Published in final edited form as:
*J Abnorm Psychol*. 2012 February ; 121(1): 151–159. doi:10.1037/a0024782.

# Discounting of probabilistic rewards is associated with gambling abstinence in treatment-seeking pathological gamblers

**Nancy M. Petry**
University of Connecticut School of Medicine

## Abstract

Individuals with addictive disorders, including substance abusers and pathological gamblers, discount or devalue rewards delayed in time more than controls. Theoretically, preference for probabilistic rewards is directly related to gambling, but limited empirical research has examined probabilistic discounting in individuals with pathological gambling. This study evaluated probability and delay discounting in treatment-seeking pathological gamblers and their association with gambling treatment outcomes during and following treatment. At time of treatment entry, 226 pathological gamblers completed probability and delay discounting tasks. They were then randomized to one of three treatment conditions, and gambling behavior was measured throughout treatment and at a one-year follow-up assessment. After controlling for possibly confounding variables and treatment condition, more shallow probability discounting was associated with greater reductions in amounts wagered during treatment and likelihood of gambling abstinence at the end of treatment and throughout the follow-up period. No associations were noted between delay discounting and gambling treatment outcomes. These data suggest that probability discounting may be an important construct in understanding pathological gambling and its treatment.

### Keywords

probability discounting; pathological gambling; treatment

Behavioral economic theories of discounting are being increasingly applied to the study of addictive behaviors. Much of this work has evaluated discounting of delayed reinforcers in individuals with addictive disorders. To assess individual differences in delay discounting, participants choose between a particular amount of money right now and a larger amount following a delay. Currently available amounts are adjusted until an indifference point is reached, at which both immediate and delayed rewards are of equal subjective value. For example, a person may be indifferent between $50 right now and $60 in a week from now, but if the currently available amount were any lower than $50, the person would prefer to wait a week to obtain $60. Equation 1 characterizes preferences for immediate versus delayed reinforcers.

$$V=A/(1+kD) \quad \text{(Equation 1)}$$

Corresponding Author Address: Nancy M. Petry, Ph.D., Calhoun Cardiology Center, University of Connecticut School of Medicine, 263 Farmington Avenue, Farmington, CT 06030-3944; Phone: 860-679-2593; Fax: 860-679-1312; Npetry@uchc.edu.

In this equation, the subjective value ($V$) of an amount $A$, obtained following delay $D$, declines hyperbolically, with $k$ being an individually determined discount parameter (Mazur, 1987). The higher the $k$ value, the more steeply the individual discounts or devalues rewards delayed in time.

A large body of literature demonstrates that those with substance use disorders (Bickel & Marsch, 2001; Bickel, Miller, Yi, Kowal, Lindquist, & Pitcock, 2007; Petry, 2001a) and pathological gambling (Dixon, Marley, & Jacobs, 2003; MacKillop, Anderson, Castelda, Mattson, & Donovick, 2006; Petry, 2001b; Petry & Casarella, 1999; Reynolds, 2006) have higher $k$ values (and more steeply devalue delayed rewards) than their non-substance using or non-pathological gambling counterparts. Results from these studies are consistent with theories of development of addictive disorders, such that using drugs or gambling can be associated with near immediate pleasure, and adverse effects of excessive drug use or gambling are delayed in time and therefore heavily discounted.

Although most of the work on discounting has focused on outcomes that are delayed in time, a perhaps equally important construct for the study of addictive disorders is evaluating preferences for outcomes that are probabilistic in nature. Persons who show preferences for risky probabilistic outcomes may be more prone to develop addictive disorders. Not all persons who try drugs become “addicted” or suffer from the adverse consequences of substance use such as contraction of HIV, and the extent to which one considers probabilistic outcomes may impact engaging in potentially addictive behaviors. Pathological gambling, in particular, is an addictive disorder that specifically relates to choices for large but risky payouts.

To evaluate individual differences in probability discounting, participants choose between certain and probabilistic outcomes (e.g., would you prefer $40 for sure or a 1-in-3 chance of getting $100?). When individuals make multiple choices across a range of values and probabilities, Equation 2 accounts for a large proportion of the variance in responses (Rachlin, Raineri, & Cross, 1991).

$$V=A/(1+h\Theta) \quad \text{(Equation 2)}$$

In this equation, V is the subjective value of an amount A, and the odds against receiving the outcome is $\Theta = (1-p)/p$. The $h$ is a free parameter that is interpreted as the degree of probability discounting. As $h$ increases in value, the subjective value of the probabilistic outcome is more steeply discounted, meaning that the individual does not greatly value low probability outcomes. Thus, in theory, pathological gamblers, who by the nature of their disorder engage in risky decisions, ought to demonstrate more shallow discounting than controls. In other words, compared to controls, pathological gamblers should place a higher value on a probabilistic than a certain outcome, which would be reflected by lower $h$ values.

Only three known studies have evaluated probability discounting in gamblers. Shead, Callan, and Hodgins (2008) found no significant correlation between probability discounting rates and scores on an index of problem gambling severity in a group of college students, but Holt, Green, and Myerson (2003) found that college students who gamble discounted probabilistic rewards less steeply than non-gambling students. In the only study with diagnosed pathological gamblers, Madden, Petry and Johnson (2009) found pathological gamblers had significantly more shallow probability discounting rates (lower $h$ values, reflecting greater preference for probabilistic rewards) than matched controls.

A better understanding of discounting not only has potential relevance to the etiology of addictive disorders, but also treatment. Data are emerging that steeper discounting of delayed reinforcers may be associated with poorer treatment outcomes in substance abusers. Substance abusers who more strongly value the present (i.e., have higher *k* values) are less likely to remain engaged in or to stop drug use while they are in treatment (Dallery & Raiff, 2007; Yoon, Higgins, Heil, Sugarbaker, Thomas & Badger, 2007).

