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EFFECTS OF EPISODIC FUTURE THINKING ON DISCOUNTING: PERSONALIZED AGE-PROGRESSED PICTURES IMPROVE RISKY LONG-TERM HEALTH DECISIONS

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Many everyday choices are associated with both delayed and probabilistic outcomes. The temporal attention hypothesis suggests that individuals' decision making can be improved by focusing attention on temporally distal events and implies that environmental manipulations that bring temporally distal outcomes into focus may alter an individual's degree of discounting. One such manipulation, episodic future thinking, has shown to lower discount rates; however, several questions remain about the applicability of episodic future thinking to domains other than delay discounting. The present experiments examine the effects of a modified episodic-future-thinking procedure in which participants viewed age-progressed computer-generated images of themselves and answered questions related to their future, on probability discounting in the context of both a delayed health gain and loss. Results indicate that modified episodic future thinking effectively altered individuals' degree of discounting in the predicted directions and demonstrate the applicability of episodic future thinking to decision making of socially significant outcomes.

Key words: episodic future thinking, health, humans, probability discounting, risky decision making, temporal attention, visual analogue scale

Steep delay discounting (i.e., the value of an outcome decreases rapidly as a function of the delay to receipt) has been associated with a wide range of substance abuse and other harmful health behaviors (Bickel, Jarmolowicz, Mueller, Koffarnus, & Gatchalian, 2012; Bickel, Johnson, Koffarnus, MacKillop, & Murphy, 2014; Madden & Bickel, 2010; Yi, Mitchell, & Bickel, 2010). In contrast to delay discounting, probability discounting occurs when the subjective value of an outcome is devalued as the likelihood of the occurrence of that outcome decreases. The value of an outcome is inversely related to the odds against receiving that outcome. There is some evidence to suggest that excessive probability discounting is associated with maladaptive behaviors and outcomes such as pathological gambling (Madden & Bickel, 2010) and substance abuse (e.g. Yi, Carter, & Landes, 2012); however, findings on the relation between excessive probability discounting and other deleterious behaviors have been mixed (e.g., Bickel, Johnson, et al., 2014) and more research is needed before conclusive statements can be made. Nonetheless, it appears that relatively extreme patterns of delay and probability discounting underlie maladaptive decision-making processes and warrant further exploration.

Discounting is a rapidly growing area of interest that aids in our understanding of socially important behavior (Critchfield & Kollins, 2001). Areas to which discounting has been applied are numerous, including drug addiction (e.g., Bickel, Odum, & Madden, 1999; MacKillop, 2013; MacKillop et al., 2011), pathological gambling (e.g., Dixon,

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Marley, & Jacobs, 2003; Petry, 2001), obesity (e.g., Bickel, Wilson, et al., 2014; Davis, Patte, Curtis, & Reid, 2010; Fields, Sabet, Peal, & Reynolds, 2011; Jarmolowicz et al., 2014; Weller, Cook, Avsar, & Cox, 2008), lack of engagement in preventive health practices (e.g., Bradford, 2010), risky sexual behavior (e.g., Chesson et al., 2006; Johnson & Bruner, 2012), environmental sustainability (e.g., Kaplan, Reed, & McKerchar, 2014), and parental or caregiver decisions regarding treatments for children with autism, developmental disabilities, or both (e.g., Call, Reavis, McCracken, Gillespie, & Scheithauer, 2015; Dixon, Whiting, & Miller, 2013). Thus, discounting may serve as a framework to understand why, and under what circumstances, these behaviors occur and how to mitigate them (Bickel, MacKillop, Madden, Odum, & Yi, 2015; Dixon & Holton, 2009; Rachlin, 2009; Rachlin & Green, 1972).

One solution to overcome the potentially adverse pattern of behavioral decision making is by strategically targeting a single-decision event (e.g., point-of-purchase situation; Ainslie, 1975; Ariely & Wertenbroch, 2002). A commitment response, another one-time decision-making event, is an active form of self-control (Skinner, 1953) in which an organism commits to a decision path that will lead to more favorable long-term outcomes. Save More Tomorrow (Thaler & Benartzi, 2004), one of the most notable programs to promote and help employees save for the future, uses commitment responses to allow users to increase their savings rate automatically by a small amount every time they are awarded a pay raise.

In an experiment by Hershfield et al. (2011) aimed at changing individuals' willingness to save for the future at the point of purchase, participants made hypothetical investment choices in the presence of a computer-generated model of themselves. While they viewed either their computer-generated present or future self, participants responded in a computerized investment simulation by sliding a line along a bar to report how much of their current income they would allocate to retirement. As participants allocated a smaller percentage of their current income to retirement, the present face's emotion changed and became "happier" (i.e., larger smile on the face) and the future face became "sadder" (i.e., a larger frown; the reverse occurred when allocating relatively more income to retirement). As a result, individuals in the future-self condition allocated a significantly higher percentage of their current income to retirement than did those in the present-self condition.

Contemporary research in the experimental analysis of behavior (EAB) has begun to investigate the mechanisms by which delayed outcomes influence decision making and how these decisions are affected by environmental manipulations. The *temporal attention hypothesis* stipulates that individuals tend to perceive time to differing degrees (Bickel, Kowal, & Gatchalian, 2006; Radu, Yi, Bickel, Gross, & McClure, 2011) and that for some individuals, relatively distal events do little to control present behavior. For example, in one study heroin-dependent individuals and matched controls completed two tasks that measured time perspective, including the Stanford Time Perception Inventory (Zimbardo, 1992) and Future Time Perspective (Petry, Bickel, & Arnett, 1998; Wallace, 1956). Compared to controls, Petry et al. (1998) found that heroin addicts scored significantly lower on scales that measured focus on future events and significantly higher on scales that measured focus on present events. Further, when asked to complete fictional stories, heroin addicts completed stories by describing events in the near future (e.g., 1 hr), whereas controls described events that happen further into the future (e.g., 7 days). These results support the temporal attention hypothesis by demonstrating that individuals known to engage in myopic patterns of decision making and display steep delay discounting tend to restrict their future into a truncated timeline.

Another way to allocate temporal attention towards distal outcomes is through the use of episodic future thinking (EpFT; Koffarnus, Jarmolowicz, Mueller, & Bickel, 2013)[1]. In contrast to other framing manipulations, EpFT requires an active, overt response by the participant before he or she makes any intertemporal tradeoffs (Atance & O'Neill, 2001). Participants typically identify several events they plan to attend in the future, and these events are assigned different delays. When participants are faced with the intertemporal tradeoff options, these subject-specific cues are displayed in an attempt to influence decision making.

To examine the effects of EpFT on rates of discounting, Peters and Büchel (2010) recruited 30 healthy participants who reported events they had planned within the next 7 months. Delays to be used in the subsequent discounting task were determined by matching the time until the planned event so that events happening relatively soon were associated with shorter delays and events happening later were associated with the longer delays. Participants then completed two sessions of delay-discounting tasks and were told that one of their choices would be randomly picked and the consequence delivered at the conclusion of the experiment. During half of the discounting trials, a subject-specific cue (e.g., a trip to Paris), determined during the prescan interview, was presented underneath the delay associated with the delayed option. In the remaining half of the trials, no subject-specific cue was presented. Results indicated that discounting rates obtained during the EpFT condition were significantly lower than in the control condition.

More recently, researchers examined the effects of EpFT on changes in delay discounting and number of food calories consumed among 26 overweight or obese women (Daniel, Stanton, & Epstein, 2013). Participants were randomly assigned to either a control or an EpFT condition, for which recently experienced (derived from a blog provided by the experimenters; control group) or possible future events (EpFT) were created to use as cues for the two groups in later experimental tasks. During the delay-discounting task, participants in the control group were instructed to think about events from the blog, and those in the experimental group were instructed to think about possible future events they provided earlier. In the ab libitum eating task, participants rated the sensory appeal of various foods and subsequently were provided with free access to food for 15 min, all while cues were present. Participants in the EpFT condition displayed significantly less discounting and consumed significantly fewer calories than did those in the control condition.

Previous research using EpFT manipulations is promising and suggests a novel, antecedent-based (rather than consequence-based) approach to change socially significant behavior. However, many of these socially significant behaviors are associated with both delayed and probabilistic outcomes, and the EpFT research to date has mostly demonstrated behavior change in the context of delayed outcomes (Lin & Epstein, 2014; Peters & Büchel, 2010; cf. Daniel et al., 2013). Although EpFT is conceptually grounded in the temporal attention hypothesis and behavior change associated with delayed outcomes would be predicted, the degree to which such a manipulation would influence decision making associated with probabilistic outcomes is unknown. Further, socially significant behaviors do not always contain a monetary aspect, yet most of the previous EpFT research has used outcomes associated with money (i.e., monetary delay discounting). Although Daniel et al. (2013) demonstrated that EpFT influenced caloric intake, there would be much applied value in showing that EpFT can effectively influence behavior associated with health outcomes. Therefore, the current experiments represent a proof-of-concept study that attempts

[1] We adopt the acronym EpFT rather than EFT as to not confuse readers with executive functioning training, another emerging technology to modulate rates of discounting (e.g., Bickel, Yi, Landes, Hill, & Baxter, 2011; Renda, Stein, & Madden, 2015).

to address behaviors that are associated with delayed and probabilistic health outcomes using a technology (i.e., EpFT) that is conceptually grounded in modern EAB research (i.e., temporal attention hypothesis).

