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ALTERING PROBABILITY DISCOUNTING IN A GAMBLING SIMULATION

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In gambling, our decisions regarding what gambles to take and how much we are willing to wager might, in part, be influenced by our histories with respect to gambling outcomes. Given a less temporally-distant history with gambling that favors losses, wins, or breaking even may create alterations in one's discounting pattern, albeit most likely temporary. Given the topographical similarity between gambling procedures and probabilistic discounting tasks, probability discounting was used to assess potential changes in discounting resulting from a gambling task designed specifically for this study. Probabilistic discounting patterns for 38 undergraduate students before and after exposure to a simulated die-rolling task were analyzed, and results of follow-up analyses supported the notion that probabilistic discounting patterns can be changed by gambling outcomes. Implications and limitations are discussed.

Keywords: gambling, probability discounting, risk-taking, computer simulation

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Delay- and probability-discounting are two behavioral measures of decision-making. Delay-discounting tasks assess an individual's preference for either a smaller amount of money available immediately or a larger amount of money to be delivered after a specified amount of time. Delay-discounting, then, is a measure of impulsivity. On one end of the continuum lies self-control, in which preference is highly correlated with larger, later rewards. Individuals who demonstrate a greater degree of preference for smaller, sooner rewards are said to be behaving impulsively. In probability-discounting tasks, the individual is presented with two options: a guaranteed smaller reward or a lesser chance at receiving a larger reward, both of which are available immediately. Probability-discounting provides a measurement of risk-taking. Those who are said to be risk-averse discount the less certain larger reward, while those who are risk-seeking show preference for larger, less probable rewards. The average point at which one begins to prefer immediate or certain rewards over delayed or uncertain rewards—or vice versa—is termed the *indifference point*. Lower indifference points indicate a preference for smaller, more immediate, or more certain rewards; high indifference points indicate a preference for larger rewards, even if those rewards are more temporally distant or less certain. In other words, lower indifference points indicate that larger rewards are valued less (i.e., discounted more) as a function of their lack of immediacy or certainty.

Debate exists over whether the two types of discounting are measures of impulsive or risk-taking behaviors. That is, do these measurements of decision-making share a single-trait process, or are they better accounted for by separate processes (Green & Myerson, 2004)? The current position is that probability and

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delay discounting are likely related but not identical. While delay to reinforcement may have some risk involved (predation, loss of access to the reinforcer), it is not necessarily the case. However, in a probabilistic approach, as long as the certainty of reward is less than 1.0, risk is inherent. In other words, you can have delay with or without risk, but risk must always be present in a probabilistic preparation.

Research has provided further evidence for the differentiation between delayed and probabilistic discounting. For example, several researchers have found that choice patterns diverge for different types of discounting. Specifically, larger rewards are discounted to a lesser extent in delay tasks when compared to probabilistic tasks, in which large rewards are discounted to a greater degree (Estle, Green, Myerson, & Holt, 2007; Green, Myerson, & Ostaszewski, 1999; Holt, Green, & Myerson, 2003). Responses also diverge when the rewards are different. For example, individuals discount monetary rewards less steeply than consumable ones when the rewards are delayed (Estle, et al., 2007; Odum, Baumann, & Rimington, 2006), but show no difference in discounting when the larger rewards are probabilistic (Estle, et al., 2007).

Myerson, Green, Hanson, Holt, and Estle (2003) reported that participants who preferred immediacy over delay also preferred certainty. Their finding runs counter to the notion of a single-process model as immediacy and uncertainty are hypothesized to both be characteristics of impulsivity. Several other factors contribute to the argument that delayed and probabilistic discounting operate under separate processes (i.e., effects of inflation rate and income level; for review, see Green & Myerson, 2004).

