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Pathological gambling is an important and large societal problem. Theorists and researchers have linked pathological gambling to rates of temporal discounting, although not all attempts to do so have been successful. Unfortunately, popular measures of temporal discounting each have weaknesses, and studies of discounting have tended to focus on one particular commodity – hypothetical monetary rewards. Evidence exists to suggest that problem and pathological gambling is also linked to escape contingencies. If so, these findings could potentially explain the link that has been found between temporal discounting and gambling. Implications and predictions of this possibility are discussed.

Keywords: Gambling, Temporal discounting, Escape

Pathological gambling is a large societal problem, with around 2% of the adult population displaying the disorder and an additional 5 – 8% displaying sub-clinical symptoms (i.e., problem gambling; Petry, 2005). According to Petry (2005), there are six known risk factors associated with pathological gambling. One is gender, with males displaying the disorder significantly more frequently than females. Another is ethnicity, with higher rates of pathological gambling being found in minority populations than in the majority population. The third is age, with young adults being most likely to display pathological gambling and the likelihood of the disorder decreasing with age. The fourth factor is socio-economic status. Those low in socio-economic status are more likely to be pathological gamblers than are those high in socio-economic status. The penultimate factor is marital status, with pathological gamblers more likely to be single or divorced than be married. The final, and by far the biggest, risk factor is drug use and abuse. The comorbidity rate of substance dependence and pathological gambling is so high that it is recommended that mental-health-care professionals working with one population screen for the other disorder (Petry, 2005).

These factors are not the only ones that have garnered research attention in the study of gambling, however. Other factors have included psychological disorders (e.g., depression; Dannewitz & Weatherly, 2007) or personality characteristics (e.g., sensation seeking; Gillis, McDonald, & Weatherly, 2008). A factor that has received a great deal of research attention is the rate of temporal discounting (see Petry & Madden, 2010). Temporal discounting occurs when the subjective value of an outcome or consequence (e.g., a sum of money) is lessened because it is delayed in time. Phrased differently, individuals will typically take less than the full amount of the outcome or consequence in order to get it immediately rather than having to wait for the full amount (e.g., Baker, Johnson, & Bickel, 2003), with the amount that is acceptable immediately decreasing as the delay to the full amount increases (e.g., Smith & Hantula, 2008). Research on temporal discounting has found that pathological gamblers discount hypo-

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thetical monetary rewards to a greater degree than do their non-pathological counterparts (e.g., Dixon, Jacobs, & Sanders, 2006; Dixon, Marley, & Jacobs, 2003).

The idea that temporal discounting may play a role in the development and maintenance of pathological gambling is not new (e.g., Fantino & Stolarz-Fantino, 2008; and see Petry, 2005, for a review) nor is the potential application of discounting isolated to gambling (e.g., see Rachlin, 1997). In fact, Weatherly and Dixon (2007) made temporal discounting an integral component of their behavioral model of gambling. Specifically, they argued that certain of the risk factors for pathological gambling (described above) could serve as setting events or establishing operations, thus altering the subjective value of money. When the value of money is altered, you would expect to get changes in how money is discounted when it is delayed in time. According to Weatherly and Dixon (2007), those changes would ultimately lead the gambler down the road of pathology.

After proposing this model, our laboratory set about testing its premises and predictions. To some extent, the results from those attempts supported the model. For instance, Weatherly, Marino, Ferraro, and Slagle (2008) recruited non-pathological individuals across a wide age range to participate in a laboratory gambling study. Participants completed a number of paper-pencil measures, including a temporal-discounting task. They were then staked with $10 in tokens that could be gambled, across a 15-min session, on a slot machine. The results showed that the only significant predictor of how many tokens the participants gambled across the session was the rate of discounting they had displayed on the temporal-discounting task. The other factors (gender, age, annual income) were not related to rates of gambling. Thus, this study became the first to demonstrate that rates of discounting were predictive of actual gambling behavior (vs. self reports or hypothetical situations). Furthermore, the results were observed in non-pathological participants, suggesting that the relationship between gambling and temporal discounting did not require the presence of pathology.

Other research, however, was not so supportive. For instance, Weatherly, Derenne, and Chase (2008) investigated the idea that the risk factors for gambling would be related to temporal discounting. Specifically, they collected demographic information from 236 college students who then completed a temporal discounting task, the South Oaks Gambling Screen (SOGS), which measures lifetime gambling behavior (Lesieur & Blume, 1987), and the Gambling Functional Assessment (GFA), which measures the contingencies that maintain gambling behavior (Dixon & Johnson, 2007). The study was designed to test the following predictions: that the risk factors for gambling would be related to rates of temporal discounting, that rates of temporal discounting would be related to the extent to which people displayed symptoms of pathological gambling (as measured by the SOGS), and that whether or not peoples' gambling behavior was maintained by monetary consequences would be related to both symptoms of gambling problems and rates of temporal discounting. However, none of these predictions were supported.

