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DELAY DISCOUNTING BY PATHOLOGICAL GAMBLERS

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Discounting of delayed rewards by pathological gamblers was compared to discounting of delayed rewards by matched control nongambling participants. All participants completed a hypothetical choice task in which they made repeated choices between $1,000 available after a delay and an equal or lesser amount of money available immediately. The delay to the large amount of money was varied from 1 week to 10 years across conditions. Indifference points between immediate money and delayed money were identified at each delay condition by varying the amount of immediate money across choice trials. For the majority of participants, indifference points decreased monotonically across delays. Overall, gamblers discounted the delayed rewards more steeply than did control participants.

DESCRIPTORS: gambling, delay discounting, choice, addiction, self-control, impulsivity

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Pathological gambling is on the rise in the United States, with recent figures suggesting that 3% to 5% of the population has problems with gambling (Harvard Mental Health Letter, 1996) compared to estimates of 1% of the population 20 years ago (Ladouceur, Boisvert, Pepin, Loranger, & Sylvain, 1994). Although these data suggest that problem gambling is present in only a small fraction of the population, the prevalence is much higher than other disorders that have been studied more extensively in behavior-analytic research (e.g., autism). A number of obstacles may hinder basic and applied research on gambling. For example, results of laboratory studies may have limited external validity because, due to ethical and legal reasons, participants cannot be required to wager their own money. Studies on problem gambling in naturalistic settings must rely on descriptive methods because it is illegal to control the outcomes of such games (i.e., gambling outcomes must be determined by chance).

The difficulties inherent in behavior-analytic research on gambling should not prevent our field from making an impact on this growing social concern. Innovative methods are needed, because applied research on pathological gambling is long overdue. One potentially successful approach is to integrate basic work on processes that are relevant to pathological gambling with applied research on this behavior disorder.

Pathological gambling has been conceptualized as a series of impulsive choices whereby the gambler selects the smaller, less probable immediate opportunity to obtain money over the larger, more probable delayed opportunity to save money (Petry & Casarella, 1999). Recasting problems such as drug addiction, dietary excess, underutilization of health care, and gambling in terms of intertemporal choice allows methods and concepts developed in basic studies of choice and decision making to be brought to bear on these socially significant problems (cf. Bickel & Vuchinich, 2000). Although it is

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readily apparent that many people often select a smaller immediate reinforcer over a larger delayed reinforcer, the reasons why they do remain uncertain. Investigations into nonoptimal human choice making often focus on the discounting, or undervaluing, of the delayed consequences.

Studies on delay discounting have shown that nonhumans and humans tend to shift their preference from a larger delayed reward to a smaller immediate reward as the amount of time to receive the delayed reward increases (Rachlin & Green, 1972; Rachlin, Raineri, & Cross, 1991). In other words, individuals tend to discount the value of a reward that is further away in time. This is often termed *impulsivity* as opposed to *self-control,* which indicates that the individual will choose a larger delayed reward over a smaller immediate reward (Dixon, Rehfeldt, & Randich, 2003; Rachlin & Green).

The following hyperbolic equation was developed by Mazur (1987) to calculate the degree of discounting:

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

In this equation, V is the subjective value of the delayed reward, also known as the indifference point or the point at which the delayed reward is equally as valuable as the immediate reward, A is the nominal amount of the delayed reward, k is a free parameter that describes sensitivity to changes in delay, and D is the length of the delay. As the empirically derived k value increases, the discounted value (V) decreases more rapidly as a function of the delay (D). In other words, the larger the degree of discounting (k), the quicker the discounted value decreases over time.

At least one study found that the degree of discounting for substance abusers with gambling problems was considerably greater than that for substance abusers without gambling problems (Petry & Casarella, 1999). Demographic research on the severity of gambling problems in smokers and nonsmokers seeking treatment for gambling addiction also has shown greater gambling and psychosocial problems in the former group (Petry & Oncken, 2002). Together, these studies suggest that when gambling problems cooccur with other forms of addictive disorders, the person suffering may face even more detrimental consequences. Although these studies do not explicitly offer behavioral interventions for these problems, they extend the generality of our understanding of choice and decision making and hold the promise of informing the development of such interventions.