The literature on discounting is expanding. Researchers are using the discounting framework to examine a broad range of topics, including smoking habits (e.g., Johnson, Bickel, & Baker, 2007; Reynolds, Richards, Horn, & Karraker, 2004), alcohol consumption (e.g., Petry, 2001a), cocaine use (e.g., Woolverton, Myerson, & Green, 2007), and decision-making related to erotica (Lawyer & Chastain, 2006). Researchers have also examined discounting rates obtained from gamblers (Petry, 2001b) as well as discounting rates between gamblers and non-gamblers (Holt, Green, & Myerson, 2003). Statistics show that probabilistic discounting by gamblers differs from non-gamblers in that gamblers discount probabilistic rewards less steeply than non-gamblers (Holt et al., 2003). Similar results are found for pathological gamblers when compared to matched controls (Madden, Petry, & Johnson, 2009). With respect to delay discounting, the majority of research suggests that pathological gamblers discount delayed rewards more steeply than non-gambling controls (e.g., Dixon, Marley, & Jacobs 2003; see also Holt et al., 2003).

Together, these data suggest that probabilistic discounting is likely to be more sensitive at measuring change in discounting, as consistent differences between participants with a history of gambling and those without that history were more highly correlated with probabilistic than temporal discounting. If risk-taking behaviors were defined as a class of behaviors, and a member of that class was subjected to various consequences for engaging in those behaviors, then it is possible that future behaviors from that class will be altered given the recent exposure to different outcomes. With respect to gambling outcomes, altering outcomes to affect the class known as risk-taking behavior would, theoretically, be most easily captured with a probabilistic-, rather than a temporal-, discounting task.

Past research has shown that altering gambling outcomes by creating favorable or unfavorable conditions for risk-taking behaviors can affect future gambling behavior for the same task. For example, Cummins, Nadorff, and Kelly (2009) tested the effects of winning