Individual differences in discounting may also be associated with response to gambling treatment, but probability discounting may be particularly relevant to gamblers, who by the nature of their disorder are drawn toward probabilistic outcomes. Although one could postulate that steeper probability discounting (higher *h* values) may be associated with better treatment outcomes, it is also plausible that more shallow probability discounting may be predictive of better outcomes. Meyerson, Green, Hanson, Holt, and Estle (2003) noted that delay and probability discounting are not consistently or intuitively related. Some studies find no correlation between delay and probability discounting (Holt et al., 2003; Madden et al., 2009; Olsen, Hooper, Collins & Lucian, 2007), although others do (Green, Myerson & Ostazewski, 1999; Meyerson et al., 2003). When significant, the correlations are in the positive direction (Green et al., 1999; Meyerson et al., 2003), a counter-intuitive result. Typically, impulsivity is conceptualized as an inability to tolerate delay (steep delay discounting) and a propensity to take risks (shallow probability discounting). Thus, a negative correlation between delay and probability discounting would be predicted, but the opposite relationship has been observed. The association between probability discounting and treatment outcomes, therefore, may also be negative in nature, with lower *h* values related to better outcomes in gamblers. In either case, no known studies have evaluated whether delay or probability discounting is associated with treatment outcomes in pathological gamblers or the directionality of any putative relationships.

This study examined probability and delay discounting in a large group of treatment-seeking pathological gamblers. The treatment trial is described in Petry et al., (2006), and cognitive-behavioral therapy for gambling, which focused on strategies for achieving and maintaining gambling abstinence, was efficacious in reducing gambling. The present study builds upon the original report by evaluating the role of discounting in predicting outcomes. First, associations were assessed between measures of discounting and baseline characteristics and severity of gambling at time of treatment entry. Second, the predictive potential of discounting parameters on gambling outcomes during treatment and throughout a one-year follow-up was evaluated.

## Method

### Participants

Participants were drawn from 231 individuals enrolled in a randomized trial (Petry et al., 2006) that evaluated the efficacy of psychosocial treatments for pathological gambling. Participants were recruited via media announcements, and inclusion criteria included age 18 years or older, Diagnostic and Statistical Manual for Mental Disorders-IV (American Psychiatric Association, 1994) criteria for pathological gambling, gambling in the past two months, and reading level at or above the $5^{th}$ grade (Zachary, 1991). Suicidal intentions, acute psychotic symptoms, or current involvement in other gambling treatment were exclusionary criteria. Criteria were minimally restrictive to increase generalization. Only four individuals who attended the baseline evaluation were ineligible, and seven refused randomization. Participants provided written informed consent, approved by the University’s Institutional Review Board. The 226 participants who completed discounting questionnaires are included in the analyses presented in this report; the remaining 5 had no or incomplete discounting questionnaires.

The sample was on average (*SD*) 44.8 (10.9) years old, and 43.8% (99 of 226) were female. The majority were White (191 of 226; 84.5%), with 8.4% (19 of 226) African American, 4.4% (10 of 226) Hispanic, and the remaining 2.7% (6 of 226) of other races/ethnicities. Average (*SD*) income of the sample was $44,396 (39,546).

### Measures and instruments

Trained research assistants administered assessments at baseline and 1, 2, 6 and 12 months later, and participants were compensated $15–$20 for each interview. Follow-up rates at the four evaluations were 78.8% (n = 178), 80.5% (n = 182), 80.1% (n = 181) and 78.8% (n = 178), respectively. No differences in follow-up rate participation occurred in terms of any baseline characteristics, and some post-baseline data were available on 212 (93.8%) participants.

### Delay Discounting Questionnaire

Kirby and Maraković's (1995) 27-item, paper-and-pencil questionnaire assessed delay discounting. Each item inquired about choice between a monetary amount delivered immediately and a larger amount delivered after a delay. For example, the questionnaire asked, "Would you prefer $14 today, or $25 in 19 days?" Kirby, Petry, and Bickel, (1999) detail all 27 items.

Responses determined the degree to which participants discounted delayed rewards, by estimating $k$ values obtained at three magnitudes of rewards contained within the questionnaire. Prior studies of this questionnaire show that $k$ values differ between substance abusers and controls in the expected manner, and the degree of delay discounting decreases as reward amount increases (e.g., Kirby et al. 1999), consistent with other methods of assessing the steepness of the delay discounting curve (Green & Myerson, 2004). Kirby et al. (1999) detail methods for deriving $k$ values from this questionnaire, and the approach is similar to that described for assessing $h$ values from the probability discounting questionnaire described below.

### Probability Discounting Questionnaire

Participants completed a three-part, paper-and-pencil questionnaire that assessed probability discounting (Madden et al., 2009). This questionnaire was designed to parallel the well established Delay Discounting Questionnaire described above, and it was also similar with respect to methods, magnitudes and probabilities of rewards used in other probability discounting studies (Acheson & deWit, 2008; Hinvest & Anderson, 2010; Holt et al., 2003; Lawyer, Williams, Prihodova, Rollins, & Lester, 2010; Richards, Zhang, Mitchell, & de Wit, 1999). Each part of the questionnaire included 10 items, and participants indicated their choice between one of two outcomes. One outcome was an amount of money delivered "for sure," and the other was a larger amount delivered probabilistically. As an example, participants chose between "$40 for sure" and "a 1-in-11 chance (18%) of winning $100." Table 1 shows the values and probabilities that appeared in the three parts of the questionnaire. The amounts and probabilities included allowed for an evaluation of a large range of $h$ values, and the three parts of the questionnaire were presented in a counterbalanced order across participants.

