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DO THE RISK FACTORS FOR PATHOLOGICAL GAMBLING PREDICT TEMPORAL DISCOUNTING?

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Weatherly and Dixon (2007) proposed that gambling was related to the increase in how individuals discount delayed (monetary) consequences and that several of the known risk factors for pathological gambling may serve as establishing operations or setting events that lead to such changes. The present study tested these predictions by having participants complete a paper-and-pencil discounting task involving hypothetical monetary consequences and determining whether self-reported measures of the known risk factors would significantly predict participants' rate of discounting. None of the risk factors served as significant predictors of discounting. Interestingly, however, the rate of discounting varied systematically as a function of the number of preference reversals participants displayed at particular delays. The present findings suggest that, if Weatherly and Dixon's proposal is correct, then it likely needs to be assessed using a more diverse sample than college freshmen. The results also suggest that measures of discounting may vary systematically as a function of procedure, which may call for a reevaluation of how discounting data are interpreted.

Keywords: Delay discounting, Gambling, Risk factors

Although many different theories have been forwarded for why people gamble and/or become pathological gamblers (see Petry, 2005, for a review), no universally accepted explanation has yet emerged. Weatherly and Dixon (2007) proposed an integrative behavioral model for gambling based on behavior-analytic principles. Unlike many past behavioral accounts for gambling behavior, the model proposed by Weatherly and Dixon went beyond contingency-driven factors such as intermittent schedules of reinforcement. Rather, the model relied on differences in how gamblers discount delayed consequences, focused on the consequences that maintain gambling, and incorporated verbal behavior.

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Delay discounting occurs when the subjective value of a consequence is reduced because it is delayed in time. For instance, when given a choice between receiving some sum of money today and receiving the exact same sum of money one year from today, all but the rare individual would choose to receive the money immediately. Thus, the delay of one year reduces the value of that sum of money below its current value.

Delay discounting has relevance to the study of gambling and gambling problems because research suggests that pathological gamblers discount delayed rewards at a greater rate than do non-pathological gamblers (e.g., Dixon, Marley, & Jacobs, 2003; see Madden et al., 2007, or Petry, 2005, for reviews). In other words, delayed consequences have less control over the behavior of the pathological gambler than of the non-pathological gambler. This finding is consistent with the idea that the factors that control delay discounting may also contribute to the formation of pathological gambling. However, it is also possible that the disorder of pathological gambling precedes changes in how the individual discounts delayed rewards. In other words, although it is possible that how one discounts delayed rewards contributes to pathological gambling, it is also possible that one's experience as a pathological gambler contributes to how one discounts delayed rewards. As is always the case with correlational data, it is also possible that some other, yet unidentified variable could produce both rapid discounting and a tendency toward pathological gambling.

Even if delay discounting contributes to pathological gambling, it is not immediately clear what circumstances would cause a change in how a person discounts delayed rewards and thus makes him or her more susceptible to becoming a pathological gambler. Weatherly and Dixon (2007) proposed a mechanism by suggesting that several of the known risk factors for pathological gambling (i.e., age, gender, socioeconomic status (SES), marital status, ethnic minority status; see Petry, 2005, for a full discussion of the risk factors) may functionally serve as establishing operations (Michael, 1993) or setting events (Kantor & Smith, 1975). These factors may alter the consequences of gambling and change, directly or indirectly, how individuals discount delayed rewards. Weatherly and Dixon further speculated that pathological gambling would be related to a specific consequence of gambling, the attainment of money, more so than other consequences (e.g., attention, sensory experience, escape; see Weatherly & Dixon, 2007, for a complete discussion).

A positive aspect of Weatherly and Dixon's proposal is that it can be tested independently of pathological gambling. If these factors are serving as establishing operations or setting events, then it should be possible to demonstrate that they are related to the rate that individuals discount delayed rewards regardless of whether or not those individuals are pathological gamblers. Furthermore, it should be possible to demonstrate that the rate that individuals discount delayed rewards is related to the consequences that maintain gambling in those individuals.

