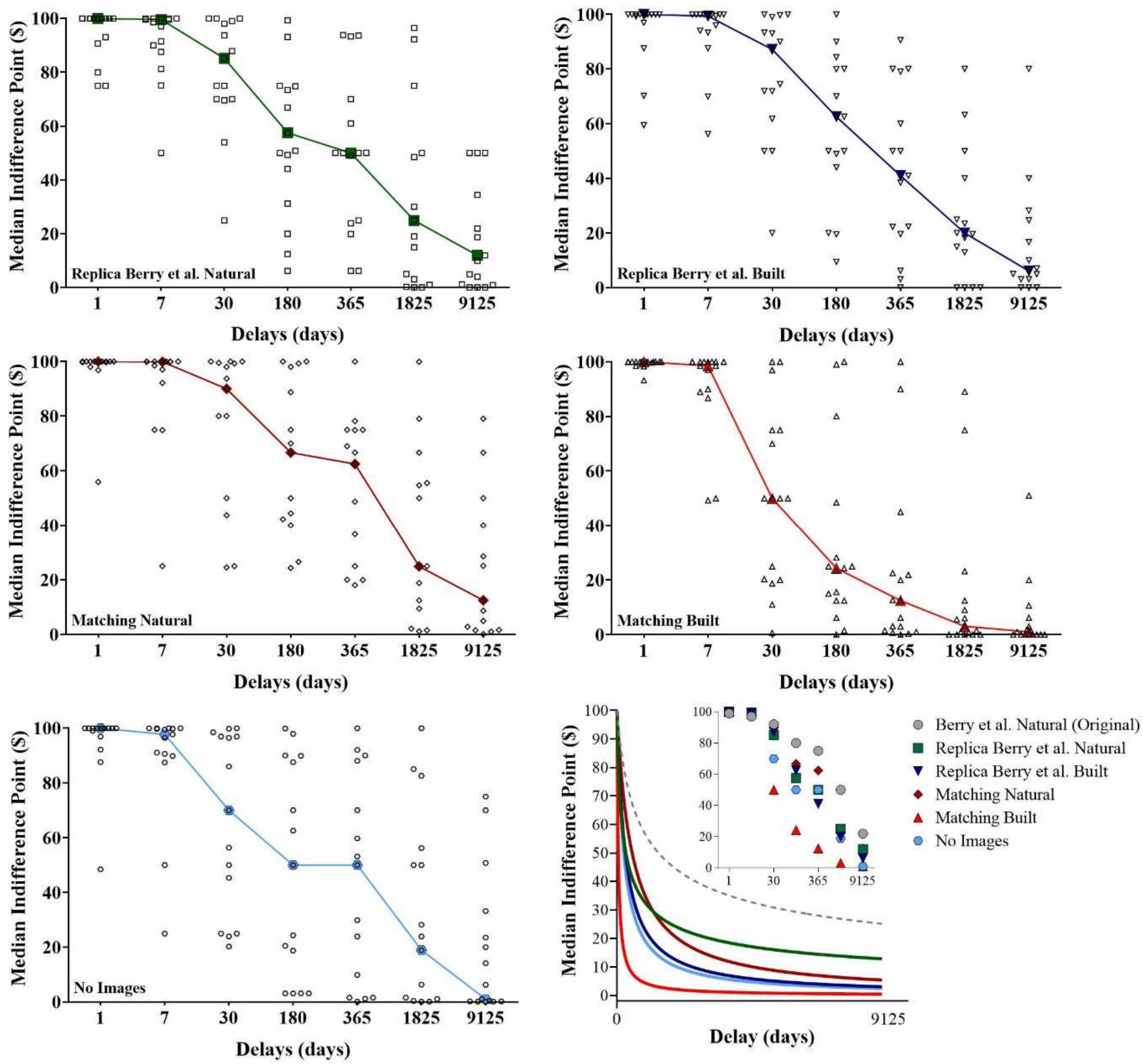

Figure 3. Median indifference points as a function of delay. Top panels show individual and median indifference points at each delay for each group of the study. The bottom graph on the right shows best fit lines of Equation 1 to those median indifference points. Note: Replica Berry et al. Natural (green squares and line), Replica Berry et al. Built (blue triangle and line), Matching Natural (red diamond and line), Matching Built (red triangle and line), and No Images (blue diamond) conditions. Original data from Berry et al. (2014) Natural is included in the bottom graph to the right for comparison purposes as grey circles and line.