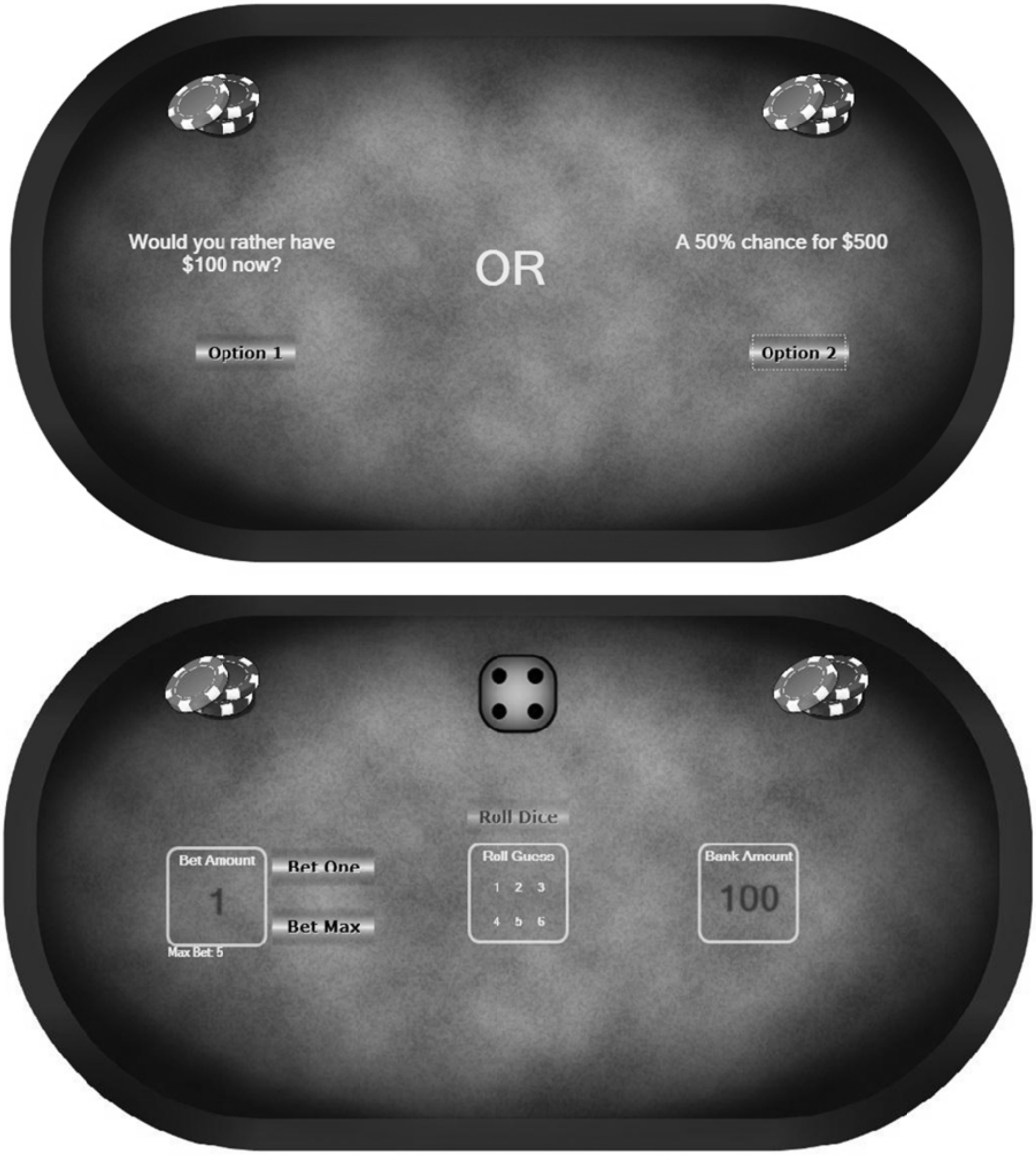

Figure 1. Discounting and gambling participant interface

and losing on subsequent betting patterns in two experiments (Experiment 1, *N* = 107; Experiment 2, *N* = 72) with predetermined win percentages on Acey-Deucey. Acey-Deucey was played by presenting the participant with three cards in a row on a computer screen. The outside cards were shown face up, and the participant was asked to wager on whether the middle card's denomination would fall between the two outer cards. Participants were assigned to one of two conditions; an initial win condition, in which 80% of 30 hands were programmed to win, or an initial lose condition, in which 80% of 30 hands were programmed to lose. Following this condition, they were asked to play again, and

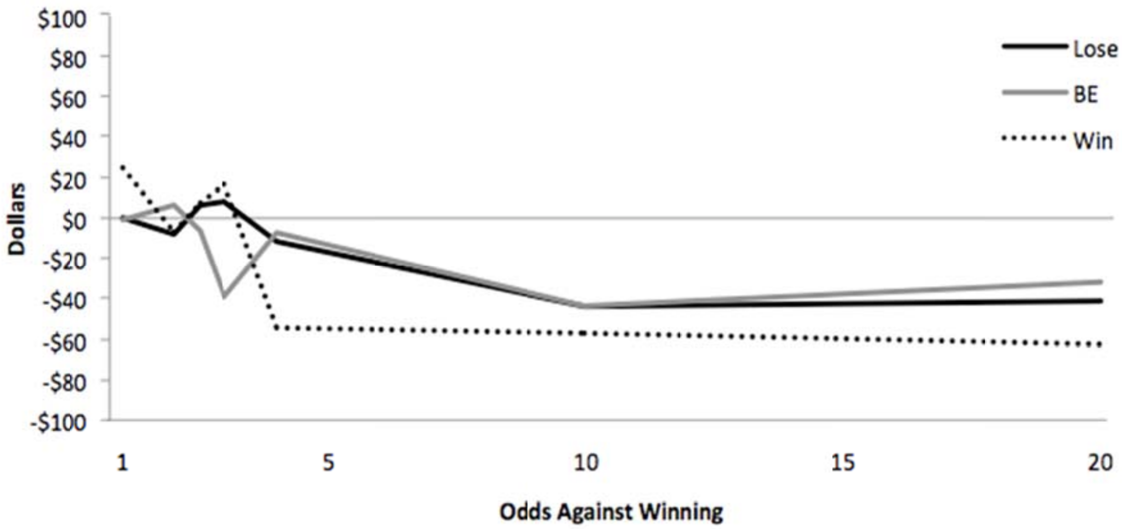

Figure 2. Mean change in indifference points as a function of odds against winning

betting style with respect to hands that were expected to win less than 50% was analyzed. Results indicated that, for both experiments, those who were in the initial win condition wagered larger bets on hands that had a low probability of being won. Tests for generalization to other risk-taking behaviors or measurements were not reported.