To date, no research comparing pathological gamblers to nongambling control participants has incorporated the intertemporal choice paradigm, and it remains to be seen if a gambling population without substance abuse problems discounts delayed rewards in a similar fashion as those with other frequently studied addictions. Furthermore, no published research has attempted to evaluate the degree of temporal discounting in a context in which the hypothesized discounting actually occurred. Specifically, pathological gamblers have never been assessed as to their degree of temporal discounting in a context in which they regularly gambled. Therefore, the current study examined discounting of delayed monetary rewards by gamblers at an off-track betting facility to determine if these individuals discount delayed monetary rewards to a greater degree than individuals who do not gamble.

METHOD

Participants and Settings

Forty subjects participated in this study. Twenty individuals (5 women and 15 men, mean age = 40.6 years) who were gambling at an off-track betting facility for horse racing and scored above 4 on the South Oaks Gambling Screen (SOGS) (Lesieur & Blume, 1987), the most widely used assessment for pathological gambling, were recruited as participants. Scores of 4 or higher on the SOGS are frequently correlated with pathological gambling. The average SOGS score for the gambling subjects was 5.85. Twenty nongambling control participants (7 women and 13 men, mean age = 40 years) also were recruited for this study through friends, local churches, coffee shops, and bookstores. Control participants also completed the SOGS and had to score less than 2 to participate in the study. The average SOGS score for the control participants was 0.7. Groups were matched on sex, age, income, and level of education. There were no significant differences in demographic characteristics of the two groups on age, $t(38) = 0.14$, $p > .05$; income, $\chi^2(4, N = 40) = 6.317$, $p = .177$; sex, $\chi^2(1, N = 40) = 0.476$, $p = .49$; or level of education, $t(38) = 1.23$, $p > .05$. There was a significant difference in the SOGS scores for the participants who gambled ($M = 5.85$, $SD = 1.66$) and control participants ($M = 0.7$, $SD = 0.86$), $t(38) = 12.28$, $p < .05$.

Verbal consent to participate was obtained from all participants to maintain their anonymity. No compensation was given to any participant. The off-track betting facility where sessions took place for the gamblers was approximately 60 m by 30 m and contained two liquor bars, a variety of tables and chairs, a betting station, and approximately 30 televisions broadcasting live horse races from around the world. The setting for sessions for control participants varied depending on where they were recruited. Regardless of setting, the experimenter sat across a table from the participant and presented them with the stimulus materials.

Materials

Hypothetical monetary amounts were printed on separate index cards. The delayed reward was always $1,000. Immediate monetary reward amounts were varied across choice trials over the following values: $1,000, $990, $960, $920, $850, $800, $750, $700, $650, $600, $550, $500, $450, $400, $350, $300, $250, $200, $150, $100, $80, $60, $40, $20, $10, $5, and $1. Delays to the fixed $1,000 reward were also printed on separate index cards. The delays were 1 week, 2 weeks, 1 month, 6 months, 1 year, 3 years, and 10 years. These amounts and delays are similar to those that have been reported in studies of delay discounting (e.g., Bickel, Odum, & Madden, 1999; Critchfield & Kollins, 2001; Madden, Bickel, & Jacobs, 1999; Petry & Casarella, 1999; Rachlin et al., 1991).

Procedure

One session (25 to 35 min long) was conducted with each participant. Before the session, participants were told that they would first complete a survey about gambling and, depending on their responses, they may also be asked to make choices between hypothetical amounts of money given immediately or after a delay. Participants were also informed that the rewards were hypothetical and that they would not receive the rewards that they chose. They were also told to choose the reward that they wanted and that there were no correct or incorrect responses. Participants were not informed of the purpose of the study but were simply told that the researchers were interested in what reward they would rather have.

After verbally consenting to participate, participants were read the following instructions:

> Today I am going to ask you to make some choices about money. You will not get the money that you choose, but I want you to make your choices as though you were really going to get the money. The card on your left shows money that you can have today. The

> card on your right shows money that you can get after you have waited for some period of time. So now you are being asked to choose between $1,000 delivered today versus $1,000 that you would get 1 week from today. Point to the reward you would rather have. I am going to keep flipping through these cards and you keep pointing to the card with the reward you would rather have.