The $h$ values shown in Table 2 represent the degree of probability discounting at each point of indifference on the three parts of the questionnaire as calculated from Equation 2. The most common approach to determine $h$ values for individual participants was applied when they selected the certain reward within each part of the questionnaire until the probability increased to a threshold value, after which they consistently selected the probabilistic outcome. For example, consider a participant who selected the certain reward ($20 for sure) over the probabilistic reward for the first four questions in Part 1 (Table 1). Once the $20 for sure was paired with a 1-in-4 chance or better for $80, that participant then selected the probabilistic outcomes. For this participant, the *h* value would be designated at 1.0 on that part of the questionnaire. In contrast, a participant who began selecting the probabilistic outcomes whenever there was a 1-in-6 chance or better for an $80 reward would have a lower *h* value of 0.61.

For participants who always or never selected the probabilistic outcome (n = 23, 10.1% of the cases), *h* values were estimated at the lowest and highest value shown in Table 1, respectively. For example, participants who always selected the probabilistic outcomes would be assigned the lowest *h* value of 0.33, and those who always selected the certain reward on Part A would be assigned the highest *h* value of 14.65. For participants whose choices were not always internally consistent (e.g., selected a certain reward at a probability greater than that at which choices switched from certain to probabilistic on one part), the *h* value similar to most of the choices was used. One or more inconsistent choice occurred in 26 (11.5%) of the cases.

Using the above methods, *h* values were determined for each participant on each of the three magnitude components of the questionnaire. An overall *h* value was derived by taking the mean of the *h* values obtained from the three parts of the questionnaire.

## Personality questionnaire

The Eysenck Impulsivity Scale (Eysenck & Eysenck, 1978) is a widely used and well validated questionnaire. It contains three subscales: Impulsivity, which measures acting without weighing consequences (e.g., “Do you generally do and say things without stopping to think?”); Venturesomeness, which measures behavior in which risk is consciously perceived and accepted (e.g., “Would you enjoy parachute jumping?); and Empathy, which was included to add variety (e.g., “Do you get very upset when you see someone cry?”). Subscale scores are associated with conceptually related behaviors (McCown, 1989; Stein, Courval, Lederman, & Shea, 1995). The Eysenck questionnaire was included in this study as a measure of concurrent validity for the probability and delay discounting questionnaires, with the expectations that *h* values would be negatively correlated with Venturesomeness scores and *k* values positively correlated with Impulsivity scores.

## Measures of gambling

Research assistants also collected demographic information and administered the Addiction Severity Index-gambling scale (ASI; Petry, 2003, 2007) and the South Oaks Gambling Screen (Lesieur & Blume, 1987) at time of treatment initiation. The gambling section of the ASI contains items related to days and dollars wagered in the last 30 days, and it has good internal consistency, test-retest reliability, and validity in assessing gambling problems and changes in gambling over time (Lesieur & Blume, 1991; Petry, 2003, 2007). It was administered at each follow-up evaluation to assess changes in gambling.

The South Oaks Gambling Screen (SOGS) (Lesieur & Blume, 1987) evaluated severity of gambling problems. It contains 20 items, with higher scores denoting more severe gambling problems. The SOGS is widely used and highly correlated with DSM-based criteria and other measures of gambling severity (Stinchfield, 2002).

Participants were asked to identify collaterals, who were aware of their gambling and were phoned for independent validation of the participant’s self-reports. Research assistants asked collaterals, “How often did (participant) gamble on average in the past month?” and “On days when (participant) gambled, how much money do you think s/he spent on average?” Responses to the first question were coded on a 5-point scale, from 0 (“not at all”) to 4 ("four or more times per week"), and responses to the latter as dollar amounts. At baseline and follow-ups, correlations of days and dollars wagered in the past month as reported by participants and collaterals ranged from 0.44 to 0.92, *p*s < .001 across treatment groups and time points. Mean correlations were 0.62 for frequency and 0.68 for quantity of gambling, *p*s < .001.

**Treatments—**After the baseline evaluation, research assistants randomly assigned participants to one of three treatment conditions. They used a computerized urn randomization procedure (Stout, Wirtz, Carbonari, & Del Boca, 1994) that balanced groups on severity of gambling problems, age, gender, and race. All services were provided at no costs to participants, and all interventions encouraged abstinence from gambling as the primary goal of treatment.

**Referral to Gamblers Anonymous (GA; n = 59):** For participants assigned to this condition, the researcher discussed GA with participants for about 10–15 minutes, including their prior attendance, expectations, and potential concerns. The researcher also provided a list of local GA meetings, told participants that many individuals who become involved in GA stop gambling, and encouraged participants to select a GA meeting to attend.

**Referral to GA plus cognitive-behavioral (CB) therapy via workbook (n = 84):** These participants received the same information about GA outlined above. After GA referral, a researcher provided a 70-page workbook, containing CB exercises (Petry, 2005). The workbook contained descriptions and fill-in-the-blank exercises identical to those in the therapy condition (see below). Participants were instructed to complete one chapter a week for 8 weeks.

**Referral to GA plus professionally delivered CB therapy (n = 83):** After GA referral, these participants met with a therapist on an individual basis for one hour a week for eight weeks. Handouts provided structure for each session (Petry, 2005) and addressed: (a) Triggers of gambling, (b) Functional analysis of gambling, (c) Increasing pleasant activities, (d) Self-management planning, (e) Coping with urges to gamble, (f) Assertiveness training and gambling refusal skills, (g) Changing irrational thinking, and (h) Coping with lapses. Homework exercises, in addition to the structured in-session handouts, were also provided. Ten masters-level and three doctoral-level therapists delivered the CB therapy. As noted in the primary report (Petry et al., 2006), each received didactic training and supervision of at least one case, along with ongoing supervision via review of therapy notes, audiotapes, and case discussion.