The purpose of the current study was to examine the effects gambling has on probability discounting. Probability discounting was used instead of delay discounting, as probability discounting is arguably more topographically similar to gambling (e.g., gambling is based on probability; c.f. Rachlin, Raineri, & Cross, 1991). Further, probability discounting has been shown to be correlated with differences between gamblers and non-gambler controls more so than delay-discounting tasks. Participants completed an initial probabilistic-discounting task. A gambling task was created in which participants bet hypothetical money on which number would appear next on a single die roll, wagering between $1 and $5 in whole number increments. Participants were randomly assigned to one of three conditions; win more than chance, lose more than chance, and break even. Once completed, a second discounting task was presented, exactly the same as the first.

METHOD

Participants

The participants were 38 undergraduates (Males = 20) between ages 18 and 40 (M = 21.56, SD = 4.61) at the University of Nevada, Reno. Participants had completed an average of 2.32 years of undergraduate studies (SD = 1.08). All participants were compensated with extra credit in their psychology course and the possibility of winning a $50 cash prize.

Apparatus and Setting

A computer program was developed for this study using Microsoft Visual Basic[1]. The program allowed the researchers to input any combination of probabilistic discounting questions and to arrange gambling outcomes

[1] Program is freely available by contacting the first author. Minimum requirements: a PC computer, 1GHz processor, 512 MB RAM, Windows XP Home/Professional or greater, and a download of the Microsoft .Net4 framework.

into defined groups. The gambling tasks were defined by the researchers by indicating which trials would result in a win or a loss for the participant, dependent upon group assignment. The participant interface consisted of a computer graphic of a green felt poker table with ornamental poker chips on either side (see Figure 1). The poker table displayed the discounting tasks such that the left side of the table always contained the smaller, guaranteed amount, and the right side the larger, uncertain amount. Participants could then use the mouse to make a selection. The gambling task was presented on the same background as the discounting task and contained the current wager, number guessed, bankroll, betting options, and a simulated die that would "roll" when the bet was placed (see Figure 1).

The study was conducted in a computer lab with several work stations and at a private study room in the campus' library. The computer lab consisted of several rows of computer terminals and was used when available. The library study room had one large oval table, and was located in a wing of the library that had little foot traffic, thus making it free from major distraction.

Procedure

Once participants were seated, a researcher read a prepared statement that gave a general overview of the project which also described a $50 incentive for the individual who won the most money during the gambling task. After the instructions, participants were asked to turn on the computer monitor and begin the experiment.

All discounting questions were framed as a choice between a guaranteed dollar amount and a larger dollar amount with less certainty of receipt. There were 12 certain amounts ($1, $25, $75, $100, $150, $200, $250, $300, $350, $400, $450, and $499) and 7 percentages (5%, 10%, 25%, 50%, 75%, 90%, and 95%), all representing the chance of receiving $500. Each combination of amount and uncertainty were presented once in a random sequence, controlled by the computer program.

At the completion of the first discounting task, participants began the gambling condition, which consisted of a 10-minute computerized dice game. In this game, participants were asked to bet $1 to $5, in whole number increments, on numbers between 1 and 6—the possible outcomes of a single die roll. Participants were provided an initial bankroll of $100. The software was pre-programmed for 100 die rolls in each condition, and each condition was set to run for 5 minutes. If the participant completed all 100 trials before the 5 minutes elapsed, the program would start over at trial 1 and continue until the 5 minutes were completed in that condition. That is, time terminated the condition, not the number of trials.