Equation 1, mentioned above in methods section, provided a good fit to median indifference points for the Replica Berry et al. Natural (R^2 =.96; k =.0030), Replica Berry et al. Built (R^2 =.99; k =.0035), Matching Natural (R^2 =.98; k =.0019), Matching Built (R^2 =.98; k =.0225), and No Images conditions (R^2 =.93; k =.0043). For comparison purposes, the same analysis was conducted with the data extracted from Berry et al. (2014) Natural images, showing also a good fit (R^2 =.95; k =.00064). Equation 1 also provided overall a good fit to the indifference points of individual participants (Mdn R^2 = .91, .94, .86, .92, .92 for Replica Berry et al. Natural, Replica Berry et al. Built, Matching Natural, Matching Built, and No Images conditions). The median k values were .02, .03, .01, .13, and .03 for the Replica Berry et al. Natural, Replica Berry et al. Built, Matching Natural, Matching Built, and No Images conditions, respectively. In appendix E, individual k values for each group are provided.

A Kruskal-Wallis one-way ANOVA revealed a significant difference in impulsive decision-making across conditions with a medium effect size, χ^2 (4, 63) =10.52, p =.032, η^2 = 0.08. Follow up analysis indicated that participants in the Replica Berry et al. Built and Matching Built (U = 46, p= 0.018, η^2 =0.201) condition showed less impulsive response (lower k values) as well as the Matching Natural and Matching Built (U= 46, p = .009, η^2 = 0.242) conditions. One key finding was the participants in the Matching Built condition had higher discount rates than participants in Replica Berry et al. Natural (Mann-Whitney t-test; U = 38, p = 0.006, η^2 = 0.268), which also showed less impulsive responses with large effect sizes in all cases. There were no significant differences in rate of discount between participants exposed to the Replica Berry et al. Natural and Replica Berry et al. Built condition (U = 72, p= .522, η^2 = 0.016), Replica Berry et al. Natural and Matching Natural condition (U=82, p= .898, η^2 = 0.001), Replica Berry et al. Natural and No Images condition (U=68, p= .397, η^2 = 0.028), Replica Berry et al. Built and

Matching Natural condition (U=65, p= .317, η^2 = 0.038), Replica Berry et al. Built and No Images condition (U=78, p= .739, η^2 = 0.739), Matching Natural and No Images condition (U=57, p= .158, η^2 = 0.076), and Matching Built and No Images condition (U = 73, p= .259, η^2 = 0.045).

Correlations Between *k* and Other Measures

No significant correlations were found between rate of discount (k) and any of the demographic variables measured in the present study, including number of hours directly exposed to natural environments, number of hours directly expose the built environments, number of hours spent indoors at home, and hours spent indoors at work (all during the last week).

CHAPTER 4

DISCUSSION

The present study aimed to explore variables that moderate the effect reported by Berry et al. (2014, 2015) regarding the role of exposure to images of natural and built environments on delay discounting of hypothetical monetary reinforcers. The experiment replicated Berry et al.'s (2014) procedure while focusing on Berry et al.'s hypothesized role of attention as a factor potentially responsible for the effects of exposure to natural and built environments on delay discounting. Accordingly, a matching-to-sample task designed by Henao et al. (under review) was implemented throughout the delay discounting task to increase observing responses to the visual stimulation.