The value of the data reported by Weatherly, Derenne, and Chase (2008) was not necessarily related to the association between temporal discounting and gambling behavior. Rather, the interesting outcome in their study was the temporal-discounting data themselves. Their study employed a paper-pencil, binary-choice temporal-discounting task in which participants were asked a series of questions that required them to choose between two monetary options (i.e., $1,000 available after a delay or a lesser amount available immediately). With this procedure, rate of temporal discounting is determined by identifying the point at which, at each different delay, the participant switches from preferring the full, but delayed amount to preferring the lesser, more immediate amount. To minimize the number of questions that needed to be asked, and to combat order effects, the temporal-discounting questions were randomized. Thus, from question to question, participants were presented with changes in both the delay to the full amount and the size of the immediately available amount.

Despite the scientifically sound practice of randomization, this manipulation wreaked havoc with the data. Specifically, nearly 65% of the sample displayed multiple switch points at at least one delay. For instance, at a delay of one month, a person might in one question choose $900 rather than waiting for $1,000, but when faced with another question (later in the survey) choose to wait the month to get the $1,000 rather than accepting $950 immediately. When this inconsistency occurs, the researcher is faced with a number of decisions. For one, did these participants understand the task or take it seriously? If not, then perhaps their data should be discarded. If there is no reason to believe that the data were corrupt in some way, then how does one go about estimating or determining what the indifference point should be when there are multiple switch points? Ultimately, three different data sets were constructed; one that included only participants who did not display multiple switchovers, a second that included participants who made one or less multiple switchovers, and a third that included participants who made two or less multiple switchovers. When a multiple switchover did occur at a particular delay, the indifference point for that delay was determined as the midpoint between the two switch points.

The ultimate conclusion that could be drawn from the data from Weatherly, Derenne, and Chase (2008) was that temporal discounting varied systematically across the three data sets. Specifically, the rate of temporal discounting became increasingly steeper as participants who had made multiple switchovers were added to the data set. Given that these were potentially the individuals who did not understand the task or take it seriously, that their discounting rates were determined partially by estimations based on their multiple switchover responses, and the fact that pathological gambling is related to steeper rates of temporal discounting, these results were rather disconcerting.

Measures of Temporal Discounting

Several different methods exist to measure temporal discounting. One popular technique, and the one employed by Weatherly, Derenne, and Chase (2008), is to fit the indifference (i.e., switchover) points to a hyperbolic equation (Mazur, 1987):

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

When using Equation 1, V represents subjective value of the delayed consequence, A represents the amount of the consequence, D represents the delay, and *k* is a free parameter that describes the rate that temporal discounting occurs. When Equation 1 is used, *k* is employed as the dependent measure for discounting with higher values of *k* being indicative of steeper rates of discounting. Phrased differently, previous research has shown that pathological gamblers display higher *k* values than non-pathological gamblers (e.g., Dixon et al., 2003).

A second technique for measuring temporal discounting is to determine the area under the curve (AUC) created by the indifference points across delays and assuming that the commodity is at its full value when there is no delay (Myerson, Green, & Warusawitharana, 2001). The AUC can be calculated using the following equation:

$$(x_2 - x_1)[(y_1 + y_2)/2] \quad \text{(Equation 2)}$$

When using Equation 2, AUC can vary between 0.0 and 1.0, with the rate of temporal discounting being inversely related to AUC value. Phrased differently, if pathological gamblers discount more than non-pathological gamblers, then one would expect them to display lower AUC values than non-pathological gamblers.

Although other formulas have been proposed to measure temporal discounting (e.g., Green, Fry, & Myerson, 1994; and see Killen, 2009, for a discussion), Equations 1 and 2 are commonly found in discounting studies. Each has their weaknesses. Equation 1 is, at best, an estimation of discounting and the processes that are involved in it. That is, the resulting dependent measure, *k*, is estimated given the responses the participant/subject provides, at which point the actual data are no longer considered. Studies that employ Equation 1 therefore also report how well it fit the data in terms of the variance for which it account (i.e., R^2). Often these values are quite high (e.g., Smith & Hantula, 2008). However, sometimes they are not (e.g., Weatherly, Derenne, & Terrell, 2010; Weatherly, Terrell, & Derenne, 2010). Next, implicit in the use of Equation 1 is that temporal discounting is hyperbolic in nature. Although Equation 1 has adequately fit many data sets in the literature, the theoretical reasons for why discounting should be hyperbolic in nature have been elusive (see Killeen, 2009, for a thorough discussion).