For the gambling conditions, all participants were first exposed to a 5-minute "break-even" condition. At the end of this 5-minute period, the program switched conditions to Lose, Break Even, or Win. The switch occurred for the first bet placed after 5 minutes had elapsed since the first bet was made by the participant in the gambling task. The countdown timer was not displayed on the screen. The bankroll at the end of this phase was carried over and served as the starting bankroll of the respective condition, and the participants were not signaled as to the schedule change.

After placing a bet, the participant clicked a button and the computer simulated a seemingly random die roll. If the roll did not match the number bet upon, the participant would lose that dollar amount. If, however, the number matched, the participant won six times their bet (i.e., a win on a bet of $4 would yield $24). Participants were not informed that each die roll was predetermined to match or to differ from their bet. The winning condition received 26 wins for every 100 die rolls (e.g., $156 won for every $74 lost), the break even condition received 17 wins for every 100 die rolls, and the losing group received 10 wins for every 100 die rolls. The program recorded each bet size, number guessed, outcome, and bankroll after each bet.

After the 10-minute gambling session, participants were presented again with the 84 questions regarding monetary discounting. The procedure was exactly the same as the first time, with questions presented in a random order. At debriefing, the participant was told that the conditions were predetermined and that three participants, one from each condition, would be randomly chosen to receive $50.

Data Analysis

Indifference points were calculated by averaging the point at which the participant switched from a smaller, guaranteed amount to a larger, probabilistic amount. Results were analyzed by identifying the difference in the indifference points between the first and second discounting task. A negative result indicates a decrease in the indifference point for those particular odds against winning, which is a change in preference favoring more risk-averse decision-making. A positive result represents an increase in the indifference point from the first to second discounting task, and is indicative of more risk-seeking decision-making. The change in indifference points from the initial discounting task was then graphed based on the odds against winning (see Figures 2 and 3).

RESULTS AND DISCUSSION

Gambling outcomes for the 10-minute gambling task for Analysis 1 ranged from $0 - $106 for the Lose group ($n$ = 15), $57 - $193 for the Break Even group (n = 12), and $136 - $333 for the Win group ($n$ = 11). Analysis of variance (ANOVA) tests indicated that the mean number of trials did not vary across groups for either phase 1 (i.e., 5-minute break even baseline), $F < 1$, $\eta^2 = .046$, or phase 2 (i.e., different outcomes), $F(2, 35) = 1.47$, $p = .245$, $\eta^2 = .077$. Likewise, the number of guesses participants made did not vary as a function of group in phase 1, $F < 1$, $\eta^2 = .006$, or phase 2, $F < 1$, $\eta^2 = .003$. The average bet size did vary significantly across groups in phase 1, $F(2, 35) = 4.45$, $p = .019$, $\eta^2 = .203$. Tukey LSD post-hoc comparisons indicated that the average bet size for participants in the Lose group was significantly higher (M = $3.64, SD = $1.39) than in the Break Even (M = $2.62, SD = $1.13) and Win groups ($M$ = $2.34, SD = $0.89). The difference in average bet size did not differ significantly (i.e., $p < .05$) between the Break Even and Win groups. However, average bet size did not vary significantly across groups in phase 2, $F(2, 35) = 2.10$, $p =.138$, $\eta^2 = .107$.

Change in indifference points from the first discounting task to the second are displayed in Figure 2. The change at each indifference point for individual participants was analyzed by conducting a two-way (Group X Odds against) mixed-model ANOVA, with group serving as the between-subjects factor and odds against as the within-subjects factor. This analysis yielded a non-significant main effect of group, $F < 1$, $\eta^2 = .004$, indicating that the indifference point changes did not differ across the three groups. The main effect of odds against was significant, $F(6, 210) = 4.62$, $p < .001$, $\eta^2 = .117$, with the linear polynomial contrast being significant, $F(1, 35) = 14.17$, $p = .001$, $\eta^2 = .288$. This result indicates that changes in indifference points decreased significantly as the odds against increased (see Figure 2). More specifically, participants did not necessarily become more risk-seeking when the odds against were low. Rather, they became more risk-averse as the odds against increased. The interaction between group and odds against was not significant, $F < 1$, $\eta^2 = .051$.