The present study was an attempt to test these possibilities. Participants were asked to make a series of hypothetical choices between a certain amount of money available immediately and $1,000 available after a delay. Participants' answers were used to calculate how steeply they discounted delayed rewards. Regression analyses were then performed to determine whether the risk factors for gambling were significant predictors of participants' delay discounting. Further analyses were conducted to determine if participants' discounting could predict whether or not participants' gambling behavior was controlled by the attainment of money.

If Weatherly and Dixon's (2007) model is correct, then the risk factors for pathological gambling should be significant predictors of delay discounting and how steeply one discounts delayed rewards should be associated with the monetary consequences of gambling. Furthermore, it should be possible to discover whether one or more of these factors is a greater predictor of differences in delay discounting than are other factors. Should this outcome be true, then researchers and treatment providers alike would have reason to focus their efforts on certain risk factors relative to the others.

METHOD

Participants

The participants were 236 undergraduate students enrolled at the University of North Dakota. Participants were recruited from lower-level psychology courses and received extra course credit for their participation. The demographic information pertaining to the participants can be found in table 1.

Participants were asked to complete a series of questionnaires after providing in

Table 1
Demographic information of the omnibus sample

Gender	101 Males	135 Females		
Age	Mean = 20.89 years (SD = 7.23) Range = 18-67 years			
Ethnicity	9 Hispanic	19 American Indian	1 Asian	1 African American
	2 Native Hawaiian, Pacific Islander		204 Caucasian	
SES	183 <$10,000	15 $10,000-$14,999		13 $15,000-$24,999
	7 $25,000-$34,999	4 $35,000-$49,000		9 $50,000-$74,999
	3 $75,000-$99,999	2 >$100,000		
SOGS	Mean = 1.17 (SD = 2.12)		Range: 0 – 10	
GFA Tangible	Mean = 8.08 (SD = 8.94)		Range: 0 – 25	

formed consent. The first was a demographic questionnaire that ascertained the participant's sex, age, marital status, race/ethnicity, and annual income. These factors were assessed because Weatherly and Dixon (2007) proposed that they are potentially establishing operations or setting events for pathological gambling.

The second measure was the Gambling Functional Assessment (GFA; Dixon & Johnson, 2007). The GFA is a 20-item questionnaire that attempts to assess the consequences that may be maintaining the respondent's gambling behavior. The four potential consequences for gambling are gaining attention, for the sensory experience, a tangible outcome (e.g., winning money), and as an escape. Participants can score between 0 – 30 in each of these categories. Theoretically, the strength of the controlling consequence increases with score and the highest scoring category represents the primary consequence maintaining gambling behavior. The present study focused on participants' score in the tangible category because it is this consequence that Weatherly and Dixon (2007) proposed as being important in the formation and maintenance of pathological gambling.

The third measure was the South Oaks Gambling Screen (SOGS; Lesieur & Blume, 1987). The SOGS is a 20-item questionnaire that attempts to assess the person's history with gambling. It is the most widely used screening measure for pathological gambling (see Petry, 2005). Scores can range from 0 - 20, with a score of 5 or more indicating the potential presence of pathology.

The final measure was a series of hypothetical choices between a certain amount of money available immediately ($1, 50, 100, 250, 500, 750, 900, 950, or 1,000) or $1,000 available after some delay (one week, two weeks, one month, six months, one year, three years, or ten years). Thus, participants made (by circling their preferred option) 63 hypothetical choices. The choices were presented in random order (i.e., the size of the immediate reward and the delay to the $1,000 varied from choice to choice). The choices were presented in list fashion, one after the other, on a total of three sheets of paper.