Viewing discounting within a temporal attention framework implies that environmental manipulations that expand the limits of an individual's temporal perspective by bringing focus on temporally distal outcomes (e.g., EpFT, explicit date; DeHart & Odum, 2015) may improve decision making related to those delayed outcomes. Although past EpFT manipulations have tended to use subject-specific cues alone to produce changes in discounting, the current project attempted to alter degree of discounting through a novel approach. Given the several unanswered questions that surround the applicability of EpFT procedures to influence decision making in the context of delayed and probabilistic health outcomes, the current experiments sought to examine the combined effects of computer-generated images (Hershfield et al., 2011) and an EpFT (through the use of a future-self questionnaire [FSQ]) procedure on probability discounting of a delayed health gain (Experiment 1) and loss (Experiment 2). Because one of the goals of the present study was to model decision making associated with a face-valid and real-world outcome (i.e., one in which an individual might actually experience), health gains and losses were chosen because these outcomes are inherently delayed and probabilistic and because it is likely that individuals have had or will have experience with such a scenario (e.g., consulting with a doctor or health professional).

EXPERIMENT 1

Method

Participants, Setting, and Materials

Five undergraduate women, ranging in age from 19 to 23 years ($M = 21$, $SD = 1.87$), recruited from an introductory class in applied behavior analysis, participated. Material in the introductory class covers only basic behavior-analytic content (e.g., reinforcement, extinction, stimulus control), so class content likely did not interfere with the procedures used in the current study. Participants completed an informed consent approved by the University of Kansas Human Subjects Committee at the start of the first session. Approximately three to six blocks of trials were conducted each day during a 60-min session. In exchange for each 60-min session completed, participants earned .5% of extra credit added to their final grade in the class from which they were recruited.

Each participant completed sessions in a small operant room (2.2 m by 2 m) with a darkened one-way observation panel on one side; she used a mouse to interact with a probabilistic choice task (described below) running on a Windows 7 Dell PC and presented via a 21-in. wide-aspect monitor.

Computer-generated images. At the beginning of the first session, the researcher obtained three (direct, left, and right profiles) digital photographs of the participant's face during which she was instructed to remain with a neutral emotion. Using the procedure described below, these photographs were used in conjunction with FaceGen Modeller software from Singular Inversions (Hershfield et al., 2011; http://www.facegen.com/modeller.htm) and Adobe Photoshop to create five unique computer-generated images (see Figure 1 for an example) of the participant's face.

First, the researcher uploaded the straight-on photograph to FaceGen Modeller's PhotoFit feature and subsequently tagged several key features of the participant's face (e.g., eyes, ears, mouth, and chin) to maximize accuracy of the model. The two side-profile pictures were used only if PhotoFit was unable to produce an accurate model. Next, the researcher aged the model by sliding two "age" bars (e.g., shape and color) to the maximum level (approximately 65 years old). The resulting aged picture was saved

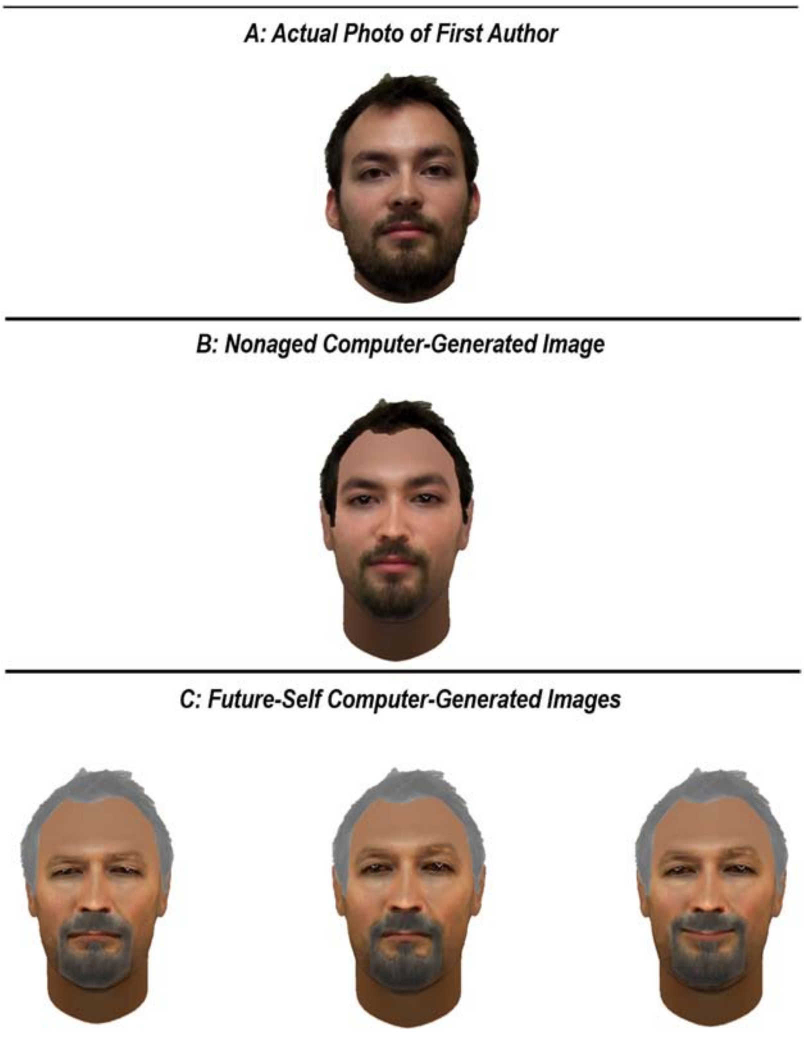

Figure 1. Example images of the age progession. The top image (A) is an actual photo of the first author. The middle image (B) is the nonaged computer-generated image created by using the photo of the first author. Although participants in the experiment never saw their nonaged computer-generated image, creating a nonaged image was necessary to create the future-self images, so we display that here. The bottom images (C) are three future-self computer-generated images with three emotions (from left to right): sad, neutral, and happy. Participants saw two additional images that approximated a balance between the sad and neutral images and between the happy and neutral images.

as the neutral image. Using the neutral image as a base, the researcher modified the image to produce four additional pictures that reflected changes in emotion. Two pictures reflected a sad emotion, and two pictures reflected a happy emotion. For one of the two pictures that reflected the sad emotion, the researcher adjusted the sliding bar corresponding with "expression: sad" (located under the Morph tab of FaceGen Modeller) to 50% of the maximum and manually adjusted the outside of the mouth down slightly. This produced the neutral sad image. For the second sad image, the researcher adjusted the aforementioned slider to the maximum and further adjusted the outside of the mouth down. This produced the sad image. To create the neutral happy image, the researcher manipulated the "smile: mouth closed" slider to 50% of the maximum and manually adjusted the outside of the mouth slightly. To create the happy image, the researcher manipulated the slider to the maximum and further adjusted the outside of the mouth. FaceGen's PhotoFit feature does not retain the hair during the modeling process; therefore, using Adobe Photoshop, the researcher extracted the hair from the original digital photograph and cropped it onto the new computer-generated images. Contrast and saturation settings were modified to change the original color of the participant's hair to gray.

Future-self questionnaire. A questionnaire was developed to direct the participant's attention to her future self, as in previous EpFT studies. This FSQ was administered before the start of each block in the experimental manipulation phase. The FSQ consisted of four questions and a box below each question where the participant wrote her answer. The questions were as follows: (a) What will you be doing as your career in 30 years?; (b) Describe the ideal spouse you will have in 30 years; (c) How many kids will you have in 30 years?; and (d) Describe the type of home you will have in 30 years.

Procedure

At the first session, the participant completed the informed consent form and the researcher obtained the three photographs described above. The participant then completed a practice trial before starting the probabilistic choice task. To rule out repeated testing effects and to account for the possibility that the effects of a future thinking manipulation on probability discounting might not reverse, we used a nonconcurrent multiple baseline design across participants.

Probabilistic choice task. Participants responded on a probabilistic choice task designed using Microsoft Visual Basic 2010. During this task, the participant moved the position of a slider on a visual analogue scale (VAS; Johnson & Bruner, 2012; Kaplan et al., 2014) to indicate her responses. To familiarize participants with the nature of the VAS, a practice trial was administered at the start of the first block during the first session. During the practice trial, the participant read the following instructions:

> The following questions will ask you to indicate your answers on a scale. Before you begin, it will be helpful to practice using the cursor. Here is an example of how to use the marker: Imagine you are asked to guess the temperature of this room. You believe the temperature is 68 degrees Fahrenheit. Thus, you must click on the marker and—without releasing the click—slide the marker to 68, and then release your click. The number below the line will indicate the location of the cursor. Go ahead and slide the marker to 68 degrees and click submit.

A VAS (13.9 cm wide), a submit button, and a label that displayed the value associated with the VAS cursor location were located below the instructions. A value of 0 was displayed if the VAS cursor was set all the way to the left, and a value of 100 was displayed if the VAS cursor was set all the way to the right. The participant was required to slide the VAS cursor to 68 degrees and submit the correct response before she continued to the main portion of the probabilistic choice task. If the participant did not correctly set the cursor to 68 degrees, a box appeared with the following instructions: "Please drag the marker to the correct value."

Baseline. At the start of every block of trials, the following instructions were presented for 45 s:

> Welcome to our experiment! The purpose of the present study is to measure how likely you would be to continue or quit a particular hobby. Please make your decisions as if all scenarios involved were real. There are no correct or incorrect answers. On the following screens, you will sometimes see a bar with a triangular cursor. You will use the cursor to scroll along the bar to decide how likely you would be to continue or quit a

> particular hobby. You will have several seconds until a button appears to submit your choice. Please submit your choice when the button appears. If you do not understand these instructions, please ask the researcher any questions you may have now. If you do understand these instructions, please click the button below.