The outcomes in the different groups during the gambling task did not always match the intended outcomes for that particular group. Thus, a second analysis was conducted using

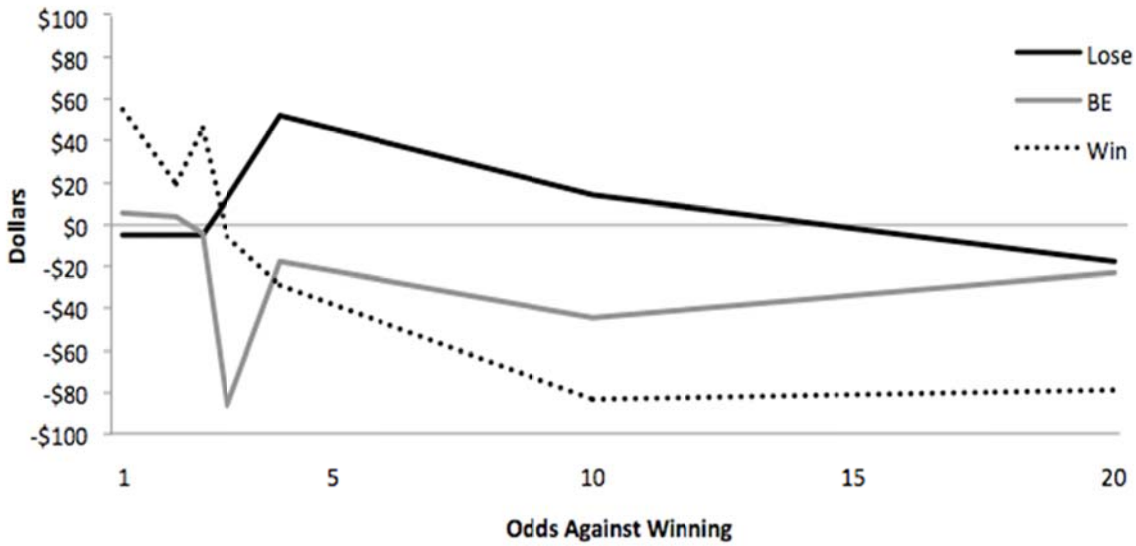

Figure 3. Mean change in indifference points for analysis 2 as a function of odds against winning

only the data from the five participants from each group who most represented the intended outcome for that group during the gambling task. Specifically, the five participants who, at the end of the gambling task, were closest to $0 for the Lose group, closest to $100 for the Break Even group, and the five participants with the most money at the end of the experiment for the Win group were selected. Change in indifference points from these participants are displayed in Figure 3 and are graphed identically to those in Figure 2.

The data used to construct Figure 3 were also subjected to a two-way (Group X Odds against) mixed-model ANOVA identical to that conducted above. In this analysis, the main effects of group, $F(1, 12) = 1.29$, $p = .312$, $\eta^2 = .177$, and odds against, $F(6, 72) = 1.07$, $p = .390$, $\eta^2 = .082$, both failed to reach statistical significance. However, the interaction between group and odds against was significant, $F(12, 72) = 1.96$, $p = .041$, $\eta^2 = .246$. Tests for simple effects showed that the change values did not differ significantly across the groups at any odds against. Furthermore, the change values across the different odds against did not vary significantly for the Lose or Break Even groups. However, they varied significantly for the Win group, $F(6, 24) = 3.28$, $p = .017$, $\eta^2 = .107$, with the linear polynomial contrast being significant, $F(1, 4) = 7.98$, $p = .048$, $\eta^2 = .666$, indicating that the indifference points decreased linearly for this group as the odds against increased. Results from this second analysis yielded more salient trends than the first analysis, showing a diffusion of patterns between the Lose, Break Even, and Win groups. At lower odds against winning following the gambling condition, indifference points increased for the Win group and steadily decrease as odds against increased (see Figure 3). These data suggest, then, that following experience with winning more than chance, individuals are more risk-averse with respect to low probabilities of winning.