## Data analyses

Initially, correlations were conducted between *h* and *k* values and continuous demographic and baseline gambling variables. For dichotomous variables (gender, race) and treatment condition, medians and interquartile ranges (IQ) of *h* and *k* values are presented across groups, with *t* or *F* tests examining between-group differences in discounting. Non-normally distributed variables (e.g., dollars wagered, *h* and *k* values) were transformed prior to analyses using log transformations, but actual values are presented in tables for ease of interpretation.

Two approaches evaluated predictors of treatment outcomes. One used dollars wagered over time, and the other examined proportions of participants abstinent from gambling. For the former, repeated measures analysis of variance was conducted with dollars wagered (logged) at baseline and post-treatment (month 2) as the dependent variables (n = 178). Overall *h* and *k* values (also log transformed) along with other variables associated with pathological gambling or gambling treatment response (Petry, Stinson & Grant, 2005; Petry et al., 2006) were included as independent variables: gender, race, age, and treatment condition. Gender, race (White vs. other), and treatment condition were entered as categorical variables, and the others were continuous. All variables were entered simultaneously into the analyses. To assess long-term outcomes, a second repeated measures ANOVA was conducted with baseline, month 2 and month 12 dollars wagered (logged) as dependent variables (n = 153).

Logistic regressions examined predictors of gambling abstinence at the post-treatment evaluation and throughout the follow-up. To ascertain abstinence, all available data were considered. Those who reported any gambling days or dollars at any of the intervening follow-ups (months 1 or 2 for during treatment analysis, and the remaining 6 or 12 months for long-term analysis) were coded as non-abstinent, as were participants who had missing data at all time points (n = 14). For these analyses, missing data were minimal, as a report of gambling at any preceding time-point resulted in coding that participant as non-abstinent; analyses were also conducted excluding participants with missing data, and results were similar to those reported herein. The same independent variables outlined above were included in the analysis, along with baseline dollars wagered in the last month, an index of gambling severity. Two regressions were performed, the first predicting abstinence between baseline and the post-treatment evaluation and the second predicting abstinence between baseline and the 12-month follow-up. Odds ratios (OR) and 95% confidence intervals (CI) are presented as the primary statistic showing associations between significant variables and abstinence outcomes. Interactions between significant independent variables were also tested, but none were significant (*p*s > .28); interaction effects are not presented for ease of interpretation. Analyses were conducted on SPSS for Windows (version 15).

## Results

Overall *h* values ranged from 0.33 to 15.34, with a median (IQ) *h* value of 1.10 (1.57). On the three respective parts of the questionnaire, the median (IQ) *h* values were 0.86 (1.03), 1.21 (1.57), and 1.06 (1.59). The *h* values obtained from the three different parts of the questionnaire correlated significantly, with *h* values from parts A and B correlating at $r = 0.60$, $p < .001$, parts A and C correlating at $r = 0.55$, $p < .001$, and parts B and C correlating at $r = 0.59$, $p < .001$. There were no differences in *h* values across the six versions of the questionnaire (i.e., the counterbalanced order in which items were administered), $F(5,220) = 1.25$, $p = .29$.

In this sample, *k* values ranged from 0.00016 to 0.250. The median (IQ) *k* value was 0.026 (0.055). The two discounting measures, *h* and *k*, were correlated at $r = 0.11$, $p = .09$.

As shown in Table 2, *h* and *k* values correlated significantly with personality measures of Venturesomeness and Impulsivity, respectively. The only demographic variable that was significantly related to discounting was race, with Whites having lower *h* and *k* values than their non-White counterparts. Neither discounting parameter was associated with gambling severity.

Table 3 shows predictors of dollars wagered over time. In terms of during treatment effects (top section; n = 178), the only variable significantly associated with changes in dollars gambled over time was *h* values. When examining long-term follow-ups (bottom section; n = 153), no variables were significantly associated with changes in dollars wagered over time.

At the post-treatment interview, 67 of 226 (29.6%) participants reported gambling abstinence throughout the treatment period. Throughout the 12-month post-treatment follow-up period, 29 of 226 (12.8%) participants maintained abstinence from gambling. Table 4 shows results of the logistic regression analyses predicting gambling abstinence during the 2-month treatment period. The individual CBT condition, male gender, and dollars wagered in the month before initiating treatment were all significantly associated with achieving short-term gambling abstinence. Even after controlling for these variables, *h* values were significantly associated gambling abstinence. The odds ratio was 0.854, indicating that each 1-point increase in *h* value was associated with a 15% reduced probability of abstinence.

The lower section of Table 4 depicts results for the logistic regression predicting long-term abstinence throughout the 12-month study period. Again, male gender, individual CBT, and dollars wagered in the month before treatment were all related to long-term gambling abstinence. In addition, rates of probability discounting assessed at baseline were a significant predictor of abstinence, with higher *h* values associated with reduced probability of maintaining abstinence.

## Discussion

In this study, the degree of probability discounting was significantly associated with Venturesomeness, as assessed by a personality questionnaire. As expected, this association was negative, such that lower *h* values (indicative of greater preference for probabilistic rewards) were related to greater Venturesomeness. Delay discounting, assessed by *k* values, was positively and significantly related to Impulsivity on this same personality questionnaire. These data suggest concurrent validity of the behavioral measures of discounting included in this study, and they also indicate that probability and delay discounting reflect different dimensions.

Discounting was generally unrelated to demographic characteristics or severity of gambling at baseline. The only baseline characteristic associated with discounting was race. Whites had lower *h* values, indicating greater preferences for probabilistic outcomes than non-Whites, and lower *k* values, reflecting greater preference for delayed reinforcers. Racial effects consistent with those reported herein have been reported, such that African Americans are more risk averse than their White counterparts (Benjamin, Choi, & Strickland, 2010). Nevertheless, results from this study should be interpreted with caution as the number of minority patients was small, and all non-White races and ethnicities were combined in the analysis.