Two of the groups included in the experiment directly replicated Berry et al.'s (2014) procedures in terms of being exposed to images of either natural or built environments. Two additional groups were exposed to matching trials involving the same images. A control group (No Images) was included, in which participants did not observe or match any image. Its purpose was to explore the effects of the discounting task alone. Overall, it was expected that participants assigned to matching images of natural scenarios would show less impulsive behavior compared to all other conditions. On the contrary, instructing participants to match images of built environments was expected to produce an opposite effect.

Three main outcomes could be identified in the results of the study. First, the rate of discounting (k) of participants exposed to the Matching-Built condition was significantly higher than that observed in the other groups. In other words, matching images of buildings and related areas significantly increased impulsive choice in participants. Secondly, there was no significant correlation between discount rate (k) and any of the demographic variables, including some measures that assessed participants' reports about exposure to built and natural environments. Third, the rate of discounting of participants exposed to the replica of Berry et al.'s natural condition discounted steeper than the original Berry et al. (2014) natural group. Overall, data on Figure 3 show Berry et al.'s original group clearly displayed less steep discount rate when compared to our replica group.

The effect observed in participants instructed to match images of built environments (i.e., higher rates of discount when compared to all groups other than No Images) partially reproduces Berry et al.'s (2014) findings, as they also displayed higher impulsive choice in their built condition. Although not statistically significantly different, the group exposed to built images but not matching, also had higher rates of discounting when compared to natural conditions. This extends the previous research conducted by Berry et al. (2014) by showing that those in the built condition discount at a higher rate than those in the natural conditions. It is important to note that in the present study, findings reflect that the Matching Built group had a higher rate of discounting than the Replica Berry et al. Built group showing that attending to the images had an effect for this condition. This suggests that when attending to images (matching) of built environments participants discounted steeper when compared to just viewing the images. However, matching did not have the same outcome when compared to Replica Berry et al. Natural as was originally predicted. The Matching Natural condition should have shown a less steep discounting rate when compared to the Replica Berry et al. Natural condition. In other words, the Replica group had a less steep discounting rate than the Matching Natural group which again, was not expected. One of the reasons for this outcome is that perhaps participants interacted with the images of built environments more than the images of natural environments. Although the programming of the experimental task included collecting information on correct matching responses, which would have provided a proxy of observing responses, careful inspection of the task showed that matching data was overwritten and in their current form are not reliable indicators of correct responses. Future research should use the number of correct responses as a measure of procedural integrity. Also, it is possible that perhaps participants failed to match more often in the built condition, and such aversive condition could have increased the impulsive choice for that group (Flora et al. 1992, 2003).

Next, self-reports pertaining to weekly time spent in natural environments, time spent in built environments, time spent indoors at home, and time spent indoors at work were used in the present study to explore if the amount of time individuals spent in built or natural environments were related to rate of discounting (see Appendix D). It was expected that participants that spent more time around natural environments, would have discounted less steeply and those that spent more time in built environments would have discounted more steeply. There was no significant correlation between the reported degree of exposure to natural and built environments and the rate of discount and the question. Berry et al. (2014) did not collect similar data. Perhaps, long-term exposure does not affect the rate of discounting, and visual stimulation only has a momentary effect, as in Berry et al.'s experiment. Moreover, the effect of the images in relation to time spent in these environments suggest the effect is only related to the images and not outside influences. One limitation of this particular part of the study is that the data was based on self-report. Research has shown that self-report method is not the most accurate (Vangsness, 2022). However, for the present study it was the only option available in order to collect such information. The fact that at least one study suggests exposure to natural environments should correlate with the rate of discounting (Repke et al., 2018), shows promise for future research in which more direct data are collected and test of associations between these variables could be conducted again.