After 45 s elapsed, a button with the text, "I have read and understand these instructions," appeared directly below the instructions. After clicking the button to proceed, participants read and answered the following health-related question associated with a probabilistic gain:

> Imagine you are in perfect health and enjoy a particular hobby. You learn that quitting this hobby permanently will increase your chances of being alive and cancer-free by XX% in 30 years. How likely are you to quit this hobby?

The value of XX, indicating the probabilities, was shown in descending order across all trials: 95, 90, 75, 50, 25, 10, and 5%. Response values ranged from 0% to 100% likely to quit. In an attempt to match real-world contingencies related to health outcomes (specifically cancer risk), the gain and loss (Experiment 2) outcomes associated with each question were set at a fixed 30-year delay.

At the beginning of each trial, only the probabilistic health question was displayed. After 5 s a VAS, a submit button, and label that read, "Note: By clicking submit, you will move on to the next question," appeared directly below the question. Participants responded to the question by sliding a cursor along the VAS and clicked the button to progress to the next trial. Anchors lay to the left and right ends of the VAS. The anchor on the left read "Not at all likely" and the anchor on the right read "Extremely likely." Unlike the practice trial, movement of the cursor rendered no feedback on the value associated with the cursor position. The VAS and button were displayed for 10 s. After 10 s or when the participant clicked the submit button (whichever came first), the VAS, button, and label disappeared for 5 s and the blackout period began, during which the entire screen turned black. If 10 s elapsed without a response, the program recorded an omission.

The amount of time for which the blackout period was in effect depended on the latency between when the submit button became visible and when the participant clicked the it. The blackout period lasted for a minimum of 14 s but could last up to an additional 9 s depending on the latency to respond. For example, if the participant clicked the submit button 4 s after it appeared, the remaining 6 s were added to the blackout duration. This aspect of the program not only ensured that all trials lasted approximately 45 s but also ensured that participants were unable to end the block, and thus ultimately the session, early by responding quickly.

Immediately following each block, the researcher used Discounter software (www.smallnstats.com) to calculate area under the curve (AUC; Myerson, Green, & Warusawitharana, 2001):

$$AUC = \Sigma(x_2 - x_1)\left[\frac{(y_1 + y_2)}{2}\right], \quad (1)$$

where x_1 and x_2 are successive odds in favor values and y_1 and y_2 are successive reports of likelihood of quitting associated with x_1 and x_2, respectively. The researcher subsequently graphed the corresponding value to determine whether stability criteria had been met. Data were included only if they met Johnson and Bickel's (2008) criteria for systematic discounting (i.e., any likelihood value less than 120% of the preceding value; last likelihood value less than 90%). Visual inspection was used to verify that there was no increasing or decreasing monotonic trend during the last three blocks in order to proceed to the next phase.

Modified episodic future thinking (mEpFT). During the mEpFT phase, the participant was shown a full-size (neutral) image of her computer-generated future self before she completed each block of the probabilistic choice task. During the first block of this phase, the participant was told the following:

> I'm going to ask you several questions. As I'm reading these questions, please look at yourself 30 years in the future and think about your answers to these questions. You do not need to say your answers out loud; I'd just like you to think about your answers. After I am done asking you these questions, I'll give you time to write your answers to these questions.

After the experimenter finished asking the questions, the participant wrote her answers on the FSQ. When the participant completed the questionnaire, the researcher reentered the room and started the program, and the participant began the probabilistic choice task. The same probabilistic health question used in baseline was used during this phase.

After starting the probabilistic choice task but before being able to respond to the question via the VAS, each participant viewed five pictures of her future self with the five unique emotions, as described earlier. The future computer-generated images were ordered from left to right from sad to happy and occupied space on the screen below the VAS. The VAS was divided into five sections, each corresponding with a single future-self picture. After the pictures had been displayed for 5 s, they disappeared and the VAS appeared for 10 s. After 10 s, a submit button and a label that read, "Note: By clicking submit, you will move on to the next question," appeared for 10 s at the bottom of the page. After the participant clicked the submit button, one of the five future-self pictures appeared for 5 s, followed by a blackout period in which the entire screen turned black. The blackout period functioned the same as in baseline. The picture presented after the participant's selection was associated with the location of the cursor on the VAS. That is, if the cursor was in the first section (VAS values between 0 and 20), the picture on the far left was displayed after submission.

Data Analysis

Prior to any data analyses, the seven probability values (ranging from 95% to 5%) were converted to odds-in-favor values using the following equation:

$$\Theta = (1 - p)/p, \tag{2}$$

where Θ is the odds in favor and p is the probability. The resulting values were as follows: 0.053, 0.111, 0.333, 1, 3, 9, and 19.

The primary dependent measure of interest was the likelihood of quitting the particular hobby, with values that ranged from 0% to 100% likely in both the baseline and mEpFT phases. By plotting the likelihood values of both phases, a standardized area between the curves was obtained by first calculating the AUC for each phase, standardizing these values out of one by dividing the total area possible by the obtained areas, and finally subtracting these standardized values from one another. A secondary measure of interest was the stability of reported likelihood values over the course of the experiment.

Results and Discussion

For each participant, two discounting curves were plotted using the mean reported likelihood of quitting at each probability from the last three blocks of baseline and first three blocks of the mEpFT phase. Comparisons between the last three blocks of baseline and the first three blocks of the mEpFT phase, rather than between baseline and the last three blocks of the mEpFT phase, were made because we were primarily interested in the immediate change in the reported likelihood of quitting, similar to a point-of-purchase setting. Figure 2 shows these curves, with error bars showing one standard

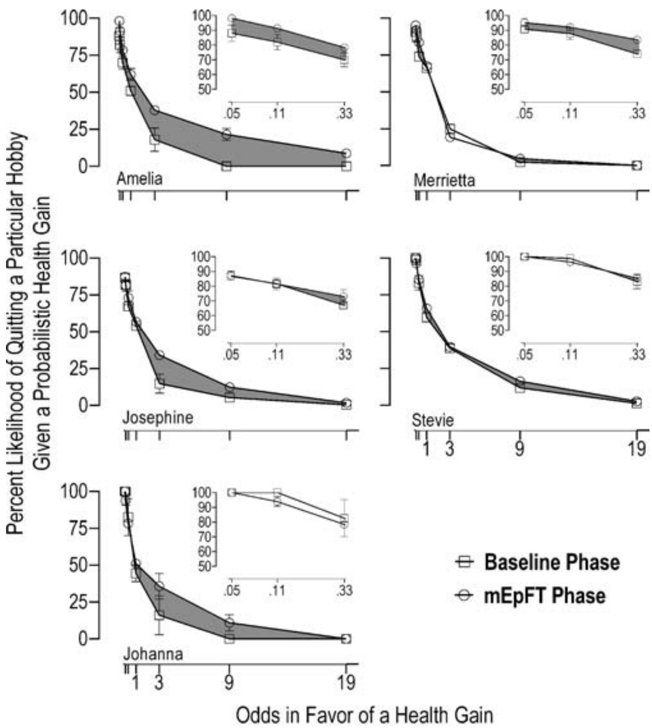

Figure 2. Mean (±*SEM*) likelihood of quitting a particular hobby given a probabilistic health gain for last three blocks of baseline (open squares) and first three blocks of mEpFT (open circles) phases. The shaded area between the curves indicates area change in the predicted direction (a negative effect is represented by a lack of shading between points for Merrietta). Semilog inserts provided for the smaller odds in favor values.

error of the mean. To aid in visualizing the difference in the reported likelihood of quitting at the smaller odds-in-favor values, semilog scaled insets are displayed within each graph. Amelia, Josephine, and Johanna show robust increases in their likelihood of quitting with mEpFT (increased area shaded), whereas Merrietta and Stevie show very little difference. Amelia and Merrietta show the greatest increase in likelihood of quitting at the smaller odds-in-favor values with mEpFT, whereas little if any increase was seen for Johanna and Stevie.

To compare the change in AUCs for each participant, we calculated a standardized area between each participant's two curves from Figure 2. We did this by taking the AUC, standardizing it against the largest possible area, and subtracting the area under the mEpFT curve from the area under the baseline curve. Amelia displayed the largest increase in standardized area between the curves (17%), followed by Johanna (9%) and Josephine (8%). Stevie showed a slight increase (3%), and Merrietta showed no change (0%). At this level of analysis, the mEpFT procedure effectively changed the degree of discounting for four of the five participants; however, it should be recognized that Stevie showed only a small change in the predicted direction. One could argue that a 9% and 8% change for Johanna and Josephine, respectively, does not meet the threshold for a clinically or socially significant change. Momentarily going beyond the data, if these results were extrapolated to a population level and we assumed that, on average, two thirds of everyone who experienced this mEpFT procedure were just 5% to 10% more likely to quit a harmful health behavior (e.g., smoking cigarettes), the resulting effects on the public health-care system could be substantial and would be considered a successful public health intervention. In addition, because mEpFT is an antecedent-based approach, there may be additional cost savings compared to a consequence-based procedure that yields a similar effect size. Although replications with larger sample sizes should be conducted to support these claims, a small effect size should not be interpreted as having little practical or societal importance (Rosenthal, 1990).