In this study, discounting was not related to baseline severity of gambling problems. One study in college students (Shead et al., 2008) found no association between probability discounting and measures of severity of gambling problems, but another (Holt et al., 2003) noted a significant negative correlation between degree of probability discounting and SOGS scores. Madden et al. (2009) found that diagnosed pathological gamblers had lower *h* values than controls using the same probability discounting questionnaire used in the present study. The current study did not have a non-gambling control group, and all participants were treatment-seeking pathological gamblers, with severe levels of gambling problems. A truncated range of gambling problems in this sample may have limited the ability to discern associations between measures of discounting and gambling problem severity at time of treatment initiation.

Although no relationship was noted between discounting and baseline severity of gambling problems in this sample, probability discounting rates were significantly associated with reductions in amounts wagered during the treatment period and gambling abstinence throughout and following treatment. Pathological gamblers who discounted probabilistic reinforcers less steeply (had lower *h* values) were more likely to reduce amounts wagered during treatment and maintain gambling abstinence than their counterparts who discounted probabalistic reinforcers more steeply. Although somewhat counterintuitive, this result is consistent with prior literature. Rates of delay discounting are modestly and positively associated with rates of probability discounting in some studies (Green et al., 1999; Meyerson et al., 2003), and higher rates of delay discounting are associated with poorer drug abuse treatment outcomes (Dallery & Raiff, 2007; Yoon et al., 2007). Similarly, in this study, higher *h* values predicted poorer treatment outcomes in pathological gamblers. This association was consistent in that it was observed for both early treatment and longer term follow-up abstinence outcomes. It was robust in that it was significant even after controlling for variables known to be related to gambling treatment outcomes, including severity of baseline gambling problems and treatment condition.

These data may imply that treatment-seeking pathological gamblers who discount probabilistic rewards less steeply may recognize that they will be unable to stop gambling if they start, and they may gravitate toward an abstinence goal. In contrast, pathological gamblers who discount probabilistic reinforcers relatively more steeply may be more prone toward gambling after initiating treatment, perhaps assuming they can stop once they start gambling. Although the optimal goal of gambling treatment is debated (Dowling & Smith, 2007; Dowling, Smith, & Thomas, 2009; Ladouceur, 2005; Ladouceur, Lachance & Fournier, 2009; Slutske, Piasecki, Blaszczynski, & Martin, 2010), the interventions applied in this study, and the most conservative recommendations for those who seek treatment, encourage abstinence. Few gamblers abstained from gambling entirely especially over the long term, but those with lower *h* values were significantly more likely to decrease amounts wagered during treatment and achieve and maintain abstinence throughout the study period than those with higher pre-treatment *h* values.

Results from this study are intriguing, but they should be considered in light of some limitations. First, all participants in this study were treatment-seeking pathological gamblers, and these results may not reflect outcomes for the larger group of pathological gamblers who do not seek treatment (Slutske, 2006). Second, discounting was assessed only once, at time of treatment initiation, and it may change over time. In addition, the *h* values in this sample were skewed toward lower values as all participants were pathological gamblers; interpretations of relatively higher or lower *h* values in a sample of persons with overall low *h* values may be less meaningful than among persons with a broader distribution of *h* values. Moreover, the questionnaire may have been difficult to understand, as about 20% of the sample made inconsistent responses or selected only the certain or probabilistic reinforcers. Additional research on psychometric properties of instruments assessing probabilistic discounting are warranted.

This study evaluated preferences for probabilistic outcomes in the context of all gains, and the results may not reflect decision-making processes used while gambling, which by definition involves the possibility of losses. A more externally valid method for evaluating probabilistic discounting congruent with gambling itself would integrate risking various amounts of money with probabilistic outcomes related to gains. Shead et al. (2008) reported a negative correlation between probability discounting of gains versus losses in college student gamblers. Thus, the relationships observed in this study may differ if potential for losses were considered.

Despite limitations, this study has a number of strengths. It is one of only a handful of studies evaluating discounting in pathological gamblers and the first to examine its association with treatment outcomes. Importantly, it included a large sample, and the duration of follow-up was long. Collateral reports confirmed participants' self-reported gambling and abstinence.

Results from this study indicate that probability discounting of monetary gains is predictive of gambling treatment outcomes. These data point to potentially unique aspects of decision making that may impact treatment decisions. In particular, pathological gamblers with less steep discounting for probabilistic reinforcers benefit from abstinence oriented treatment approaches such as those applied herein. Those who discount probabilistic reinforcers more steeply may respond to interventions that do not espouse an abstinence goal, but instead focus on assisting patients in better understanding their reasons for returning to gambling and how to prevent continued problem gambling behaviors in the absence of abstinence. Additional research is required to extend these findings to better understand the etiology of pathological gambling and to optimize treatment outcomes among those who have developed the disorder.

## Acknowledgments

This research and preparation of this report was funded by NIH grants P30-DA023918, R01-MH60417, R01-DA14618, R01-DA13444, R01-DA018883, R01-DA016855, R01-DA021567, R01-DA022739, R01-DA027615, P60-AA03510, and P50-DA09241.

## References

American Psychiatric Association. Diagnostic and statistical manual of mental disorders. 4. Washington DC: American Psychiatric Association; 1994.