The cards were arranged in front of the participant with the delayed amount always on the participant's right. The cards showing immediate amounts were stacked in descending order and placed on the participant's left. The cards showing the delays were stacked in ascending order and placed to the right of the card showing the fixed amount. A choice trial began when the experimenter gave a verbal description of the choice. For example, after positioning the cards, the participant was asked, "Would you like $1,000 now or $1,000 in 1 week?" After the participant pointed to either the immediate or delayed reward, the experimenter recorded the response on a data sheet, and the amount of the immediate reward was decreased to the amount shown on the next card.

The participant was required to cycle through the entire stack of immediate rewards twice at each of the seven delay values. After reaching the end of the stack of immediate dollar amounts, the process was repeated by presenting the immediate dollar amounts in ascending order. After completing two passes through the deck of immediate rewards, the delay to the deferred reward was increased by revealing the next card in the stack of delays, and then the cycle was repeated. This process was continued until the participant made two passes through the deck at each of the seven delays.

For each participant, indifference points were calculated by taking the average of the last immediate amount that was selected on the ascending cycle and the first immediate amount that was selected on the descending cycle at each of the seven delays. The discounting equation was fit to individual and aggregate data using Microsoft® Excel's Solver Add-In. Degrees of discounting parameters (*k* values) were derived using delays measured in weeks.

Interobserver Agreement

Data at each choice point were recorded on a paper data sheet consisting of two columns labeled "now" and "later." The experimenter placed an "x" in the column representing the participant's preference. Interobserver agreement was collected during 25% of sessions by having a second independent observer record all responses made by the participant. Interobserver agreement was calculated by dividing the number of agreements for immediate or delayed reinforcer by the number of agreements plus the number of disagreements and multiplying by 100%. Interobserver agreement was 100%.

RESULTS

Table 1 shows the indifference points obtained at each of the seven delays for gamblers and control participants. In the strictest sense of delay discounting, indifference points should decrease across each successive delay value. Although the indifference points were generally a monotonically decreasing function of delay, there were numerous departures from this theoretically ideal pattern. Indifference points frequently remained the same across successive delays and occasionally increased. The latter pattern was more frequently observed in the gamblers. To accommodate some variability in the data, we adopted less stringent criteria. For the present analyses, a participant's data were considered generally consistent with delay dis-

Table 1
Indifference Points at Each Delay, Derived *k* Values, Proportions of Variance Accounted for by the Hyperbolic Model (R^2), and Areas under the Curve (AUC) for Gamblers and Control Participants

	Delay (weeks)									
	1	2	4	25	52	156	520	*k*	R^2	AUC
Gamblers										
G1	1,000	1,000	860	700	425	250	1	0.0223	0.98	0.2235
G2	1,000	920	920	750	500	400	300	0.0122	0.87	0.4084
G3	920	920	920	920	775	700	500	0.0025	0.81	0.6559
G4	725	750	500	500	200	150	1	0.1022	0.72	0.1320
G5	475	425	225	200	150	40	15	0.6601	0.65	0.0599
G6	860	750	625	475	475	400	80	0.0320	0.32	0.3084
G7	1,000	1,000	990	550	500	750	400	0.0057	0.24	0.5935
G8	100	1	1	1	1	1	1			0.0029
G9		600	500	1	1	1	1	0.3233	0.95	0.0163
G10		850	550	175	125	150	80	0.1534	0.94	0.1367
G11		550	325	125	80	100	1	0.4335	0.94	0.0724
G12		960	775	750	500	400	300	0.0128	0.77	0.4054
G13			775	750	750	101	1			
G14				1	1	1	1			
G15					475	550	1			
G16						500	1			
G17	880	905	885	775	550		625			
G18	850	920	920	500	400	550	1			
G19	725	600	725	550	425	275	300			
G20	600	700	450	525	475	400	76			
Controls										
C1	1,000	1,000	1,000	990	960	920	800	0.0005	0.99	0.8885
C2	1,000	1,000	1,000	1,000	990	850	500	0.0016	0.95	0.7562
C3	990	990	960	920	850	800	550	0.0017	0.94	0.7290
C4	1,000	990	850	850	700	500	325	0.0063	0.91	0.4907
C5	1,000	1,000	1,000	1,000	600	300	250	0.0093	0.91	0.3721
C6	1,000	920	920	850	750	550	400	0.0046	0.88	0.5470
C7	1,000	990	990	920	800	550	500	0.0033	0.86	0.5934
C8	920	920	920	920	800	800	500	0.0020	0.81	0.7040
C9	1,000	990	920	960	920	920	750	0.0007	0.74	0.8628
C10	1,000	990	920	1,000	800	550	550	0.0028	0.74	0.6130
C11	1,000	1,000	990	920	850	750	700	0.0012	0.66	0.7597
C12	920	850	850	750	650	550	400	0.0061	0.45	0.5280
C13	1,000	1,000	920	920	550	550	550	0.0043	0.43	0.5779
C14	990	990	920	850	550	550	550	0.0046	0.36	0.5746
C15	990	960	920	920	920	800	750	0.0008	0.35	0.8068
C16	885	885	880	700	750	700	500	0.0030	−0.01	0.6416
C17	1,000	1,000	1,000	600	550	850	550	0.0024	−0.09	0.6999
C18	990	980	750	600	550	525	500	0.0084	−0.34	0.5305
C19	1,000	1,000	1,000	920	850	885	885	0.0004	−0.39	0.8854
C20	1,000	1,000	1,000	1,000	1,000	1,000	1			