Furthermore, temporal discounting data are not always that "clean." Some participants do not decrease the value of the commodity as it is delayed (non-discounters; e.g., see Beck & Triplett, 2009). Others might in fact display the inverse of discounting (i.e., expecting more of the immediately available amount with increasing delays to the full amount). A typical reaction to such patterns of responding is to exclude them from data analyses and it is common to see 10 – 15% of a data set excluded for this reason (e.g., see Beck & Triplett, 2009). This practice is often done without much comment. An assumption is made that these individuals did not understand the task or questions. However, one could argue that these data are excluded because they do not fit with the researchers' assumptions, which is troubling. Even if one could make a reasonable defense of this practice from a scientific basis, it is still troubling. If the relationship between pathological gambling and temporal discounting is a meaningful one, it seems odd that we should need to routinely exclude 1 out of every 7 - 10 participants in temporal discounting studies in our attempt to explain the 1 in every 50 individuals who suffer from the disorder.

AUC values, on the other hand, directly represent the responses provided by the participants/subjects. It is also atheoretical in terms of the form temporal discounting should take. However, that is not necessarily a good thing. That is, it is potentially possible for the responses of two individuals to generate the same AUC value by displaying two distinctly different patterns of responding (e.g., one accepting increasingly less of the commodity as it is delayed and the other expecting increasingly more of the commodity as it is delayed; and see Smith & Hantula, 2008, for another example). Thus, one cannot determine by looking at an AUC value, as one can with a *k* value, the form of the participant's/subject's responses.

It is also the case that, in typical studies of temporal discounting, AUC values will be highly correlated with participants'/subjects' responses at long delays. Research on temporal discounting has historically found that individuals display steep rates of discounting across short delays and discounting rates flatten at longer delays (the *delay effect*; see Chapman, 1996, for a discussion). For this reason, studies of temporal discounting often have an overabundance of short delays and a few long delays. Because discounting is measured as a function of time, the long delays will constitute much of the overall AUC value whereas each of the short delays will potentially make up a lesser amount of the AUC value. In other words, if one uses Equation 2 and AUC as the dependent measure for temporal discounting, it is possible that the *delay effect* may get masked.

Variations in Temporal Discounting Methodology and Interpretation

As noted above, the meaningfulness of the relationship between temporal discounting and gambling has been driven by the finding that rates of discounting have been shown to differ as a function of gambling status (e.g., Dixon et al., 2003, 2006). These studies have found greater rates of temporal discounting in gamblers than in non gamblers. However, it is worth noting that the opposite finding has also been reported (Holt, Green, & Myerson, 2003).

One issue that has not received much, if any, research attention is the commodity that the participants in these studies are asked to discount. The commodity in these studies, and most studies of temporal discounting in general, is a hypothetical amount of money. Two questions can be asked about this particular commodity. First, is discounting of this particular commodity indicative of an individual's temporal discounting of all commodities? Second, if the answer to the first question is "no," then is it the best commodity to use in such studies?

The answer to the first question does indeed appear to be "no." Recent research from our laboratory has asked just such a question. Weatherly, Terrell, and Derenne (2010) had 648 college students complete a temporal-discounting task that included five commodities. There were two sets of commodities (two monetary values, cigarettes, a dating partner, & one's own body image or two monetary values, retirement income, medical treatment, and federal education legislation). For both data sets, two outcomes were observed. First, significant differences in rates of discounting were observed across the five commodities (AUC was the dependent measure because Equation 1 provided a poor fit to the data). Second, a factor analysis of each data set resulted in a two-factor solution. Germane to the present topic, the monetary commodities loaded on to one of the factors while other commodities loaded on to a second, independent factor. Phrased differently, results from both data sets indicated that knowing how participants discounted money did not provide the information necessary to predict how they discounted all other commodities.

Given that rates of discounting hypothetical monetary rewards are not universally predictive of an individual's rate of discounting of all commodities, is the commodity of hypothetical monetary rewards the one we should be studying? Here the research literature is relatively silent (but see Yi, Mitchell, & Bickel, 2010, for a discussion). As noted above, the majority of studies on discounting have used this particular commodity. One could ask whether temporal discounting of hypothetical monetary rewards is similar to temporal discounting of real monetary rewards. Although it is impractical to use real monetary rewards of the size typically used in studies that employ hypothetical ones (e.g., $1,000) or use the same time delays (e.g., 10 years), research that has attempted to compare discounting of real and hypothetical monetary rewards have found similar rates of discounting between the two (e.g., Dixon, Mui, Green, & Myerson, in press; Madden, Begotka, Raiff, & Kastern, 2003). One might assume that because gamblers gamble money, that money is the correct commodity to study. That is, however, an assumption. Future research is needed to determine if temporal discounting of other commodities might be just as strongly, if not more strongly, associated with gambling behavior as is that of hypothetical monetary amounts.