In addition to examining the change in discounting immediately after the mEpFT procedure, the degrees to which the reported likelihood of quitting changed at specific probabilities at different points during the experiment were compared. To do this, participants' reported likelihood at each probability value for the last three blocks in baseline and first and last three blocks of the experimental manipulation were averaged. On average, the most pronounced shifts in reported likelihood occurred at the 25% (baseline [BL] $M = 22.49$, first three mEpFT [FT] $M = 33.33$, last three mEpFT [LT] $M = 30.89$) and 10% (BL = 3.89, FT = 13.16, LT = 10.98) probabilities. Levels remained relatively stable at the larger probabilities (i.e., 95%: BL = 93.01, FT = 96.10, LT = 96.40; 90%: BL = 90.05, FT = 91.02, LT = 93.46; 75%: BL = 75.38, FT = 79.74, LT = 78.9; 50%: BL = 55.07, FT = 60.62, LT = 61.41) and the smallest probability (i.e., 5%: BL = 0.35, FT = 2.64, LT = 2.71). Given the aggregate nature of these data, we further explored each individual's reported likelihood of quitting using higher resolution analyses by plotting the likelihood of quitting at each probability over the course of the experiment.

Figure 3 shows individuals' reported likelihood of quitting at each probability across consecutive blocks. Amelia, Josephine, and Stevie show the clearest demonstration of differentiation in reported likelihood to quit between the different probability values. The immediate effect of mEpFT on reported likelihood is best illustrated by examining these levels before and after implementation of mEpFT. For Amelia, small increases in her likelihood values were seen after the phase change across all probability values, with the largest increases at 25% (range, 12.5% to 35.3%) and 10% (range, 0% to 18.9%). Johanna and, to some extent, Josephine, display similar patterns. Stevie displayed small increases across several probability values as well. As indicated by the relatively small amount of shading between the curves for Merrietta in Figure 2, her levels of responding before and after the phase change were similar. At the aggregate level, the largest changes in the reported likelihood to quit the hobby occurred at the 10% and 25% probabilities; however, the high-resolution analysis reveals that some participants showed relatively larger increases at other probabilities (e.g., Merrietta and Stevie, 75%) whereas other participants showed decreases at other probabilities (e.g., Johanna, 75%). Nevertheless, both levels of analysis demonstrated small changes at the largest probabilities.

It may be the case that a ceiling effect contributed to the relatively small changes in the largest probabilities. For example, although Johanna's reported likelihood of quitting decreased for the second largest probability (90%) immediately after the phase change, level of reported likelihood just before the phase change was high (100 vs. 90.56). The potential ceiling effect may have been a result of the wording of the question, "How likely are you to quit this hobby?" With such high probabilities associated with the health gain (e.g., 95%, 90%) and the already high reported likelihood of quitting during baseline, it may have been the case that there was little room for individuals to increase their reported likelihoods of quitting. To address this potential

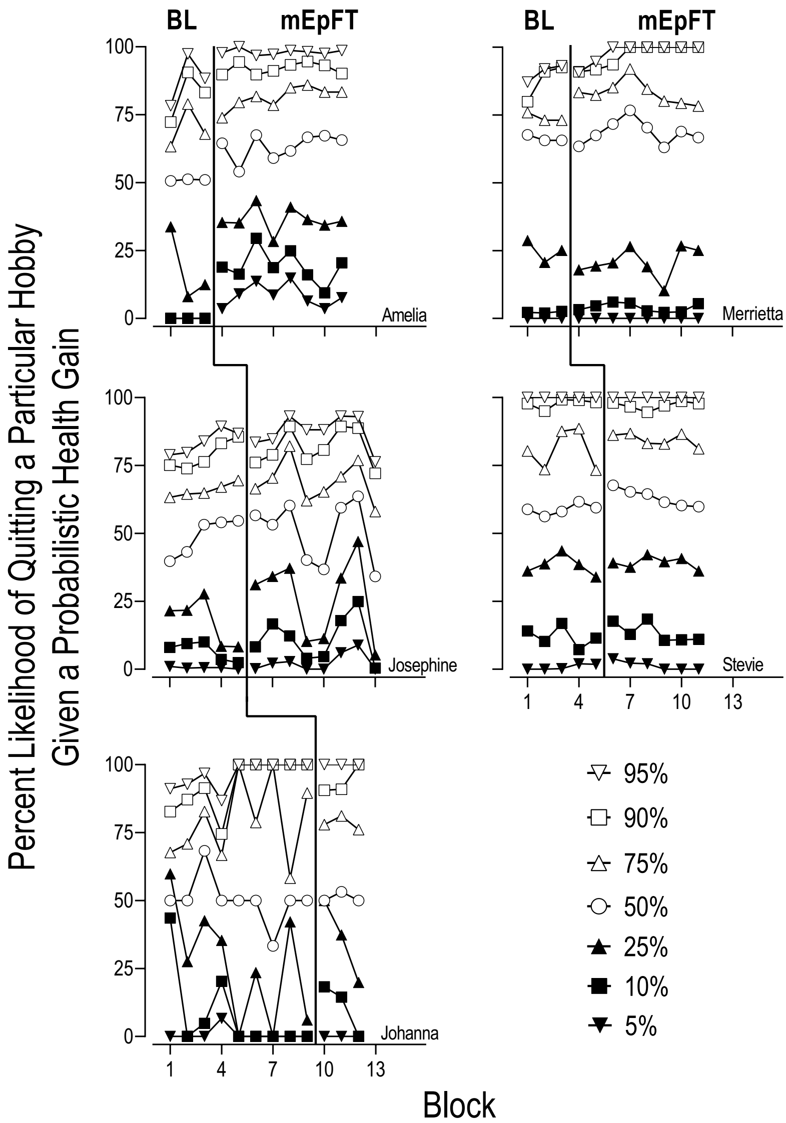

Figure 3. Likelihood of quitting a particular hobby given a probabilistic health gain at each probability value across consecutive blocks. Major phase-change lines indicate transition from baseline to mEpFT phase.

limitation, we used a different wording of the question in Experiment 2.

Taken together, the results of Experiment 1 indicate that exposure to an mEpFT (i.e., computer-generated future-self images and completion of an FSQ) procedure increased reported likelihood of quitting for four of the five participants in the mEpFT phase compared to baseline across a range of probabilities, with the most notable increases occurring at the 10% and 25% probabilities. To our knowledge, this is the first demonstration of an EpFT derivative to change degree of probability discounting of a health gain. Although the results show that the manipulation altered the degree of discounting in the predicted direction, these changes were demonstrated only in the context of a health gain. However, the delayed and probabilistic outcomes associated with many health-related decisions are often negative, and it is unknown whether similar changes would be observed in the context of a health loss. In an attempt to model a situation an individual might encounter when consulting with a trained physician (e.g., a doctor might inform you that continuing a particular hobby, e.g., smoking, might result in developing cancer), Experiment 2 explored whether the current experimental manipulation would result in changes in discounting in the context of a health loss.

EXPERIMENT 2

The purpose of Experiment 2 was to examine the effects of the mEpFT procedure on probability discounting of a delayed health loss.

Participants, Setting, and Materials

Five undergraduate women ranging in age from 19 to 21 years ($M = 20.2$, $SD = 0.84$) and one undergraduate man (22 years old), recruited from an introductory class in applied behavior analysis, participated. All other aspects of the experiment, including compensation, session and block durations, materials, and setting, were the same as Experiment 1.

Computer-generated images. The same procedure from Experiment 1 to create the computer-generated images was used in the current experiment.

Future-self questionnaire. The FSQ contained the same questions as in Experiment 1.

Procedure

All aspects of the experiment were the same as in Experiment 1 except for the wording of the probabilistic health question and the ordering of the five unique computer-generated images. Participants in the current experiment read the following question:

> Imagine you are in perfect health and enjoy a particular hobby. You learn that continuing this hobby one more time will increase your risk of dying of cancer by XX% in 30 years. How likely are you to continue this hobby?

The same probabilities from Experiment 1 were used in the current experiment: 95%, 90%, 75%, 50%, 25%, 10%, and 5%. Response values also ranged from 0% to 100% likely to continue. Unlike Experiment 1, in which the order from left to right of the five unique computer-generated images underneath the VAS ranged from sad to happy, this order was reversed so that the happy face was now closest to the *Not at all likely* anchor.

Data Analysis

Data were analyzed using the same methods as in Experiment 1.

Results and Discussion

As in Experiment 1, for each participant, two discounting curves were plotted using the mean reported likelihood of continuing at each probability from the last three blocks of baseline and first three blocks of the mEpFT phase. Figure 4 shows these curves, with error bars showing one standard error of the mean. To aid in visualizing the difference in the reported likelihood of quitting at the smaller odds-against values, semilog scaled insets are displayed in each graph. As indicated by the area shaded between the curves, five of the six participants reported a lower likelihood of continuing after exposure to mEpFT. The lack of shading in André's graph shows the opposite effect; his pattern of responses indicated that he would be more likely to continue the hobby in the face of a health loss. Jossilyn and Bryanna showed the greatest area between the curves at the smaller odds-against values, whereas Richelle, André, and Marcia showed little to no area between the curves at these values.

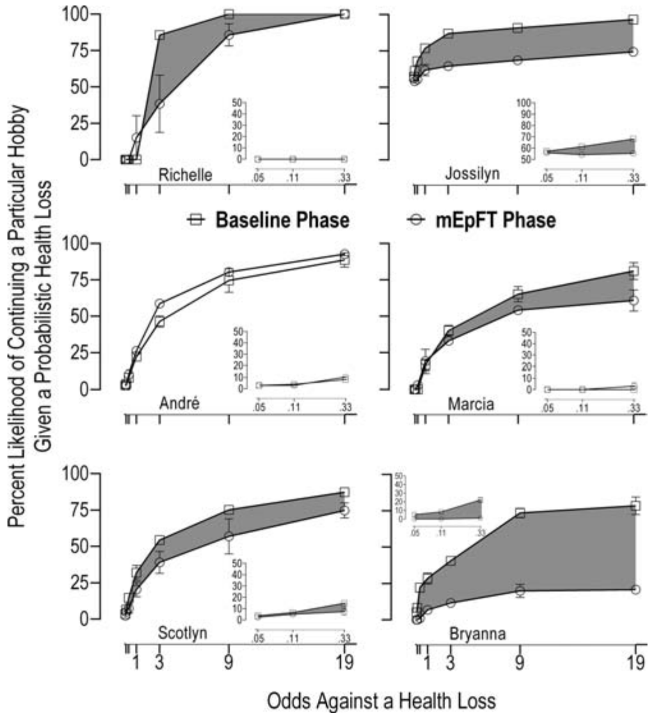

Figure 4. Mean (±*SEM*) likelihood of continuing a particular hobby given a probabilistic health loss for last three blocks of baseline (open squares) and first three blocks of mEpFT (open circles) phases. The shaded area between the curves indicates area change in the predicted direction (a negative effect is represented by a lack of shading between points for André). Semilog inserts provided for the smaller odds-against values.