Analyses

To determine the extent to which individual participants discounted delayed rewards, the point that the participant switched from preferring the immediate reward to the delayed reward was determined for each delay. Because participants were faced with every possible monetary comparison at each different delay presented in random order (vs. presenting the comparisons in linear order at a particular delay until the participant's preference switched and then moving on to the next delay), it was possible for participants to reverse preference more than once at a given delay (i.e., display multiple "changeover" points at a particular delay). Three data sets were therefore created. The first was the sub sample of the 236 participants who only had a single preference reversal or changeover point at each of the seven delays (n = 83; 44 female, 39 male). The second was the sub sample of the 236 participants who had displayed multiple changeover points at none or one particular delay (n = 141; 77 female, 64 male). At the hypothetical delay for which a participant displayed multiple changeover points, value at that delay was determined by calculating the mean between the two changeover values. The third sub sample was of participants who displayed multiple changeover points at two or fewer delays (n = 178; 103 females, 78 males). When multiple changeover points occurred, value was determined as described above. Participants who displayed multiple changeover points at three or more delays (n = 58) were ultimately excluded from the analyses because they displayed inconsistency on nearly (or more than) half of the delays.

Each data set was then subjected to two analyses related to delay discounting. In each case, the delays were analyzed in terms of days (see Figure 1). First, the following hyperbolic function was fit to each participant's data:

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

In Equation 1, V stands for the subjective monetary value of the delayed reward, A for the amount of the reward, k for a free parameter that describes the rate at which discounting occurs, and D for the delay (e.g., Mazur, 1987). For the present study, k from Equation 1 was calculated for each participant. Larger values of k represent steeper rates of delay discounting. Thus, k was used as a dependent measure for participants' rate of discounting.

Equation 1 is theory bound because it makes certain assumptions about the nature of delay discounting (e.g., that discounting follows a hyperbolic function). It is also the case that the distribution of the values of the parameters in Equation 1 is skewed. Thus, a second analysis of discounting was performed. The area under the discounting curve was calculated using the changeover points for each participant (see Myerson, Green, & Warusawitharana, 2001). This measure suffers from neither of the above problems. With this measure, participants who steeply discounted delayed rewards would have smaller values of area under the curve (AUC) than would individuals who did not steeply discount delayed rewards.

Once Equation 1 and the area under the curve were determined for each participant's data, several regression analyses were performed. Specifically, each participant's age, gender, SES (defined by the participant's self report of annual income measured on an ordinal scale), marital status (single, married, divorced, or widow/widower), ethnic minority status (Hispanic/Latino, American Indian, Asian, Black/African American, Native Hawaiian/Other Pacific Islander, or White) and SOGS score were numerically coded and used as predictor variables in a backward regression with either k or the area under the curve serving as the dependent variable. This particular regression analysis was chosen because it determines each factor's explanatory power independent of the other factors in the model. These analyses tested the hypothesis that the risk factors for pathological gambling would predict how individuals discount delayed rewards.

Finally, for each data set, participants' k or AUC values were used as predictor variables for their cumulative score on the "tangible" questions on the GFA (Dixon & Johnson, 2007). These analyses tested the hypothesis that differences in how individuals discount delayed rewards would be predictive as to whether money served as the maintaining consequence for gambling behavior.

RESULTS

Figure 1 presents the discounting data for the mean of all participants in each of the three groups. The solid line represents the best fit function using Equation 1. The value of *k* for that fit is also presented in each graph. The results of the regression analyses conducted on each data set, for both the value of *k* and the AUC, are presented in Table 2. In no instance in the six analyses did participants' age, gender, SES, marital status, ethnicity, or SOGS score serve as a significant predictor of either *k* or AUC, although in several instances individual factors did approach significance. Furthermore, the total variance accounted for by any individual factor was small, never exceeding 3%.

The *k* and AUC values for each data set presented in Figure 1 were also used as predictor variables for individuals' "tangible" score on the GFA. The results of these tests are presented in Table 3. As can be seen in Table 3, neither *k* nor AUC was a significant predictor of participants' "tangible" GFA score in any analysis. Furthermore, the amount of variance for by either factor was negligible.

DISCUSSION

Weatherly and Dixon (2007) suggested that several of the known risk factors for pathological gambling may be serving as establishing operations or setting events that alter the value of the consequence maintaining gambling (i.e., money). This alteration would lead individuals to discount delayed monetary rewards more steeply than when the risk factors are absent. The present study attempted to test this suggestion by determining whether the risk factors would be significant predictors of how participants discounted delayed monetary rewards. None of the risk factors (nor participants' scores on the SOGS) were predictive of participants' level of discounting.