A related issue (and one that is beyond the scope of the present discussion) is not whether money is the correct commodity to be studying, but rather whether temporal discounting is the correct type of discounting to be studying. That is, probability and temporal discounting are two potentially distinct phenomena (see Green & Myerson, 2004). Given that gambling involves risking something of value on a probabilistic outcome, the field might be better served to pursue the potential relationship between probability discounting and gambling rather than temporal discounting and gambling (see Petry & Madden, 2010, or Weatherly & Flannery, 2008, for a discussion).

Even if the study of temporal discounting of hypothetical monetary rewards turns out to be the correct one in relationship to gambling behavior, the relationship between temporal discounting and gambling, as it stands today, is a correlational one. That is, studies that have shown a relationship between rates of temporal discounting and pathological gambling have done so in pre-existing populations (e.g., pathological gamblers). Thus, it is not possible to tell whether changes in one's gambling behavior led to changes in temporal discounting, whether changes in temporal discounting led to changes in one's gambling behavior, or whether both phenomena are related to some third, yet unidentified, factor or process.

Now for Something Slightly Different

Dixon and Johnson (2007) proposed the GFA. The GFA is a paper-pencil measure intended to identify the contingency that is maintaining a person's gambling behavior. It was adapted from a similar measure that was designed to measure self-injurious behavior (Durand & Crimmins, 1988) and represents the first functional-assessment tool created for gambling behavior. It attempts to identify four maintaining consequences for gambling: tangible (i.e., money), social attention, sensory experience, and escape. There are 20 questions total, with five questions associated with each of the four consequences. The respondent can endorse each question from 0 (never) to 6 (always). Summing the scores of all responses gives one a total score on the GFA (maximum = 120). Summing the scores in each category is intended to identify the primary maintaining contingency (i.e, the consequence receiving the highest score; maximum = 30 for each consequence).

Miller, Meier, Muehlenkamp, and Weatherly (2009) attempted to test the validity of the GFA by giving it to 949 undergraduate students. This sample was randomly divided into two groups, one on which an exploratory factor analysis was conducted and the second on which a confirmatory factor analysis was conducted. The results of both analyses were similar. Although the GFA was designed to identify four possible maintaining contingencies for gambling, both analyses identified only two factors. Factor loadings for the individual items on the GFA grouped in a logical fashion. Those items intended to measure tangible, social attention, and sensory experience consequences tended to load on one factor, which was labeled positive reinforcement. Those items intended to measure escape loaded on the second factor, which was labeled negative reinforcement. Thus, although the GFA was designed to identify four separate contingencies, these data suggested that it, in fact, measured only two.

Further analysis of the data, however, revealed a potentially intriguing finding. If one looked at the respondents' factor scores on the two factors, a distinct linear pattern was observed for both. As one's total score on the GFA increased, one's factor one score (i.e., positive reinforcement) increased accordingly. This result was not necessarily surprising given that the majority of the questions on the GFA were related to factor one. Thus, if one scored high on the GFA overall, one would expect to see high scores on factor one. However, the same result was not observed for factor two (negative reinforcement). For both males and females in both the exploratory and confirmatory data sets, as overall scores on the GFA increased, scores on factor two tended to be zero. However, there were a number of outliers. The intriguing finding was the placement of those outliers. Participants who scored high on factor two also tended to be the individuals who scored quite high on the GFA overall. In other words, those who gambled as an escape tended to score high on the measure as a whole. Our question was whether these individuals were potentially the problem or pathological gamblers in the data set?

To test this possibility, Miller, Dixon, Parker, Kulland, and Weatherly (this issue) administered the GFA and the SOGS (Lesieur & Blume, 1987) to 204 people on the streets of Las Vegas and Wendover, Nevada and to 101 people in two sports bars in Rockford, Illinois. The SOGS is the most widely used screening measure for the potential presence of pathological gambling, with a score of 5 or more on the SOGS indicative of the potential presence of pathology. The question was whether scores in the escape category on the GFA would identify those individuals who scored 5 or more on the SOGS. Using an overall score of 8 or more in the escape category as the cutoff, the GFA correctly identified individuals scoring 5 or more on the SOGS in 20% of the cases in the Nevada sample and in over 50% of the cases in Illinois sample. Thus, although the GFA was designed to measure the consequences that maintain gambling behavior, it also appears to do a decent job as a diagnostic tool. If one scores high in the escape category of the GFA, then it would be wise to screen the person for pathological gambling.