We calculated a standardized area between the curves for each participant by standardizing each of the two curves for each participant in Figure 4 and subtracting the area under the mEpFT curve from the area under the baseline curve. All participants except André (+6%) showed a negative percentage change in the area between the mEpFT and baseline curves (indicated by the lack of shading in Figure 4). Specifically, Bryanna showed the greatest decrease in standardized area (–46%) followed by Jossilyn (–21%). Richelle and Scotlyn displayed equal decreases in standardized area (–15%), with Marcia showing the smallest change (–11%) in the predicted direction. This pattern is expected, given that we hypothesized that exposure to the experimental manipulation would decrease the reported likelihood of continuing the hobby.

To evaluate further where these changes occurred with respect to specific probability values, we averaged participants' likelihood values at different points throughout the experiment (i.e., last three blocks of baseline, first three blocks of mEpFT, and last three blocks of mEpFT). After the phase change, the largest decreases in the average likelihood of continuing occurred at the 5% (BL $M = 88.64$, FT $M = 70.51$, LT $M = 79.58$), 10% (BL = 79.83, FT = 60.93, LT = 70.38), and 25% (BL = 59.00, FT = 40.86, LT = 49.92) probabilities. Although there was a small decrease at the 75% (BL = 18.83, FT = 12.85, LT = 15.84) probability, substantial overlap in the largest probabilities (≥50%) still occurred (i.e., 50%: BL = 29.31, FT = 24.91, LT = 27.11; 90%: BL = 13.31, FT = 10.35, LT = 11.83; 95%: BL = 11.49, FT = 10.21, LT = 10.85). Given the

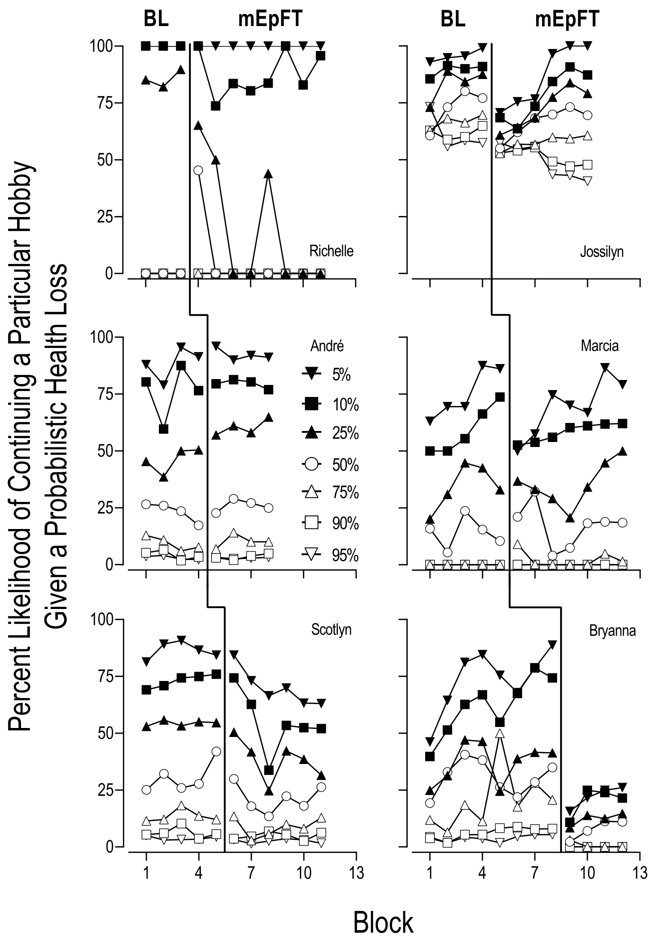

Figure 5. Likelihood of continuing a particular hobby given a probabilistic health loss at each probability value across consecutive blocks. Major phase-change lines indicate transition from baseline to mEpFT phase. Note that unlike Figure 3, the topmost symbols are associated with the smallest probability values, and the bottommost symbols are associated with the largest probability values.

substantial overlap in the largest probabilities, we investigated individuals' reported likelihood of continuing using a high-resolution analysis.

Individual reports of likelihood of continuing across consecutive blocks are displayed in Figure 5. Note the ascending sequence of probability values associated with the legend. Several patterns emerge at this level of analysis. The large decreases in level associated with the two smallest probability values can be seen for Jossilyn, Marcia, Scotlyn, and Bryanna. Jossilyn, Marcia, and Bryanna show an immediate decrease in the reported likelihood of continuing after exposure to mEpFT, whereas Scotlyn shows a more gradual decline across the first three blocks of mEpFT. Jossilyn and Bryanna also show a large and immediate decrease associated with probability values larger than 5% and 10%. Interesting patterns were observed for Jossilyn, Marcia, and Bryanna. For Jossilyn, there was an initial convergence in the reported likelihood of continuing immediately after the phase change. However, across blocks, the data paths became more differentiated and mostly returned to baseline levels (note the decrease from baseline levels for the highest probabilities, 90% and 95%). Marcia's reported likelihood of continuing showed a gradual return to baseline levels towards the end of the mEpFT phase, and Bryanna's reported likelihood of continuing also converged after the phase change but did not return to baseline levels. Richelle showed a distinct pattern in that the reported likelihood of continuing was either very high (100%) or very low (0%) with little variability. Taken together, for most participants a clear decrease in likelihood of continuing occurred after the phase change, with levels beginning to return to those similar in baseline towards the end of the phase.

The largest changes in reported likelihood to continue occurred at the smallest probabilities, specifically 5%, 10%, and 25%. Visual inspection suggests that there were larger changes at the lower probabilities for the health loss than the health gain. This might be due to a framing effect in which the health loss was perceived to be more aversive than the health gain, in line with prospect theory (Tversky & Kahneman, 1986, 1992). Conclusions should be tempered because the framing of the wording of the two health questions are not statistically equivalent. Previous studies that have examined the framing effect have typically used statistically equivalent outcomes (e.g., Tversky & Kahneman, 1981); however, the health-related questions in the current study differ based on the initial level of risk. For example, quitting a hobby that otherwise increases the risk of developing cancer by 95% is not the same as a 5% chance of being alive and well by continuing the hobby. Although we phrased the questions to match real-world contingencies, similar to what an individual might be told by a doctor, future researchers should address this limitation by stating exact risk (e.g., continuing a certain hobby will result in a 95% risk of dying of cancer) rather than a relative increase in risk.

Another potential reason why we might not have seen changes at the larger probabilities might be due to floor effects. In Figure 5, almost 0% reported likelihood levels were associated with the 90% and 95% probabilities for five of the six participants. Thus, when the participant was faced with a health loss given continuation of a hobby, reported likelihood was already low during baseline; therefore, there was little room for those reports to decrease after the mEpFT procedure.

GENERAL DISCUSSION

The goal of the current experiments was to determine the extent to which exposure to computer-generated future-self images and completion of an FSQ in an mEpFT procedure would alter participants' reported likelihood of quitting or continuing a hobby that would result in a delayed but probabilistic health gain or loss, respectively. Indeed, four of the five participants in Experiment 1 and five of the six participants in Experiment 2 displayed changes in the predicted direction in their reported likelihood to quit or continue. This is the first study of which we are aware to apply an EpFT manipulation in an effort to alter individuals' degree of probability discounting in the context of both a health gain and a health loss.

We stress that the current study should be regarded as a proof of concept; thus, as with the typical progression of science, it raises many interesting questions that only further experimental investigations will answer. Therefore, our conclusions remain within the bounds of the data and provide possible mechanisms and areas for future research. For example, although evidence suggests that delay discounting and probability discounting are affected by different variables (Estle, Green, Myerson, & Holt, 2006; Green, Myerson, & Ostaszewski, 1999; Yi, de la Piedad, & Bickel, 2006) and thus might be separate processes (Green & Myerson, 2013; Jarmolowicz, Bickel, Carter, Franck, & Mueller, 2012), it is interesting that the mEpFT procedure used in the current study resulted in robust changes in probability discounting of both gains and losses. Even though the current study demonstrates that the mEpFT package effectively altered individuals' degree of discounting, the degree to which the individual components (e.g., computer-generated future-self images, FSQ) were responsible for the observed changes is unknown, and a component analysis will be needed to determine the relevant components.