Weatherly and Dixon (2007) also suggested that pathological gambling would be associated with one type of consequence, money. Given that steep discounting is associated with pathological gambling, the present study tested whether discounting would significantly predict whether participants' gambling was maintained by monetary consequences. Participants' discounting was not predictive of how strongly monetary consequences maintained gambling behavior.

Failing to find that the known risk factors for gambling are predictive of how steeply participants discount delayed rewards runs contrary to the predictions of Weatherly and Dixon (2007). There are several possible explanations for this failure. For instance, the present sample consisted mostly of university freshmen and thus several of the risk factors related to pathological gambling, such as age, marital status, and SES, may have been artificially constrained. Furthermore, because of the population of the upper Midwest of the United States, the present sample may have also provided a limited test of ethnicity.

A remaining possibility is that Weatherly and Dixon's view of the risk factors for pathological gambling as potential establishing operations or setting events is incorrect. For instance, one could argue that establishing operations or setting events operate at the level of individual participants whereas the risk factors for gambling are correlations that exist across a population. Thus, one should not necessarily expect the risk factors to significantly predict individuals' discounting. A full discussion of this issue is beyond the scope of the present paper. However we would argue that such a view diminishes, if not eliminates, the value of risk factors if they can never be

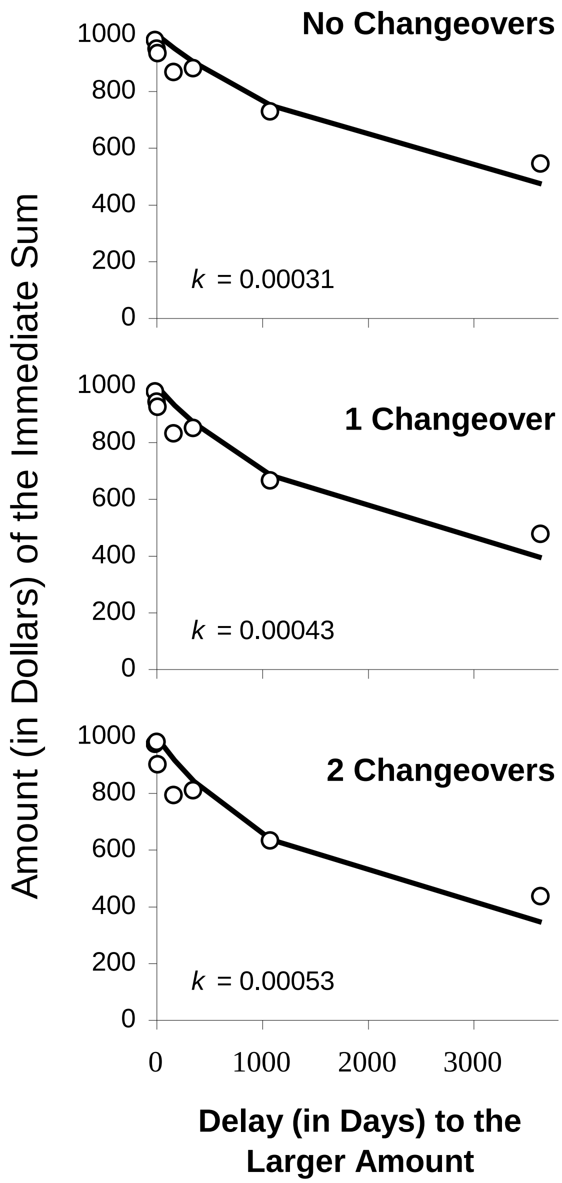

Figure 1. Discount functions for participants dependent on the number of changeovers in responses

used to predict individuals' behavior.

The present data also failed to support Weatherly and Dixon's (2007) prediction that pathological gambling is associated both with steep discounting and to one type of consequence for gambling, money. Again, it is possible that Weatherly and Dixon's proposal was incorrect. It is also possible that the failure to observe this relationship was related to the potential problems with the sample (see above). Another potential reason for this failure is the measure used to determine the consequences maintaining participants' gambling. Although Dixon and Johnson (2007)

Table 2
Results from the regression analyses conducted on the data used to construct Figure 1.