These results seem inconsistent with Cummins, Nardoff, and Kelly (2009), who found an increase in bet size following a win-more-than-chance condition for gambles with a low probability of winning (i.e., more risk seeking at high odds against winning). It could be the case that the interjection of a break-even condition prior to the win condition in the current study may be correlated with this difference. However, the data from the current study do seem in line with those found by Weatherly, Sauter, and King (2004). In their study participants who were exposed to a big win, defined as 16 credits won with an original stake of 100 credits which were exchangeable at the rate of $0.10 per credit, on trial one were significantly less resistant to extinction than groups that experienced the big win on trial five, two small wins (8 credits each) on trials two and five, and a control group which never contacted a win. Much like the participants in the big win on trial one condition in Weatherly, Sauter, and King, participants in the Win group in the current study exhibited a greater tendency toward risk-aversion.

Given the inconsistency amongst these studies, it could be argued that, in different contexts, some winning situations result in risk-averse behavior while other winning situations result in risk-seeking behavior, potentially dependent upon the degree of risk involved.

Typically, the reward in a discounting task is hypothetical money, although other rewards have been utilized (e.g., Estle, Green, Myerson, & Holt, 2007; Lawyer & Chastain, 2006). Studies suggest that hypothetical money is equivalent to actual currency when using a delay-discounting task (Madden, Begotka, Raiff, & Kastern, 2003; Madden, et al., 2004; Hinvest & Anderson, 2010) but not probability-discounting tasks (Hinvest & Anderson, 2010), although the effect was small in the case of the latter. Most of this research, however, has been limited to small amounts of money (Green & Myerson, 2004). In an attempt to bridge betting with hypothetical money and actual monetary rewards, a $50 incentive was introduced. The incentive was also included to motivate betting large amounts of money and to roll the die frequently, thus increasing the likelihood of making the programmed outcomes in the different gambling conditions as salient as possible.

Although past research has shown that discounting is generally stable (Ohmura, Takahashi, Kitamura, & Wehr, 2006), and probabilistic discounting in particular (Ostaszewski, Green, & Myerson, 1998), the data from the current study support an initial notion that probabilistic discounting can be manipulated, even if only in the short term, by exposing individuals to various probability-based outcomes. These changes to individual discounting outcomes may reflect on future gambling decisions. It may be the case that, with certain gambles, those who recently lost, won, or simply broke even for the session, may be more risk-averse, while other gambles would result in the individual being more risk-seeking.

When all participants are considered, an increase in odds-against winning following the gambling procedure resulted in the participant being more risk averse, regardless of group assignment. When considering the most representative gambling outcomes for each group, however, only the Win group demonstrated this result. These results seem to indicate that those who are winning may experience a greater effect on probabilistic discounting than those who are losing, or at least not winning. This finding may contribute to literature regarding how individuals alter, or fail to alter, gambling style after winning or losing.

Future research could capitalize on the results of the second analysis and create conditions with a set number of trials with more restrictive betting ranges. That is, participants should end the Break Even condition with 100 credits (assuming 100 credits to start), and end their respective condition with the exact amount programmed by the researchers. This moves to a trial-based approach to conditions, as opposed to the time-based approach adopted by the current study. The former would result in better experimental control through the elimination of variability through bet size combined with rate of betting.

Data regarding any rules the participant may have been following (i.e., "I'm on a hot streak, time to bet big") may prove insightful, as verbal behavior is theorized to play a significant role in gambling behavior (Dymond & Whelan, 2007; Weatherly & Dixon, 2007). Further, if verbal behavior can influence gambling, perhaps engaging the participant in verbal behavior regarding gambling outcomes may produce similar effects without the use of an actual gambling procedure, which would subsequently add a much needed control condition. Suggestions regarding methodology for studying the role of verbal behavior with respect to gambling behavior has been put forth (see Arntzen, 2008).

The results are hopeful, however, that under the right conditions, momentary changes in probabilistic discounting can be achieved by manipulating gambling outcomes. These results, then, help provide a functional link between probabilistic discounting and gambling behavior.

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