counting if the indifference points decreased at least twice across successive delay values and did not increase more than once across successive delay values. At the 1-week delay, indifference points less than $1,000 were counted as decreases. By these criteria, the data from 13 gamblers (G1 through G13) and 19 controls (C1 through C19) were considered consistent with delay discounting.

Nine of the 20 participants who gamble (G9 through G17) showed an unanticipated pattern of responding. Under one or more delay conditions, these participants refused to accept any amount of money immediately, even when the delayed and immediate amounts were equal. That is, they preferred to receive $1,000 after the delay than to receive $1,000 immediately. These instances are left blank in Table 1. For all but 1 of these participants (G17), this response pattern occurred at the shorter delays, and indifference points then generally decreased across successive delay values in a manner consistent with delay discounting. When asked why they chose to wait rather than to receive an equal amount of money immediately, a number of these participants reported that they had a sufficient amount of money to gamble with at the moment and would prefer to receive the money later when they would once again need money. G17 reported that she was planning to move in 3 years and would need money to relocate.

The hyperbolic equation developed by Mazur (1987) was fit to the data for each participant with at least six indifference points, as long as the data were consistent with delay discounting using the criteria described above. G13, G14, G15, and G16 were excluded from the analysis because of insufficient data. G17 through G20 and C20 were excluded because their choice patterns were inconsistent with delay discounting. For participants with seven indifference points, data from the 1-week delay condition were excluded from the analysis so that the same number of data points would be analyzed for each participant. Excluding the 1-week data for these participants did not appreciably alter the derived discounting parameter value (*k*) or the proportion of variance accounted for (R^2) by the hyperbolic equation. One notable exception was G8. The hyperbolic equation could not be fit to G8's last six indifference points because he chose $1 at all delays longer than 1 week. Fitting the model to all seven indifference points yielded a *k* value of 12.4478 and an R^2 of .71. Thus, G8 discounted the delayed reward steeply relative to other participants. Exclusion of his data from the between-group comparisons made the groups less disparate and, thus, produced a more conservative analysis.

The empirically derived discounting parameters (*k* values) and the individual proportions of variance (R^2) accounted for by the hyperbolic equation are shown in Table 1. The *k* values for gamblers should be higher than those for controls if excessive gambling is correlated with greater degrees of delay discounting. A Wilcoxon rank-sum test (Huck, 2000) was performed to determine if the ranks of the degrees of discounting (*k*) were significantly higher for the participants who gamble than for the controls. A nonparametric test was used because the distributions of the parameter estimates are not normal. However, only *k* values from participants with R^2 over .50 were included in the analysis. The proportion of variance accounted for by the hyperbolic equation fell below .50 for 2 of 11 gamblers (G6 and G7) and for 8 of 19 controls (C12 through C19). Thus, the hyperbolic model failed to provide an adequate description of discounting for one third of the available subjects. In a few cases, the hyperbolic model failed despite relatively orderly discounting patterns (e.g., see C18). The proportions of variance accounted for by the hyperbolic equation were high for the participants who refused to accept immediate rewards at the shortest delay (G9 through G12). Thus, their response patterns were consistent with delay discounting once the participants began choosing immediate rewards. The difference in the sums of ranks of the discounting parameters (*k*) between the groups was statistically significant ($W_s = 50$, $n_1 = 9$, $n_2 = 11$, $p < .001$).