It could be the case that participants in the current study responded to the probabilities as participants in previous EpFT studies responded to delays. Further support for this notion and the temporal attention hypothesis, by way of the EpFT procedure, comes from the conceptualization that uncertainty and delay are analogous (Weber & Chapman, 2005) and that the more uncertain the event is, the more psychologically distant it is perceived to be (Todorov, Goren, & Trope, 2007; Wakslak, Trope, Liberman, & Alony, 2006). Although their procedure was different than the current one, Weber and Chapman (2005) found that, in some cases, not only did delay eliminate the certainty effect (i.e., overweighting certain outcomes), but risk also eliminated the immediacy effect (i.e., overweighting immediate outcomes). This might suggest that temporal attention can be allocated to aspects other than distal outcomes and that the mEpFT procedure used in the current study did change participants' responses to the probabilistic aspect of the health question. Future research should examine the extent to which techniques that have been shown to modify delay discounting alter probability discounting. In addition, we kept the delay constant throughout both experiments as to not confound interpretations. Therefore, it would be beneficial to replicate the current findings while also manipulating delay in a parametric-like fashion, as in Vanderveldt, Green, and Myerson's procedure (2015), to determine whether interactions between delay and risk are present.

Although the probabilistic health question was delayed, the mEpFT procedure effectively changed individuals' degree of probability discounting for both gains and losses. These results have immediate, applied implications in the realm of promoting healthy behavior. Framing effects are a reliable phenomenon (Kühberger, 1998) and, depending on the outcome of engaging (or failure to engage) in a particular behavior, framing the outcome in terms of a gain or a loss might be differentially effective in promoting the desired behavior (Rothman, Bartels, Wlaschin, & Salovey, 2006). The type of framing used in the current study best aligns with Levin, Schneider, and Gaeth's (1998) typology of a *goal frame*. A goal frame, often used in health-related scenarios, attempts to enhance the evaluation of a specific outcome or behavior, and the outcome can be framed to focus attention on obtaining a positive consequence (gain frame) or avoiding a negative consequence (loss frame). In a review of 28 research articles that used goal frames to change behavior, Levin et al. found the loss frame to be more effective in changing behavior. Although direct comparisons between the two experiments in the current study cannot be made given the differences in the question used (e.g., quitting vs. continuing the hobby), visual inspection of the data (Figures 2 and 4) and standardized percentage change (see Experiments 1 and 2, Results and Discussion) suggests the loss frame resulted in a greater change in the reported likelihood of quitting or continuing. A future study might evaluate the effects of the two kinds of frames while the question (e.g., quitting vs. continuing the hobby) is kept constant. Nonetheless, the results from the current study demonstrate that the mEpFT procedure was effective at changing behavior regardless of the frame.

The current study has applied implications for manipulating decision making at the point of purchase. Merrill Edge, a large wealth-management company, recently introduced this concept of age progression in their Face Retirement campaign (http://faceretirement.merrilledge.com/) in an attempt to influence the user to make wise financial decisions by age-progressing users' faces via webcam while they log into their online retirement portfolio. We believe that it is possible to apply these age-morphing techniques, along with other targeted questions and evaluation forms, to influence decision making in domains other than money and to make the tyranny of small decisions (Bickel & Marsch, 2001) work for, rather than against, the individual. For example, it might be possible to create a mobile device application that will automatically render future computer-generated images of the user's face and combine this with information regarding the current weight, resting heart rate, and blood pressure of the user, as well as the last time the user worked out, to project a probabilistic risk assessment of not engaging in any exercise for that day. Integration between applications that manage health and money tracking, along with more sophisticated forms of image capturing, will allow these kinds of interventions to be readily accessible.

Because this is the first study to apply an EpFT derivative to probability discounting and the probabilistic choice task contained a delayed element, the extent to which the same manipulation would alter probability discounted without a delayed component is unknown. Had the mEpFT procedure merely targeted the delayed aspect of the health outcome, we might have expected the reported likelihood of continuing or quitting to change systematically across all the probability values. A logical next step would be to remove the delayed aspect of the probabilistic question to isolate the effects of EpFT on probability discounting. Nevertheless, the results are promising, given the ubiquity of everyday choices that involve both delayed and probabilistic components (e.g., Bickel & Marsch, 2001; Green & Myerson, 2004; Vanderveldt et al., 2015).

As with many previous discounting studies (Bickel et al.,1999; Dixon & Holton, 2009; Dixon et al., 2003; Johnson & Bickel, 2002; Odum, Madden, Badger, & Bickel, 2000), the current study used hypothetical outcomes rather than real outcomes, posing a potential limitation to our methodology. However, previous research that has compared real and hypothetical outcomes has found that both types of outcomes are discounted similarly (Dixon, Mui Ker Lik, Green, & Myerson, 2013; Johnson & Bickel, 2002; Lawyer, Schoepflin, Green, & Jenks, 2011; Madden et al., 2004; Madden, Begotka, Raiff, & Kastern, 2003). That self-reported behavior and actual behavior in discounting tasks have been shown to produce similar results is an important aspect that is often discounted, especially when viewed in the context of the behavioral dimension put forth by Baer, Wolf, and Risley (1968):

> Applied research is eminently pragmatic; it asks how it is possible to get an individual to do something effectively. Thus it usually studies what subjects can be brought to do rather than what they can be brought to say; unless, of course, a verbal response is the behavior of interest. Accordingly a subject's verbal description of his own non-verbal behavior usually would not be accepted as a measure of his actual behavior unless it were independently substantiated. (p. 93)

Although we did not personally substantiate the participants' verbal reports in the current study, we rely on the substantial discounting literature that has done so (Bickel, Pitcock, Yi, & Angtuaco, 2009; Dixon, Mui Ker Lik, et al., 2013; Johnson & Bickel, 2002; Lagorio & Madden, 2005; Lawyer et al., 2011; Madden et al., 2003, 2004; Matusiewicz, Carter, Landes, & Yi, 2013). The correspondence between self-reports and actual behavior need not be perfect, especially if one's goal is to determine the relative extent to which behavior changes in the presence of some manipulation (e.g., mEpFT). There is much applied utility in knowing that one individual is relatively more susceptible to a given intervention than another.

Furthermore, as Odum (2011) points out, discounting tasks ask questions that are qualitatively different from typical self-report measures (e.g., asking about past behavior), which may be one explanation for the suitable correspondence between real and hypothetical rewards. In addition, there are usually no right or wrong answers, because the participant is simply choosing between options or reporting his or her likelihood of engaging in some behavior. Relevant to the current study, it would be difficult, if not impossible, to deliver the health-related consequences used in the probabilistic choice task directly. We conceptualized the health questions as ones an individual might encounter from a trained physician, a situation with which many people probably have experience. Notwithstanding the novel aspect of the probabilistic choice question, participants discounted the risks associated with the hobby systematically, and all data passed Johnson and Bickel's (2008) criteria for nonsystematic data.

An additional limitation surrounds the mEpFT component entailing the age-progressed images. It could have been the case that for some participants, their computer-generated face was too dissimilar from what they might imagine or hope themselves to look like 30 years from now. Previous EpFT literature suggests that the more vivid the subject-specific cues are or the reported degree of imagery (i.e., high vs. low), the greater the change in degree of discounting (Peters & Büchel, 2010). The difference between how participants viewed their computer-generated future self and their perceptions of what their future self will look like may have contributed to differences in the change in discounting across participants. However, during debriefing, we asked participants to rate on a Likert scale (1 = *extremely dissimilar*; 7 = *extremely similar*) the degree to which the images looked like them. The average rating in Experiment 1 was 4.5 (*SD* = 1), and the average rating in Experiment 2 was 3.75 (*SD* = 1.25). These differences in scores may have contributed to the idiosyncratic effects observed with respect to change in reported likelihood across the various probabilities in terms of the majority of participants showing changes in the predicted direction at the lower probabilities and, for some participants, increases at other probabilities.

Our mEpFT was also limited by the open-ended nature of the FSQ. It is possible that asking participants to self-generate the hobby might have differentially affected how they responded to the question. For example, one participant reported that the hobby she was thinking of was indoor tanning, whereas another participant reported that she was thinking of smoking cigarettes, even though she was not a current smoker. Use of a concrete hobby or activity that participants identify beforehand might result in more consistent effects across participants and may even amplify the effects we obtained. Furthermore, more robust effects might occur with clinical populations with the hobby being engagement in their preferred activity or consumption of their substance of abuse. A logical next step would be to simply layer the age-progression component used in the current study onto more standard EpFT procedures (e.g., use of subject-specific tags; Peters & Büchel, 2010).

Certain aspects of the probabilistic choice task pose limitations for the current study. The program was designed so that every trial lasted approximately 45 s in an effort to standardize block duration. As a result, participants had a total of 10 s to respond during each trial and, depending on how quickly he or she responded, the remainder of that 10 s was added to that trial's blackout period. Although these aspects were included so that participants could not respond faster in an attempt to end the session quicker, there were instances in which a participant failed to respond within 10 s; when that occurred, the program recorded an omission. An omission occurred on at least one trial for all but one participant (Merrietta) in Experiment 1 and all but two participants (Bryanna and Jossilyn) in Experiment 2. However, of those participants who did omit a response on at least one trial, the average number of omissions per person was 2.25 (range, 1 to 4; $SD = 1.04$), and these omissions typically occurred during the first or second block of baseline. Therefore, the number of omitted trials comprised only 2% of the total number of trials. Although it does not appear that the time constraint had a systematic effect on degree of discounting, Ebert (2001) found that participants who were under a time constraint of 3 s displayed lower rates of delay discounting but only for the first half of the session. In addition, Dixon, Mui Ker Lik, et al. (2013) found that when blackout periods contingent on immediate choices were used to hold reinforcement rate constant, participants displayed little to no discounting, whereas more typical discounting was observed when these blackouts were absent. Several differences might account for why we observed more typical patterns of discounting even with the use of blackout periods. First, participants in the current study had more time to respond (e.g., 10 s) than they did in Ebert's study. Although the effect obtained in his study was in the opposite direction as other studies that have taxed executive functioning (Hinson, Jameson, & Whitney, 2003), similar to Ebert's, our study asked individuals to report a single value (e.g., likelihood of continuing or quitting) rather than to make a choice between options. It is unknown whether time constraints affect discount rates the same way when individuals report a single value compared to when they have to choose between options. Second, the aforementioned studies assessed delay discounting rather than probability discounting. Although the probabilistic choice question did have a delayed component, delays were not systematically altered and pitted against an explicit immediate outcome, as is more often the case in delay-discounting studies.