It was expected that our Replica Berry et al. Natural condition would have same or similar rate of discounting to the original Berry et al. Natural condition. However, that was not the case. The Berry et al.'s original natural condition overall had a less steep discounting rate when compared to our analogue condition. This extends the research by Johnson et al. (2017, 2018, 2019), which shows the effects from Berry et al. (2014) in the natural condition could not be reproduced. In other words, *k* values were consistently higher in Berry et al. (2014, 2015) when compared to all replications (present study and Johnson (2017, 2018, 2019). One explanation for this phenomenon is the setting of the present and Johnson et al.'s studies. Unfortunately, Berry et al. (2014, 2015) provided very limited details about the context of their studies. Perhaps key details have been missing in the different replication attempts, which explain the lack of reproducible effects. For example, there was no report of how the participants were overseen or supervised during the experiment (e.g., a possible effect of social contingencies), what time of year data collection occurred (e.g., possible seasonal effect), or what the setup of the experimental room was.

Limitations

One limitation of the study was the layout of the images presented on the computer screen. Personal communication with M. Berry indicated that the pictures in their study covered the entire computer screen. In the present study, images covered a majority of the screen (90% approximately) but not in its entirety. This occurred because the software that was used to create the task for the present study (Qualtrics) was different than that implemented in Berry et al.

(2014), namely E-Prime. Future research could test the effects of the size of the image and its position on the computer screen.

Another, limitation of this study was the use of a group design. This decision was mostly based on the fact that this was a systematic replication of Berry et al.'s original design. However, single-case methods are more closely linked to behavior analysis and its conceptual framework (Hurtado-Parrado & Lopez-Lopez, 2015). Thus, their strengths could be used to produce data more suitable to identify and test relevant behavioral processes that explain the effects of natural and built images on delay discounting. The flexibility on how independent variables and control conditions can be implemented and changed when studying individual subjects is one of the features that distinguishes single-subject from group designs (Connell & Thompson, 1986). For instance, the same participants could have been exposed to the different types of images and other controls and manipulations could have been tested systematically depending on observation of target and alternative behavior and steady performance.

It is precisely those differences in participants' behavior while being exposed to images with different content and the delay discounting task which could explain the individual variability observed in the data across the different groups (see individual data on Figure 3 and Appendix E). For instance, participants could have been or not attending effectively to the images presented (observing responses, exploration) depending on different control of motivating operations. It is unclear to what extent each participant was or not deprived of access to these type of stimulation, and a single subject design could have allowed better to identify and/or test these factors.

Alternatively, natural or built images could elicit relaxation or discomfort responses. Research has shown that relaxation-related behavior can lead to change of target behavior, including reduction of emotional responses or symptoms (Baer, 2003). Also, research with other choice tasks has shown that aversive stimuli (e.g., intense noise, cold pressor) and stimulants (caffeine) increase impulsive choice (Flora et al., 1992, 1993, 2003). A single-subject design could be used in the future to test systematically if participant engagement with different types of images, and instructional control, could lead to changes in breathing, muscular tension, etc, which possibly could be related with changes in impulsive choice during the monetary discounting task here reported.

Another possible interpretation was offered by Johnson and Hodes (2017). The authors proposed that natural images served as an SD where it signaled there was nothing for participants to spend their money on and vis versa for the built environments. A single-subject study again could be a fruitful approach in the future to further test this notion, and ultimately continue exploring reasons for the difficulties reproducing the effects found by Berry et al. (2014).

Finally, careful inspection of the experimental task and resulting data showed issues with the implementation of the matching-to-sample task. When participants found the hidden image (i.e., correctly matched the sample), a green box surrounding the target image appeared (correct response feedback). Unfortunately, if in successive trials that appeared interspersed between delays the same picture was randomly selected, the green box was not removed (i.e., the matching trial was not reset). Although data on how often this happened is not available, since as mentioned above, matching data was overwritten, it seems plausible that observing responses would have decreased throughout the task as participants accumulated more correct responses and trials were not reset. Although the effect of this issue cannot be fully assessed now, it is of extreme importance to note that the first 25 matching trials for all groups did not have this problem (i.e., the first 25 matching trials were implemented correctly and issues only occurred during interspersed trials between delays). Thus, the effect observed in the Matching Built group seems unlikely related to this issue. In any case, future research could improve procedural integrity and data collection of matching responses to fully explore this potential extraneous variable.