Factor	Coefficient	Beta Weight	t	Significance	Semi-Partial R^2
No Changeovers DV = k					
Age	.000	-.009	-.058	.954	.000
Gender	-.002	-.107	-.865	.390	.010
SES	.000	-.035	-.266	.791	.001
Marital Stat.	.000	.018	.003	.910	.000
Ethnicity	.000	.020	.162	.871	.000
SOGS	.000	.038	.318	.752	.001
No Changeovers DV = AUC					
Age	.008	.165	1.045	.300	.013
Gender	.084	.178	1.479	.143	.027
SES	-.013	-.105	-.822	.413	.008
Marital Stat.	-.016	-.093	-.594	.554	.004
Ethnicity	.023	.158	1.325	.189	.022
SOGS	.021	.148	1.248	.216	.019
One or less Changeovers DV = k					
Age	.000	.119	.997	.321	.007
Gender	-.001	-.022	-.248	.805	.018
SES	-.001	-.071	-.708	.480	.006
Marital Stat.	.000	.021	.196	.845	.004
Ethnicity	.000	-.005	-.049	.961	.007
SOGS	-.001	-.056	-.621	.536	.007
One or Less Changeovers DV = AUC					
Age	-.006	-.162	-1.406	.162	.013
Gender	.084	.158	1.886	.061	.024
SES	.002	.015	.152	.879	.000
Marital Stat.	-.004	-.025	-.236	.814	.000
Ethnicity	.022	.137	1.480	.141	.015
SOGS	.013	.100	1.147	.253	.009
Two or Less Changeovers DV = k					
Age	.000	.085	.827	.409	.004
Gender	.000	-.012	-1.56	.876	.000
SES	-.001	-.081	-.901	.369	.005
Marital Stat.	.001	.061	.649	.517	.002
Ethnicity	.000	-.012	-.143	.887	.000
SOGS	.000	-.053	-.675	.500	.003
Two or Less Changeover DV = AUC					
Age	-.004	-.099	-.982	.327	.005
Gender	.074	.136	1.808	.072	.018
SES	.017	.093	1.054	.293	.006
Marital Stat.	-.014	-.078	-.840	.402	.004
Ethnicity	.016	.099	1.157	.249	.007
SOGS	.012	.085	1.101	.272	.007

designed the GFA to measure weather "tangible" outcomes were maintaining gambling behavior, recent evidence suggests that the GFA may identify whether positive reinforcement is maintaining gambling behavior, but may not necessarily accurately delineate between the potential positively reinforcing consequences (e.g., tangible vs. sensory experience; Miller, Meier, Muehlenkamp, & Weatherly, in press).

Table 3
Results from the regression analyses when k or AUC were used to predict participants' "tangible" score on the GFA for each of the three datasets.

Factor	Coefficient	Beta Weight	*t*	Significance	Semi-Partial R^2
No Changeovers					
k	-.29.956	-.035	-.319	.750	.001
AUC	2.040	.054	.488	.627	.003
One or Less Changeovers					
k	54.950	.118	1.405	.162	.014
AUC	-.126	-.004	-.043	-.043	.000
Two or Less Changeovers					
k	56.411	.112	1.515	.132	.013
AUC	.815	.025	.338	.736	.001

The present data also highlight another, unexpected reason why our hypotheses were not supported. Namely, the procedure used in the present study to determine participants' delay discounting did not reliably produce a single preference reversal at each delay. It did, however, produce reliable changes in rates of discounting as a function of the number of multiple preference reversals participants displayed at different delays. This result may constitute the main contribution of the present paper.

Figure 1 demonstrates that how rapidly participants discounted the delayed monetary consequence increased as individuals who displayed multiple changeover points across the seven different tested delays were added to the sample. Because the 83 participants who did not display multiple changeovers are included in the calculations for all three graphs, this increase in discounting is completely due to individuals who had multiple changeovers at one or two delay points. Furthermore, this change in discounting was not trivial. The value of *k* increased 71% from the group displayed in the top graph of Figure 1 to the group displayed in the bottom graph[1].