What Does This Information Have to do With Temporal Discounting?

The data from Miller et al. (2009, this issue) suggest that, at least for a fair number of potential pathological gamblers, the contingency maintaining their gambling behavior is negative reinforcement (i.e., escape). That connection should not be overly surprising given that gambling as an escape is an official symptom of pathological gambling (American Psychiatric Association, 2003). The connection between pathological gambling, gambling as an escape, and temporal discounting, however, may not be as clear.

Research on temporal discounting has shown a finding that has come to be known as the *magnitude effect* (e.g., Chapman, 1996; Thaler, 1981). Specifically, the greater the size or value of the full commodity, the less participants/subjects tend to discount it when it is delayed. For example, you might be willing to accept $900 today rather than waiting one year for $1,000. However, you might be unwilling to accept $90,000 today and instead wait a year to get $100,000. Thus, although the rate of discounting in the former example is at least 10% over a year, when the magnitude of the commodity is increased (i.e., the latter example) the discounting rate is less than 10%. For this reason, rates of temporal discounting have also been used as a means for measuring the subjective value of a particular commodity (e.g., Weatherly, Derenne, & Terrell, 2010).

If problem and pathological gamblers differ from their non-problem and non-pathological counterparts in the reason why they are gambling, then finding differences in how they temporally discount money would be expected. That is, if someone is gambling for a reason other than winning money, then it would seem to be a reasonable assumption that winning money holds less subjective value for this person than it does for someone who is gambling for monetary gain. Likewise, if monetary gain holds less value for this individual than it does for another, one would expect a greater rate of temporal discounting for hypothetical monetary rewards for this individual than for another.

Thus, is there a relationship between gambling and temporal discounting? The answer is likely "yes." Is it a meaningful relationship? The answer to that question is less clear. For some individuals, it might indeed be a meaningful relationship. However, for others, the relationship may be the outcome of a third, independent factor or process. That is, pathological gamblers do not hold in high value (at least relative to non-pathological gamblers) the commodity that researchers are using in their studies of temporal discounting.

PREDICTIONS

The present idea would seem to be consistent with existing data. Clearly, however, its predictions need to be tested before it is accepted. Below three predictions are outlined that could potentially support or disconfirm the argument made in the present paper.

First, gambling behavior should be related to one's escape score on the GFA. As noted above, Weatherly, Marino, Ferraro, and Slagle (2008) demonstrated that participants' gambling on a slot machine was predicted by their rate of temporal discounting. They did not specifically test, however, whether escape scores on the GFA were equally or more predictive. If rates of temporal discounting by pathological gamblers are being lowered indirectly because they are gambling as an escape, then it would be reasonable to predict that rates and levels of gambling would be at least as, if not more highly, correlated with escape scores on the GFA than with rates of temporal discounting.

Second, pathological gamblers will not always display greater rates of temporal discounting than non gamblers. The current argument is that most studies of temporal discounting have employed hypothetical monetary amounts as the commodity and this commodity might have a lowered value for pathological gamblers if they are indeed gambling as an escape. If this argument is correct, a temporal-discounting study that employs a commodity that potentially serves as an escape (e.g., winning a video game or a trip to a theme park, both of which could provide competing forms of escape) may find that pathological gamblers discount that commodity *less* than non gamblers because that commodity would hold a greater subjective value to them than for non gamblers.

Third, for individuals whose pathological gambling is maintained by escape, therapies that involve finding alternative mechanisms to achieve that escape may prove successful in treating their gambling. However, if that is the case, you would not necessarily expect to eliminate the difference observed between that person's temporal discounting of hypothetical monetary rewards relative to his/her non-pathological counterpart because finding an alternative escape contingency would not address/alter the subjective value of money for that person.

CONCLUSION

Is the relationship between temporal discounting and gambling a meaningful one? It may be. Certainly, there are many researchers out there, including myself (e.g., Weatherly & Dixon, 2007), who have argued that it is. However, the results are not universally supportive of the idea, our techniques for studying temporal discounting have not been perfected or extensively explored, and it remains to be determined whether we are even pursuing the correct type of discounting when it comes to studying gambling. Furthermore, I have attempted to outline a scenario in which the relationship between temporal discounting and gambling is related to a third factor or process. With all of the emphasis one can find on temporal discounting in the literature today, the field would be sage to give at least as much attention to the possibility that the relationship is perhaps less meaningful than once thought as it does to the possibility that the relationship is in fact a meaningful one.

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