Finally, although we employed a novel VAS procedure to assess degree of discounting, previous literature has supported the use of the VAS as a feasible response medium (Johnson & Bruner, 2013; Kaplan et al., 2014), especially in the contexts of questions in which money is not easily equated. Degree of discounting, as calculated using AUC (Myerson et al., 2001), remained relatively stable throughout the duration of the experiment, even though trials and sessions were presented separately, corroborating the test–retest reliability analysis of the VAS (Johnson & Bruner, 2013). This demonstrates a promising approach to examine discounting across a wide range of domains.

In sum, results from the current study suggest that the mEpFT procedure was effective in changing the degree of probability discounting of both a delayed health gain and a delayed health loss. These results expand the scope of both the temporal attention hypothesis and the EpFT literature. The current study also demonstrates the applied utility of using EpFT and framing techniques to change behavior, especially in the context of health outcomes and situations in which a one-time decision-making event is important to target. Therefore, future research should examine the experimental variables that affect delay discounting and related processes (e.g., temporal perspective, reinforcer value, risky choice), particularly those that produce lasting effects.

REFERENCES

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

Ariely, D., & Wertenbroch, K. (2002). Procrastination, deadlines, and performance: Self-control by precommitment. *Psychological Science*, *13*, 219–224. doi: 10.1111/1467-9280.00441

Atance, C. M., & O'Neill, D. K. (2001). Episodic future thinking. *Trends in Cognitive Sciences*, *5*, 533–539. doi: 10.1016/s1364-6613(00)01804-0

Baer, D. M., Wolf, M. M., & Risley, T. R. (1968). Some current dimensions of applied behavior analysis. *Journal of Applied Behavior Analysis*, *1*, 91–97. doi: 10.1901/jaba.1968.1-91

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

Bickel, W. K., Johnson, M. W., Koffarnus, M. N., MacKillop, J., & Murphy, J. G. (2014). The behavioral economics of substance use disorders: Reinforcement pathologies and their repair. *Annual Review of Clinical Psychology*, *10*, 641–677. doi: 10.1146/annurev-clinpsy-032813-153724

Bickel, W. K., Kowal, B. P., & Gatchalian, K. M. (2006). Understanding addiction as a pathology of temporal horizon. *The Behavior Analyst Today*, *7*, 32–47.

Bickel, W. K., MacKillop, J., Madden, G. J., Odum, A. L., & Yi, R. (Eds.). (2015). Experimental manipulations of delay discounting and related processes [Special issue]. *Journal of the Experimental Analysis of Behavior*, *103*.

Bickel, W. K., & Marsch, L. A. (2001). Toward a behavioral economic understanding of drug dependence: Delay discounting processes. *Addiction*, *96*, 73–86. doi: 10.1046/j.1360-0443.2001.961736.x

Bickel, W. K., Odum, A. L., & Madden, G. J. (1999). Impulsivity and cigarette smoking: Delay discounting in current, never, and ex-smokers. *Psychopharmacology*, *146*, 447–454. doi: 10.1007/pl00005490

Bickel, W. K., Pitcock, J. A., Yi, R., & Angtuaco, E. J. (2009). Congruence of BOLD response across intertemporal choice conditions: Fictive and real money gains and losses. *The Journal of Neuroscience*, *29*, 8839–8846. doi: 10.1523/JNEUROSCI5319-08.2009

Bickel, W. K., Wilson, A. G., Franck, C. T., Mueller, E. T., Jarmolowicz, D. P., Koffarnus, M. N., & Fede, S. J. (2014). Using crowdsourcing to compare temporal, social temporal, and probability discounting among obese and non-obese individuals. *Appetite*, *75*, 82–89. doi: 10.1016/j.appet.2013.12.018

Bickel, W. K., Yi, R., Landes, R. D., Hill, P. F., & Baxter, C. (2011). Remember the future: Working memory training decreases delay discounting among stimulant addicts. *Biological Psychiatry*, *69*, 260–265. doi: 10.1016/j.biopsych.2010.08.017

Bradford, W. D. (2010). The association between individual time preferences and health maintenance habits. *Medical Decision Making*, *30*, 99–112. doi: 10.1177/0272989×09342276

Call, N. A., Reavis, A. R., McCracken, C. E., Gillespie, S. E., & Scheithauer, M. C. (2015). The impact of delays on parents' perceptions of treatments for problem behavior. *Journal of Autism and Developmental Disorders*, *45*, 1013–1025. doi: 10.1007/s10803-014-2257-9

Chesson, H. W., Leichliter, J. S., Zimet, G. D., Rosenthal, S. L., Bernstein, D. I., & Fife, K. H. (2006). Discount rates and risky sexual behaviors among teenagers and young adults. *Journal of Risk and Uncertainty*, *32*, 217–230. doi: 10.1007/s11166-006-9520-1

Critchfield, T. S., & Kollins, S. H. (2001). Temporal discounting: Basic research and the analysis of socially important behavior. *Journal of Applied Behavior Analysis*, *34*, 101–122. doi: 10.1901/jaba.2001.34-101

Daniel, T. O., Stanton, C. M., & Epstein, L. H. (2013). The future is now: Comparing the effect of episodic future thinking on impulsivity in lean and obese individuals. *Appetite*, *71*, 120–125. doi: 10.1016/j.appet.2013.07.010

Davis, C., Patte, K., Curtis, C., & Reid, C. (2010). Immediate pleasures and future consequences. A neuropsychological study of binge eating and obesity. *Appetite*, *54*, 208–213. doi: 10.1016/j.appet.2009.11.002

DeHart, W. B., & Odum, A. L. (2015). The effects of the framing of time on delay discounting. *Journal of the Experimental Analysis of Behavior*, *103*, 10–21. doi: 10.1002/jeab.125

Dixon, M. R., & Holton, B. (2009). Altering the magnitude of delay discounting by pathological gamblers. *Journal of Applied Behavior Analysis*, *42*, 269–275. doi: 10.1901/jaba.2009.42-269

Dixon, M. R., Mui Ker Lik, N., Green, L., & Myerson, J. (2013). Delay discounting of hypothetical and real money: The effect of holding reinforcement rate constant. *Journal of Applied Behavior Analysis*, *46*, 512–517. doi: 10.1002/jaba.42

Dixon, M. R., Marley, J., & Jacobs, E. A. (2003). Delay discounting by pathological gamblers. *Journal of Applied Behavior Analysis*, *36*, 449–458. doi: 10.1901/jaba.2003.36-449

Dixon, M. R., Whiting, S. W., & Miller, J. R. (2013). Discounting of restraint usage, problem behavior management, and risk of autism severity. *Research in Autism Spectrum Disorders*, *7*, 1211–1220. doi: 10.1016/j.rasd.2013.07.004

Ebert, J. E. J. (2001). The role of cognitive resources in the valuation of near and far future events. *Acta Psychologica*, *108*, 155–171. doi: 10.1016/s0001-6918(01)00033-6

Estle, S. J., Green, L., Myerson, J., & Holt, D. D. (2006). Differential effects of amount on temporal and probability discounting of gains and losses. *Memory & Cognition*, *34*, 914–928. doi: 10.3758/bf03193437

Fields, S. A., Sabet, M., Peal, A., & Reynolds, B. (2011). Relationship between weight status and delay discounting in a sample of adolescent cigarette smokers. *Behavioural Pharmacology*, *22*, 266–268. doi: 10.1097/FBP.0b013e328345c855

Green, L., & Myerson, J. (2004). A discounting framework for choice with delayed and probabilistic rewards. *Psychological Bulletin*, *130*, 769–792. doi: 10.1037/0033-2909.130.5.769

Green, L., & Myerson, J. (2013). How many impulsivities? A discounting perspective. *Journal of the Experimental Analysis of Behavior*, *99*, 3–13. doi: 10.1002/jeab.1

Green, L., Myerson, J., & Ostaszewski, P. (1999). Amount of reward has opposite effects on the discounting of delayed and probabilistic outcomes. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *25*, 418–427. doi: 10.1037/0278-7393.25.2.418

Hershfield, H. E., Goldstein, D. G., Sharpe, W. F., Fox, J., Yeykelis, L., Carstensen, L. L., & Bailenson, J. N. (2011). Increasing saving behavior through age-progressed renderings of the future self. *Journal of Marketing Research*, *48*(SPL), S23–S37. doi: 10.1509/jmkr.48.spl.s23

Hinson, J. M., Jameson, T. L., & Whitney, P. (2003). Impulsive decision making and working memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *29*, 298–306. doi: 10.1037/0278-7393.29.2.298

Jarmolowicz, D. P., Bickel, W. K., Carter, A. E., Franck, C. T., & Mueller, E. T. (2012). Using crowdsourcing to examine relations between delay and probability discounting. *Behavioural Processes*, *91*, 308–312. doi: 10.1016/j.beproc.2012.09.001

Jarmolowicz, D. P., Cherry, J. B. C., Reed, D. D., Bruce, J. M., Crespi, J. M., Lusk, J. L., & Bruce, A. S. (2014). Robust relation between temporal discounting rates and body mass. *Appetite*, *78*, 63–67. doi: 10.1016/j.appet.2014.02.013