Acheson A, de Wit H. Bupropion improves attention but does not affect impulsive behavior in healthy young adults. Experimental and Clinical Psychopharmacology. 2008; 16:113–123. [PubMed: 18489015]

Benjamin DJ, Choi JJ, Strickland AJ. Social identity and preferences. American Economic Review. 2010; 100:1913–1928. [PubMed: 20871741]

Bickel WK, Marsch LA. Toward a behavioral economic understanding of drug dependence: Delay discounting processes. Addiction. 2001; 96:73–86. [PubMed: 11177521]

Bickel WK, Miller ML, Yi R, Kowal BP, Lindquist DM, Pitcock JA. Behavioral and neuroeconomics of drug addiction: Competing neural systems and temporal discounting processes. Drug and Alcohol Dependence. 2007; 90:S85–S91. [PubMed: 17101239]

Dallery J, Raiff BR. Delay discounting predicts cigarette smoking in a laboratory model of abstinence reinforcement. Psychopharmacology. 2007; 190:485–496. [PubMed: 17205320]

Dixon MR, Marley J, Jacobs EA. Delay discounting by pathological gamblers. Journal of Applied Behavior Analysis. 2003; 36:449–458. [PubMed: 14768665]

Dowling N, Smith D. Treatment goal selection for female pathological gambling: A comparison of abstinence and controlled gambling. Journal of Gambling Studies. 2007; 23:335–345. [PubMed: 17479359]

Dowling N, Smith D, Thomas T. A preliminary investigation of abstinence and controlled gambling as self-selected goals of treatment for female pathological gambling. Journal of Gambling Studies. 2009; 25:201–214. [PubMed: 19199009]

Eysenck SBG, Eysenck HJ. Impulsiveness and venturesomeness: Their position in a dimensional system of personality description. Psychological Reports. 1978; 43:1247–1255. [PubMed: 746091]

Green L, Myerson J. A discounting framework for choice with delayed and probabilistic rewards. Psychological Bulletin. 2004; 130:769–792. [PubMed: 15367080]

Green L, Myerson J, Ostaszewski P. Amount of reward has opposite effects on the discounting of delayed and probabilistic outcomes. Journal of Experimental Psychology: Learning, Memory, and Cognition. 1999; 25:418–427.

Hinvest NS, Anderson IM. The effects of real versus hypothetical reward on delay and probability discounting. Quarterly Journal of Experimental Psychology. 2010; 63:1072–1084.

Holt DD, Green L, Myerson J. Is discounting impulsive? Evidence from temporal and probability discounting in gambling and non-gambling college students. Behavioural Processes. 2003; 64:355–367. [PubMed: 14580704]

Kirby KN, Marakovic NN. Modeling myopic decisions: Evidence for hyperbolic delay-discounting within subjects and amounts. Organizational Behavior and Human Decision Processes. 1995; 64:22–30.

Kirby KN, Petry NM, Bickel WK. Heroin addicts have higher discount rates for delayed rewards than non-drug-using controls. Journal of Experimental Psychology General. 1999; 128:78–87. [PubMed: 10100392]

Ladouceur R. Controlled gambling for pathological gamblers. Journal of Gambling Studies. 2005; 21:49–59. [PubMed: 15789190]

Ladouceur R, Lachance S, Fournier PM. Is control a viable goal in the treatment of pathological gambling? Behaviour Research and Therapy. 2009; 47:189–197. [PubMed: 19118818]

Lawyer SR, Williams SA, Prihodova T, Rollins JD, Lester AC. Probability and delay discounting of hypothetical sexual outcomes. Behavioural Processes. 2010; 84:687–692. [PubMed: 20385215]

Lesieur HR, Blume SB. The South Oaks Gambling Screen (SOGS): A new instrument for the identification of pathological gamblers. American Journal of Psychiatry. 1987; 144:1184–1188. [PubMed: 3631315]

Lesieur HR, Blume SB. Evaluation of patients treated for pathological gambling in a combined alcohol, substance abuse and pathological gambling treatment unit using the Addiction Severity Index. British Journal of Addiction. 1991; 86:1017–1028. [PubMed: 1912747]

MacKillop J, Anderson EJ, Castelda BA, Mattson RE, Donovick PJ. Divergent validity of measures of cognitive distortions, impulsivity, and time perspective in pathological gambling. Journal of Gambling Studies. 2006; 22:339–354. [PubMed: 16826455]

Madden GJ, Petry NM, Johnson PS. Pathological gamblers discount probabilistic rewards less steeply than matched controls. Experimental and Clinical Psychopharmacology. 2009; 17:283–290. [PubMed: 19803627]

Mazur, JE. An adjusting procedure for studying delayed reinforcement. In: Commons, ML.; Mazur, JE.; Nevin, JA.; Rachlin, H., editors. Quantitative analysis of behavior: The effect of delay and of intervening events of reinforcement value. Hillsdale, NJ: Erlbaum; 1987. p. 55-73.

McCown W. The relationship between impulsivity, empathy and involvement in 12-step self-help substance abuse treatment groups. British Journal of Addiction. 1989; 84:391–393. [PubMed: 2720191]

Myerson J, Green L, Hanson JS, Holt DD, Estle SJ. Discounting delayed and probabilistic rewards: Processes and traits. Journal of Economic Psychology. 2003; 24:619–635.

Olson EA, Hooper CJ, Collins P, Luciana M. Adolescents' performance on delay and probability discounting tasks: Contributions of age, intelligence, executive functioning, and self-reported externalizing behavior. Personality and Individual Differences. 2007; 43:1886–1897. [PubMed: 18978926]

Petry NM. Delay discounting of money and alcohol in actively using alcoholics, currently abstinent alcoholics, and controls. Psychopharmacology. 2001a; 154:243–250. [PubMed: 11351931]

Petry NM. Pathological gamblers, with and without substance use disorders, discount delayed rewards at high rates. Journal of Abnormal Psychology. 2001b; 110:482–487. [PubMed: 11502091]

Petry NM. Validity of the Addiction Severity Index in assessing gambling problems. Journal of Nervous and Mental Disease. 2003; 191:399–407. [PubMed: 12826922]

Petry, NM. Pathological gambling: Etiology, comorbidity and treatments. Washington, DC: American Psychological Association Press; 2005.