CHAPTER 5

CONCLUSION

The present study tested if manipulating the participants' observing responses towards different types of images (natural, built, and no images) via a matching-to-sample task could increase the effect reported by Berry et al. (2014) – i.e., exposure to images of natural environments decreased impulsive responses during a monetary discounting task. Our findings only partially reproduced the effects reported by Berry et al., in that matching images of built environments increased the rate of discount, but the expected opposite effect was not observed with images of natural environments, with or without the observing-response manipulation.

As a systematic replication of Berry et al. (2014)'s study, it is aligned with the recent calls for more systematic tests of generality and reliability of findings in psychology and behavior analysis (Tincani & Travers, 2019). Overall, replications are important to resolve contradiction and advance our science of behavior (Perone, 2018). The generality and reliability of findings are a key factor when it comes to replications and what to do with them further, including application to social issues. When a properly designed and executed experiment fails to replicate previous published findings, it exposes flaws in our understanding of the phenomenon. Possibly, in recognizing the boundary conditions of the phenomenon, identifying the relevant variables and/or bringing the variables under sufficient control (Perone, 2018). In doing so, we are accepting the contradictory findings as valuable and valid and can continue to resolve them by pursuing an experimental analysis of the possible reasons. Single-case research methods could be especially useful for these efforts in behavior analysis (Hurtado-Parrado & Lopez-Lopez, 2015). Accordingly, although the findings of the present study only partially aligned with those of previous research that was replicated, they still hold value, especially considering they add to efforts of Johnson et al. (2017, 2018, 2019), who also reported similar outcomes with their replications of Berry et al. (2014). It is thus important that future research continue testing potential interpretations of Berry et al.'s (2014, 2015) effects, including exploring factors that may be responsible for fully reproducing them.

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APPENDIX A

NATURAL IMAGE STIMULI

Source: Berto, 2005

APPENDIX B

BUILT IMAGE STIMULI

Source: Berto, 2005

APPENDIX C

DELAY DISCOUNTING TASK

Would you rather have $50 now or $100 in 1 week?

$50 now ○ | $100 in 1 week ○

APPENDIX D

DEMOGRAPHICS

Q1

What is your gender?

- ○ Male
- ○ Female
- ○ Other

Figure D1.

Q2

What is your age?

- ○ Under 18
- ○ 18 - 24
- ○ 25 - 34
- ○ 35 - 44
- ○ 45 - 54
- ○ 55 - 64
- ○ 65 - 74
- ○ 75 - 84
- ○ 85 or older

Figure D2.

Q3

What is your current employment status?

- ○ Employed full time (40 or more hours per week)
- ○ Employed part time (up to 39 hours per week)
- ○ Unemployed and currently looking for work
- ○ Unemployed not currently looking for work
- ○ Student
- ○ Retired
- ○ Homemaker
- ○ Self-employed
- ○ Unable to work

Figure D3.

Q4

How many hours approximately you spent during the last week directly exposed to natural environments, including lakes, rivers, hills, woods, orchards, forests, etc.?

- ○ ⃠ N/A
- ○ 0-3 hours
- ○ 3-6 hours
- ○ 6-9 hours
- ○ 9-12 hours
- ○ 12-15 hours
- ○ 15+ hours

Figure D4.

Q5

How many hours approximately you spent during the last week directly exposed to built environments, including city streets, industrial zones, housing, porches, urban areas, and skyscrapers, etc.?

- ⃝ N/A
- ⃝ 0-3 hours
- ⃝ 3-6 hours
- ⃝ 6-9 hours
- ⃝ 9-12 hours
- ⃝ 12-15 hours
- ⃝ 15+ hours

Figure D5.

Q6

How many hours approximately you spent during the last week indoors at home?