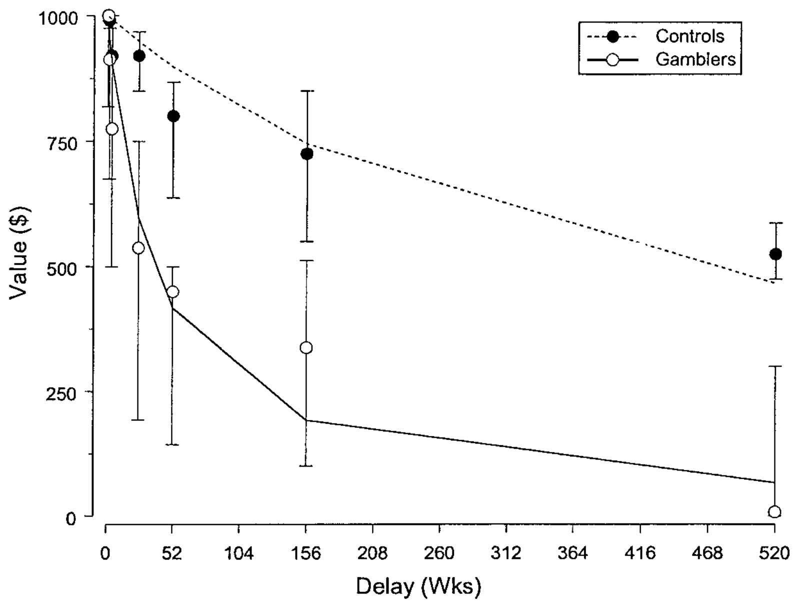

Figure 1. Aggregate indifference curves for gamblers and control participants. Data points show medians of the individual indifference points, and the error bars show the interquartile range of the individual indifference points at each of the seven delays. The solid reference line shows the best fit line for participants who gamble, and the dashed reference line shows the best fit line for control participants.

Area under the indifference curve (AUC), another measure of delay discounting, also was calculated for each participant with at least six indifference points, as long as the data were consistent with delay discounting using the criteria described above. Unlike the hyperbolic model, the AUC is theoretically neutral with respect to the form of the indifference curve and, thus, can accommodate a greater range of data than the hyperbolic model (see Myerson, Green, & Warusawitharana, 2001). The AUC can range from 0 (steepest discounting) to 1 (no discounting). The AUC should be lower for gamblers than for controls if excessive gambling is correlated with relatively high degrees of delay discounting. The AUC means were .2513 and .6611 for the gamblers and controls, respectively. The difference in the means from the two groups was statistically significant, $t(29) = 4.95$, $p < .001$, one-tailed t test.

Figure 1 shows aggregate discounting curves for all participants in each group. To provide a more conservative test of group differences in discounting, the median indifference points for the gamblers were calculated with $1,000 substituted for those points at which participants chose $1,000 after a delay rather than $1,000 immediately. Presumably this choice pattern indicates that the momentary subjective value of the delayed money was greater than $1,000. By including these values in the calculation, the medians were adjusted upward to reflect the influence of the choice patterns of these participants on the aggregate pattern. The exact value of the indifference points was unknown, but substituting $1,000 had the same effect on the medians as substituting any higher value. The adjustment increased the median at six of the seven delays, thus bringing the aggregate curves closer together to provide a more conservative test of differences in discounting between the two groups. A paired t test was conducted on the medians of the indifference points from the two groups, and the differences were statistically significant, $t(12) = 3.03$, $p < .006$.

The hyperbolic equation was fit to the median indifference points for both groups and provided a good description of the aggregate delay-discounting data. The proportions of variance accounted for by the hyperbolic equation were .93 and .89 for gamblers and control participants, respectively (Figure 1). The derived k value for the aggregate data was higher for gamblers (k = 0.0269) than for controls (k = 0.0022). Also, the area under the aggregate curve was smaller for gamblers (AUC = .2588) than for controls (AUC = .6793).

DISCUSSION

Multiple measures of delay discounting indicated that gamblers discounted delayed rewards more steeply than did control participants. Contrary to the findings of previous studies, the hyperbolic equation did not uniformly provide a good fit to the individual indifference curves. For participants whose data were well described by the hyperbolic equation, however, the derived discounting parameters (k values) were significantly higher for gamblers than for matched controls. Likewise, the mean of the individual AUC measures was significantly lower for gamblers than for matched controls. Similar findings were obtained when the data for all participants were analyzed at the aggregate level.