Petry NM. Concurrent and predictive validity of the Addiction Severity Index in pathological gamblers. American Journal on Addictions. 2007; 16:272–282. [PubMed: 17661195]

Petry NM, Ammerman Y, Bohl J, Doersch A, Gay H, Kadden R, Steinberg K. Cognitive-behavioral therapy for pathological gamblers. Journal of Consulting and Clinical Psychology. 2006; 74:555–567. [PubMed: 16822112]

Petry NM, Casarella T. Excessive discounting of delayed rewards in substance abusers with gambling problems. Drug and Alcohol Dependence. 1999; 56:25–32. [PubMed: 10462089]

Petry NM, Stinson FS, Grant BF. Comorbidity of DSM-IV pathological gambling and other psychiatric disorders: Results from the National Epidemiological Survey on Alcohol and Related Conditions. Journal of Clinical Psychiatry. 2005; 66:564–574. [PubMed: 15889941]

Rachlin H, Raineri A, Cross D. Subjective probability and delay. Journal of Experimental Analysis of Behavior. 1991; 55:233–244.

Reynolds B. A review of delay-discounting research with humans: relations to drug use and gambling. Behavioural Pharmacology. 2006; 17:651–667. [PubMed: 17110792]

Richards JB, Zhang L, Mitchell SH, de Wit H. Delay or probability discounting in a model of impulsive behavior: effect of alcohol. Journal of the Experimental Analysis of Behavior. 1999; 71:121–143. [PubMed: 10220927]

Shead NW, Callan MJ, Hodgins DC. Probability discounting among gamblers: Differences across problem gambling severity and affect-regulation expectancies. Personality and Individual Differences. 2008; 45:536–541.

Slutske WS. Natural recovery and treatment-seeking in pathological gambling: Results of two U.S. national surveys. American Journal of Psychiatry. 2006; 163:297–302. [PubMed: 16449485]

Slutske WS, Piasecki TM, Blaszczynski A, Martin NG. Pathological gambling recovery in the absence of abstinence. Addiction. 2010; 105:2169–2175. [PubMed: 20854336]

Stein AD, Courval JM, Lederman RI, Shea S. Reproducibility of responses to telephone interviews: demographic predictors of discordance in risk factor status. American Journal of Epidemiology. 1995; 141:1097–1105. [PubMed: 7771444]

Stinchfield R. Reliability, validity, and classification accuracy of the South Oaks Gambling Screen (SOGS). Addictive Behaviors. 2002; 27:1–19. [PubMed: 11800216]

Stout RL, Wirtz RW, Carbonari J, Del Boca FK. Ensuing balanced distribution of prognostic factors in treatment outcome research. Journal of Studies on Alcohol. 1994; 12:70–75.

Yoon JH, Higgins ST, Heil SH, Sugarbaker RJ, Thomas CS, Badger GJ. Delay discounting predicts postpartum relapse to cigarette smoking among pregnant women. Experimental and Clinical Psychopharmacology. 2007; 15:176–186. [PubMed: 17469941]

Zachary, RA. Shipley Institute of Living Scale: Revised manual. Los Angeles: Western Psychological Services; 1991.

**Table 1**

Probability discounting questions and h values indicative of indifference

| Part | | | | | *h* |
|---|---|---|---|---|---|
| A | Would you prefer | $20 for sure | or | a 1-in-10 chance (10%) of winning $80? | 0.33 |
| | Would you prefer | $20 for sure | or | a 1-in-8 chance (13%) of winning $80? | 0.45 |
| | Would you prefer | $20 for sure | or | a 1-in-6 chance (17%) of winning $80? | 0.61 |
| | Would you prefer | $20 for sure | or | a 1-in-5 chance (20%) of winning $80? | 0.75 |
| | Would you prefer | $20 for sure | or | a 1-in-4 chance (25%) of winning $80? | 1.00 |
| | Would you prefer | $20 for sure | or | a 1-in-3 chance (33%) of winning $80? | 1.48 |
| | Would you prefer | $20 for sure | or | a 1-in-2 chance (50%) of winning $80? | 3.00 |
| | Would you prefer | $20 for sure | or | a 2-in-3 chance (67%) of winning $80? | 6.09 |
| | Would you prefer | $20 for sure | or | a 3-in-4 chance (75%) of winning $80? | 9.00 |
| | Would you prefer | $20 for sure | or | a 5-in-6 chance (83%) of winning $80? | 14.65 |
| B | Would you prefer | $40 for sure | or | a 2-in-11 chance (18%) of winning $100? | 0.33 |
| | Would you prefer | $40 for sure | or | a 2-in-9 chance (22%) of winning $100? | 0.42 |
| | Would you prefer | $40 for sure | or | a 2-in-7 chance (29%) of winning $100? | 0.62 |
| | Would you prefer | $40 for sure | or | a 1-in-3 chance (33%) of winning $100? | 0.74 |
| | Would you prefer | $40 for sure | or | a 2-in-5 chance (40%) of winning $100? | 1.00 |
| | Would you prefer | $40 for sure | or | a 1-in-2 chance (50%) of winning $100? | 1.50 |
| | Would you prefer | $40 for sure | or | a 2-in-3 chance (67%) of winning $100? | 3.04 |
| | Would you prefer | $40 for sure | or | a 4-in-5 chance (80%) of winning $100? | 6.00 |
| | Would you prefer | $40 for sure | or | a 6-in-7 chance (86%) of winning $100? | 9.21 |
| | Would you prefer | $40 for sure | or | a 10-in-11 chance (91%) of winning $100? | 15.17 |
| C | Would you prefer | $40 for sure | or | a 2-in-5 chance (40%) of winning $60? | 0.33 |
| | Would you prefer | $40 for sure | or | a 6-in-13 chance (46%) of winning $60? | 0.43 |
| | Would you prefer | $40 for sure | or | a 6-in-11 chance (55%) of winning $60? | 0.61 |
| | Would you prefer | $40 for sure | or | a 3-in-5 chance (60%) of winning $60? | 0.75 |
| | Would you prefer | $40 for sure | or | a 2-in-3 chance (67%) of winning $60? | 1.01 |
| | Would you prefer | $40 for sure | or | a 3-in-4 chance (75%) of winning $60? | 1.50 |
| | Would you prefer | $40 for sure | or | a 6-in-7 chance (86%) of winning $60? | 3.07 |
| | Would you prefer | $40 for sure | or | a 12-in-13 chance (92%) of winning $60? | 5.75 |
| | Would you prefer | $40 for sure | or | a 18-in-19 chance (95%) of winning $60? | 9.50 |