- ⃝ N/A
- ⃝ 0-3 hours
- ⃝ 3-6 hours
- ⃝ 6-9 hours
- ⃝ 9-12 hours
- ⃝ 12-15 hours
- ⃝ 15+ hours

Figure D6.

Q7

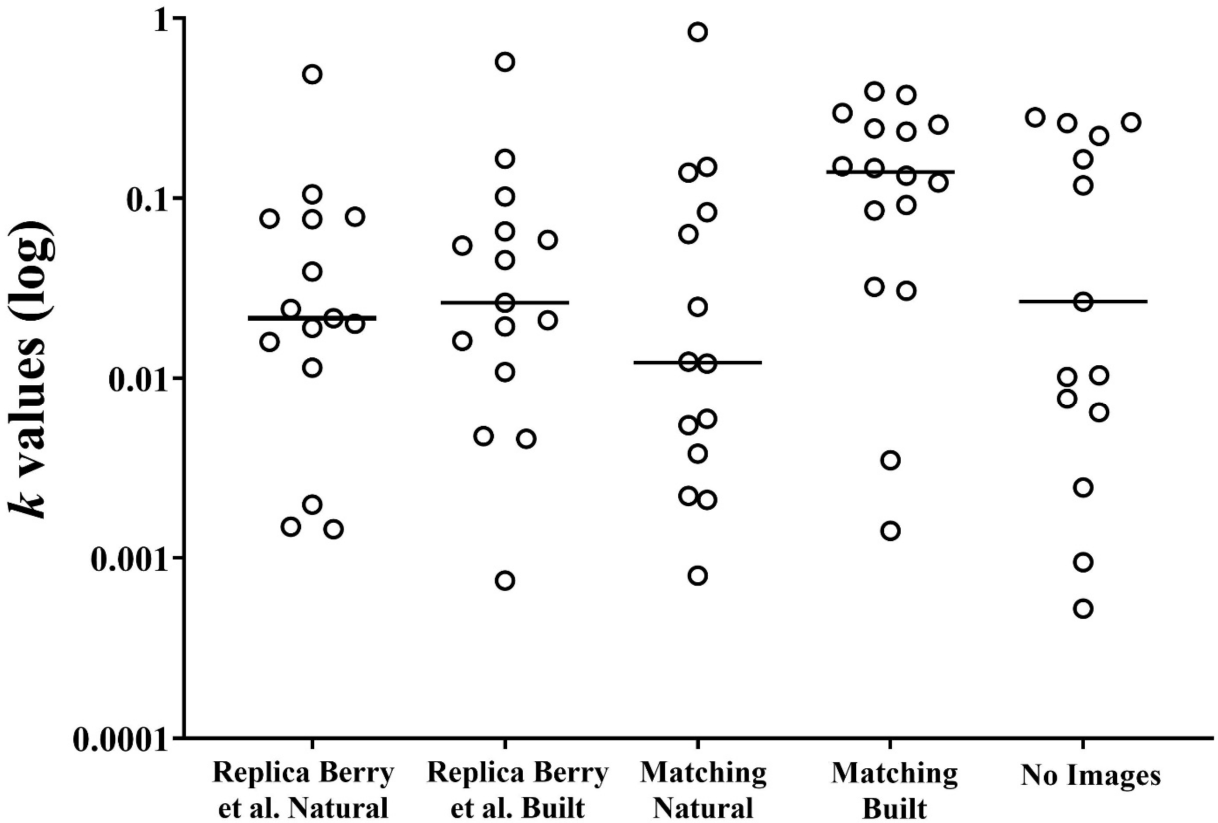
How many hours approximately you spent during the last week indoors at work (if you did not work last week, please choose N/A)?

- ○ ⊘ N/A
- ○ 0-3 hours
- ○ 3-6 hours
- ○ 6-9 hours
- ○ 9-12 hours
- ○ 12-15 hours
- ○ 15+ hours

Figure D7.

APPENDIX E

INDIVIDUAL *k* VALUES



VITA

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