Johnson, M. W., & Bickel, W. K. (2002). Within-subject comparison of real and hypothetical money rewards in delay discounting. *Journal of the Experimental Analysis of Behavior*, *77*, 129–146. doi: 10.1901/jeab.2002.77-129

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

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

Johnson, M. W., & Bruner, N. R. (2013). Test-retest reliability and gender differences in the sexual discounting task among cocaine-dependent individuals. *Experimental and Clinical Psychopharmacology*, *21*, 277–286. doi: 10.1037/a0033071

Kaplan, B. A., Reed, D. D., & McKerchar, T. L. (2014). Using a visual analogue scale to assess delay, social, and probability discounting of an environmental loss. *The Psychological Record*, *64*, 261–269. doi: 10.1007/s40732-014-0041-z

Koffarnus, M. N., Jarmolowicz, D. P., Mueller, E. T., & Bickel, W. K. (2013). Changing delay discounting in the light of the competing neurobehavioral decision systems theory: A review. *Journal of the Experimental Analysis of Behavior*, *99*, 32–57. doi: 10.1002/jeab.2

Kühberger, A. (1998). The influence of framing on risky decisions: A meta-analysis. *Organizational Behavior and Human Decision Processes*, *75*, 23–55. doi: 10.1006/obhd.1998.2781

Lagorio, C. H., Madden, G. J. (2005). Delay discounting of real and hypothetical rewards: III. Steady-state assessments, forced-choice trials, and all real rewards. *Behavioural Processes*, *69*, 173–187. doi: 10.1016/j.beproc.2005.02.003

Lawyer, S. R., Schoepflin, F., Green, R., & Jenks, C. (2011). Discounting of hypothetical and potentially real outcomes in nicotine-dependent and nondependent samples. *Experimental and Clinical Psychopharmacology*, *19*, 263–274. doi: 10.1037/a0024141

Levin, I. P., Schneider, S. L., & Gaeth, G. J. (1998). All frames are not created equal: A typology and critical analysis of framing effects. *Organizational Behavior and Human Decision Processes*, *76*, 149–188. doi: 10.1006/obhd.1998.2804

Lin, H., & Epstein, L. H. (2014). Living in the moment: Effects of time perspective and emotional valence of episodic thinking on delay discounting. *Behavioral Neuroscience*, *128*, 12–19. doi: 10.1037/a0035705

MacKillop, J. (2013). Integrating behavioral economics and behavioral genetics: Delayed reward discounting as an endophenotype for addictive disorders. *Journal of the Experimental Analysis of Behavior*, *99*, 14–31. doi: 10.1002/jeab.4

MacKillop, J., Amlung, M. T., Few, L. R., Ray, L. A., Sweet, L. H., & Munafò, M. R. (2011). Delayed reward discounting and addictive behavior: A meta-analysis. *Psychopharmacology*, *216*, 305–321. doi: 10.1007/s00213-011-2229-0

Madden, G. J., Begotka, A. M., Raiff, B. R., & Kastern, L. L. (2003). Delay discounting of real and hypothetical rewards. *Experimental and Clinical Psychopharmacology*, *11*, 139–145. doi: 10.1037/1064-1297.11.2.139

Madden, G. J., & Bickel, W. K. (Eds.). (2010). *Impulsivity: The behavioral and neurological science of discounting*. Washington, DC: American Psychological Association.

Madden, G. J., Raiff, B. R., Lagorio, C. H., Begotka, A. M., Mueller, A. M., Hehli, D. J., & Wegener, A. A. (2004). Delay discounting of potentially real and hypothetical rewards: II. Between- and within-subject comparisons. *Experimental and Clinical Psychopharmacology*, *12*, 251–261. doi: 10.1037/1064-1297.12.4.251

Matusiewicz, A. K., Carter, A. E., Landes, R. D., & Yi, R. (2013). Statistical equivalence and test-retest reliability of delay and probability discounting using real and hypothetical rewards. *Behavioural Processes*, *100*, 116–122. doi: 10.1016/j.beproc.2013.07.019

Myerson, J., Green, L., & Warusawitharana, M. (2001). Area under the curve as a measure of discounting. *Journal of the Experimental Analysis of Behavior*, *76*, 235–243. doi: 10.1901/jeab.2001.76-235

Odum, A. L. (2011). Delay discounting: I'm a k, you're a k. *Journal of the Experimental Analysis of Behavior*, *96*, 427–439. doi: 10.1901/jeab.2011.96-423

Odum, A. L., Madden, G. J., Badger, G. J., & Bickel, W. K. (2000). Needle sharing in opioid-dependent outpatients: Psychological processes underlying risk. *Drug and Alcohol Dependence*, *60*, 259–266. doi: 10.1016/s0376-8716(00)00111-3

Peters, J., & Büchel, C. (2010). Episodic future thinking reduces reward delay discounting through an enhancement of prefrontal-mediotemporal interactions. *Neuron*, *66*, 138–148. doi: 10.1016/j.neuron.2010.03.026

Petry, N. M. (2001). Pathological gamblers, with and without substance abuse disorders, discount delayed rewards at high rates. *Journal of Abnormal Psychology*, *110*, 482–487. doi: 10.1037/0021-843X.110.3.482

Petry, N. M., Bickel, W. K., & Arnett, M. (1998). Shortened time horizons and insensitivity to future consequences in heroin addicts. *Addiction*, *93*, 729–738. doi: 10.1046/j.1360-0443.1998.9357298.x

Rachlin, H. (2000). *The science of self-control*. Cambridge, MA: Harvard University Press.

Rachlin, H., & Green, L. (1972). Commitment, choice and self-control. *Journal of the Experimental Analysis of Behavior*, *17*, 15–22. doi: 10.1901/jeab.1972.17-15

Radu, P. T., Yi, R., Bickel, W. K., Gross, J. J., & McClure, S. M. (2011). A mechanism for reducing delay discounting by altering temporal attention. *Journal of the Experimental Analysis of Behavior*, *96*, 363–385. doi: 10.1901/jeab.2011.96-363

Renda, C. R., Stein, J. S., & Madden, G. J. (2015). Working-memory training: Effects on delay discounting in male long evans rats. *Journal of the Experimental Analysis of Behavior*, *103*, 50–61. doi: 10.1002/jeab.115

Rosenthal, R. (1990). How are we doing in soft psychology? *American Psychologist*, *45*, 775–777. doi: 10.1037/0003-066X.45.6.775

Rothman, A. J., Bartels, R. D., Wlaschin, J., & Salovey, P. (2006). The strategic use of gain- and loss-framed messages to promote healthy behavior: How theory can inform practice. *Journal of Communication*, *56*(S1), S202–S220. doi: 10.1111/j.1460-2466.2006.00290.x

Skinner, B. F. (1953). *Science and human behavior*. New York, NY: Macmillan.

Thaler, R. H., & Benartzi, S. (2004). Save more tomorrow: Using behavioral economics to increase employee saving. *Journal of Political Economy*, *112*(S1), S164–S187. doi: 10.1086/380085

Todorov, A., Goren, A., & Trope, Y. (2007). Probability as a psychological distance: Construal and preferences. *Journal of Experimental Social Psychology*, *43*, 473–482. doi: 10.1016/j.jesp.2006.04.002

Tversky, A., & Kahneman, D. (1981). The framing of decisions and the psychology of choice. *Science*, *211*, 453–458. doi: 10.1126/science.7455683

Tversky, A., & Kahneman, D. (1986). Rational choice and the framing of decisions. *Journal of Business*, *59*(S4), S251–S278. doi: 10.1086/296365

Tversky, A., & Kahneman, D. (1992). Advances in prospect theory: Cumulative representation of uncertainty. *Journal of Risk and Uncertainty*, *5*, 297–323. doi: 10.1007/bf00122574

Vanderveldt, A., Green, L., & Myerson, J. (2015). Discounting of monetary rewards that are both delayed and probabilistic: Delay and probability combine multiplicatively, not additively. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *41*, 148–162. doi: 10.1037/xlm0000029

Wakslak, C. J., Trope, Y., Liberman, N., & Alony, R. (2006). Seeing the forest when entry is unlikely: Probability and the mental representation of events. *Journal of Experimental Psychology: General*, *135*, 641–653. doi: 10.1037/0096-3445.135.4.641

Wallace, M. (1956). Future time perspective in schizophrenia. *Journal of Abnormal and Social Psychology*, *52*, 240–245. doi: 10.1037/h0039899

Weber, B. J., & Chapman, G. B. (2005). The combined effects of risk and time on choice: Does uncertainty eliminate the immediacy effect? Does delay eliminate the certainty effect? *Organizational Behavior and Human Decision Processes*, *96*, 104–118. doi: 10.1016/j.obhdp.2005.01.001

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

Yi, R., Carter, A. E., & Landes, R. D. (2012). Restricted psychological horizon in active methamphetamine users: Future, past, probability, and social discounting. *Behavioural Pharmacology*, *23*, 358–366. doi: 10.1097/FBP.0b013e3283564e11

Yi, R., de la Piedad, X., & Bickel, W. K. (2006). The combined effects of delay and probability in discounting. *Behavioural Processes*, *73*, 149–155. doi: 10.1016/j.beproc.2006.05.001

Yi, R., Mitchell, S. H., & Bickel, W. K. (2010). Delay discounting and substance abuse-dependence. In G. J. Madden & W. K. Bickel (Eds.), *Impulsivity: The behavioral and neurological science of discounting* (pp. 191–211). Washington, DC: American Psychological Association.

Zimbardo, P. G. (1992). *Stanford Time Perception Inventory manual*. Stanford, CA: Stanford University.

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