The delay-discounting task in the present study consisted of 63 choice combinations. These choices were randomly ordered and participants answered all of them. This method was chosen because randomly ordering the choices would theoretically guard against order effects. Doing so also seemed to provide face validity in the sense that individuals are rarely faced with a series of choices that vary systematically along one continuum (e.g., amount) when all other factors remain constant (e.g., delay). Rather, "real life" choices typically different along a number of continuums from choice to choice. However, using the current procedure, the result was that the vast majority of participants displayed multiple preference reversals at one or more delays.

[1] Given the changes in the rate of discounting across the graphs in Figure 1, one could legitimately ask whether participants who displayed no, one, or two multiple preference reversals represented distinct populations. To test this possibility, the analyses outlined in the results were conducted using only those participants who displayed one or two multiple changeovers. These analyses yielded only one major change compared to those presented in the results. Specifically, age and marital status were significant predictors of *k* for those individuals who displayed multiple preference reversals at two (and only two) delays. Discounting tended to be steeper for younger and single participants. The predictive relationship of ethnicity approached, but did not reach, significance (p=.054). None of the risk factors were significant predictors of AUC. Furthermore, none of the risk factors were significant predictors of *k* or AUC for those participants who displayed one (and only one) multiple preference reversal.

The procedure used to ascertain participants' rate of delay discounting in the present study is not the only one that has been used. Ostaszewski, Green, and Myerson (1998), for instance, had participants respond to a series of choices at a particular delay with the amount of the immediate option varying systematically in either an ascending or descending sequences. Participants in this study experienced both sequences across the procedure, a practice recommended by some (e.g., Critchfield & Kollins, 2001). Du, Green, and Myerson (2002), on the other hand, used an adjusting procedure in which participants were originally presented with an immediately available amount that was a certain percentage of the delayed amount. Depending on the participant's choice, the next immediately available amount was adjusted upwards or downwards and this process continued until a changeover point was determined for that particular delay.

Both of these techniques make multiple changeover points improbable (although one could argue that a different changeover point could be established for ascending vs. descending sequences or if the adjusting procedure was repeated). However, although these procedures avoid the problem that occurred in the present procedure, they are highly artificial. The systematic nature of presenting the questions creates order effects. In fact, one could argue that the intention is to create an order effect.

However, before one dismisses the changes in the present data as procedural artifacts, it is worthy of noting that an alternative interpretation exists. That is, the individuals who displayed multiple changeovers may not have done so because of the procedure, but rather because these individuals were insensitive to the presented choices relative to individuals who did not display multiple changeovers. Representing discounting for these individuals as a single function may thus be potentially misleading. In other words, these individuals may have had a range of indifference points at each delay, not a single one. This idea is worth exploring in the future. Individuals who display this "range" of indifference may be unique relative to individuals who do not. Furthermore, such an interpretation may alter conclusions that are drawn from studies of delay discounting in general.

A final procedural aspect that requires addressing is the fact that the present procedure, and the procedures used in myriad published studies, asked participants to make hypothetical choices. It is unclear how this fact influences the results. Research from our laboratory (Weatherly & Brandt, 2004; Weatherly & Meier, 2007) has shown that participants in laboratory studies of gambling become more conservative in their gambling as the value of what they are gambling increases. If the same result held true in studies of delay discounting of monetary rewards, then one would expect steeper discounting when hypothetical, rather than "real," choices were required.

The value of the present study may lie in the systematic changes in the main dependent variable as a function of whether a single preference reversal could be identified. Given that researchers have made much ado about the association between delay discounting and pathological gambling, finding such systematic changes is a major concern. Have those associations been based on data sets that contain similar systematic changes? Do procedures designed to avoid these systematic changes result in a valid representation of the individuals' delay discounting? Do multiple changeovers represent ranges of indifference rather than a particular value of a delayed consequence? Do hypothetical choices generalize to actual choices? Does discounting measured in the laboratory accurately predict how the individual actually behaves? These questions, and many additional ones, are worthy of further investigation.

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