The finding that gambling participants discounted monetary rewards to a greater degree than did control participants is consistent with findings from studies on individuals with drug dependencies (e. g., Bickel et al., 1999; Madden, Petry, Badger, & Bickel, 1997; Petry & Casarella, 1999). These results extend the current literature to pathological gamblers who do not have comorbid substance abuse problems and suggest that, relative to other problems associated with dependencies (e.g., poverty, age, income; Ghezzi, Lyons, & Dixon, 2000), greater degrees of discounting may be more closely related to impulse control disorders.

Interestingly, nearly half of the gambling participants chose to wait to receive the monetary rewards during some delays rather than to accept any of the hypothetical money immediately, a finding that has not been previously reported. Most of these individuals stated that they would spend the money to gamble if it was given to them immediately, so they would rather wait to receive the money. This outcome, which was not obtained with any of the control participants, may reflect contextual control over discounting. The gambling participants may have made different choices if they had not been in a gambling facility when they participated in the study. Future research on delay discounting should examine the role of establishing operations (Michael, 1993) and other contextual variables on delay discounting.

The study was unique because the sessions were conducted in the naturalistic setting where participants were recruited. Results of studies conducted in naturalistic settings may have greater external validity than those of studies conducted in laboratory settings. Utilizing a naturalistic context also opens the door for innovative research in this area. For example, further studies could evaluate within-subject effects of setting, context, or deprivation level (e.g., 1 week vs. 1 day prior to payday) on delay discounting. However, naturalistic settings undoubtedly contain many uncontrolled variables that may affect internal validity (i.e., noise, interested bystanders, time constraints, drug and alcohol consumption). Furthermore, basing conclusions solely on a self-report measure, such as the hypothetical choice money task, should be made with caution. Verbal reports do not necessarily correspond to observable behavior. By utilizing a naturalistic context, experimenters may be able to include direct observations of behavior in assessments of discounting.

These results may serve as a possible foundation for understanding treatment success for problem gamblers. If Gamblers Anonymous has a success rate of just 8% after 1 year (Petry & Armentano, 1999), alternative treatment options should be explored. The hyperbolic nature of the current data suggests that effective treatments for other impulse control disorders (e.g., smoking, drinking, using drugs) may hold promise for pathological gamblers. For example, an individual in treatment for pathological gambling might be placed in a gambling situation but not allowed to gamble immediately. Pushing the opportunity to gamble further and further out in time may reverse the preference to gamble. Results of the current study suggest that gamblers often prefer immediate consequences that are less optimal to delayed consequences that are more optimal. Thus, another treatment approach might be to provide an alternative immediate consequence for a behavior that is incompatible with gambling, perhaps shifting response allocation away from gambling without necessarily changing the degree of delay discounting (Madden, 2000). Responding may shift to the incompatible behavior if the alternative consequence is functionally similar to the immediate consequence of gambling and has a more probable delivery schedule than gambling.

The implications of the delay discounting literature for framing interpretations of addictive behaviors are compelling and may inform the development of effective interventions, but the temptation to make sweeping generalizations must be avoided. Gamblers may engage in the behavior for a variety of reasons. One might be to acquire money, yet another might be to escape from aversive events at home (e.g., marital conflicts). Others might gamble for the physiological arousal, as noted by Coulombe, Ladouceur, Desharnais, and Jobin (1992). Function-based treatments have not been evaluated with problem gamblers and should be studied in future research. As the number of problem gamblers continues to rise, research is needed that will lead to more effective treatment strategies to assist persons suffering from this psychologically and financially debilitating disorder.

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STUDY QUESTIONS

1. What types of obstacles hinder basic and applied research on gambling?

2. Describe how pathological gambling has been conceptualized in behavior-analytic terms.

3. What is meant by the term *delay discounting*?

4. Briefly describe the experimental task used in this study and the two parameters that were manipulated in the task.

5. What is an indifference point, and how was it calculated in this study?

6. How did the delay discounting patterns observed in this study differ from those observed in previous studies?

7. What criteria were used to determine that a participant's data were consistent with delay discounting?

8. What were the authors suggesting when they stated that the gambling facility might have exerted "contextual control" over discounting responses?

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