| Part | | | | | $h$ |
|---|---|---|---|---|---|
| | Would you prefer | $40 for sure | or | a 30-in-31 chance (97%) of winning $60? | 16.17 |

## Table 2

Associations between baseline variables and probability (h) and delay (k) discounting

| | ***h* values** | | ***k* values** | |
|---|---|---|---|---|
| **Continuous variables** | ***r*** | ***p*** | ***r*** | ***p*** |
| Age | 0.12 | .08 | −0.11 | .09 |
| Annual income | −0.07 | .28 | −0.04 | .54 |
| Eysenck Impulsivity Score | 0.00 | .99 | 0.27 | <.001 |
| Eysenck Venturesomeness Score | −0.16 | .01 | −0.01 | .86 |
| Eysenck Empathy Score | −0.07 | .28 | −0.07 | .32 |
| South Oaks Gambling Screen Score | −0.07 | .28 | 0.02 | .74 |
| Dollars wagered in past month | −0.03 | .66 | −0.11 | .88 |
| Categorical variables | | | | |
| Median (IQ) by gender | Males | Females | | $t$(224) = |
| *h* values | 1.13 (1.25) | 1.07 (1.83) | | .97, $p$ = .34 |
| *k* values | 0.033 (0.050) | 0.026 (0.050) | | .50, $p$ = .62 |
| Median (IQ) by race | White | Other | | $t$(224) = |
| *h* values | 1.09 (1.35) | 1.52 (4.75) | | 2.27, $p$ = .02 |
| *k* values | 0.026 (0.050) | 0.041 (0.140) | | 2.08, $p$ = .04 |
| Median (IQ) by treatment condition | GA referral | CB workbook | CB therapy | $F$(2,223) = |
| *h* values | 0.87 (1.16) | 1.10 (1.78) | 1.28 (1.67) | 1.27, $p$ = .28 |
| *k* values | 0.016 (0.050) | 0.037 (0.070) | 0.026 (0.050) | 1.63, $p$ = .20 |

GA = Gamblers Anonymous, CB = cognitive behavioral; Median (IQ = Interquartile range) values are presented for ease of interpretation, but logged values were utilized in the analyses.

**Table 3**

Results from repeated measures analysis of variance of dollars wagered

| Pre- to post-treatment (n = 178) | F (df) = | p |
|---|---|---|
| Age | F (1,170) = 0.12 | .78 |
| Gender | F (1,170) = 2.74 | .10 |
| Race | F (1,170) = 0.22 | .64 |
| Treatment condition | F (2,170) = 2.56 | .08 |
| *k* value | F (1,170) = 0.32 | .57 |
| *h* value | F (1,170) = 3.92 | .04 |
| Throughout 12-month follow-up (n = 153) | | |
| Age | F (2,290) = 0.21 | .81 |
| Gender | F (2,290) = 0.95 | .39 |
| Race | F (2,290) = 0.39 | .68 |
| Treatment condition | F (4,290) = 1.43 | .23 |
| *k* value | F (2,290) = 0.49 | .61 |
| *h* value | F (2,290) = 1.58 | .20 |

**Table 4**

Results from logistic regressions predicting gambling abstinence (N = 226)

| Post-treatment | Beta (SE) | Wald, p | Odds ratio (95%CI) |
|---|---|---|---|
| Age | 0.03 (0.02) | 2.81, .09 | |
| Gender | −0.90 (0.34) | 7.07, .008 | 0.41 (0.21–0.79) |
| Race | −0.29 (0.48) | 0.37, 0.54 | |
| Dollars gambled pre-treatment | −0.27 (0.14) | 3.75, .04 | 0.76 (0.58–1.00) |
| Treatment condition | | | |
| Cognitive-behavioral workbook | 0.54 (0.44) | 1.52, .22 | |
| Cognitive-behavioral therapy | 1.12 (0.43) | 6.92, .009 | 3.07 (1.33–7.07) |
| *k* value | 1.34 (2.30) | 0.34, .56 | |
| *h* value | −0.16 (0.8) | 4.37, .03 | 0.85 (0.73–0.99) |
| 12-month Follow-up | | | |
| Age | 0.01 (0.02) | 0.06, .81 | |
| Gender | −1.17 (0.52) | 5.18, .02 | 0.31 (0.11–0.85) |
| Race | 0.15 (0.61) | 0.06, .81 | |
| Dollars gambled pre-treatment | −0.47 (0.16) | 9.13, .01 | 0.63 (0.46–0.85) |
| Treatment condition | | | |
| Cognitive-behavioral workbook | 0.57 (0.67) | 0.73, .39 | |
| Cognitive-behavioral therapy | 1.47 (0.64) | 5.33, .02 | 4.35 (1.25–15.16) |
| *k* value | 3.33 (3.07) | 1.18, .28 | |
| *h* value | −0.36 (0.18) | 3.87, .04 | 0.70 (0.49–0.99) |

For gender, male is the reference category. For race, White is the reference category. For treatment condition, Gamblers Anonymous referral is the reference category.