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ORIGINAL PAPER

Examining DSM-IV Criteria for Pathological Gambling: Psychometric Properties and Evidence from Cognitive Biases

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Abstract We examined the DSM-IV criteria for pathological gambling as assessed with the DSM-IV-based Diagnostic Interview for Gambling Severity (DIGS; Winters, Specker, & Stinchfield, 2002). We first analyzed the psychometric properties of the DIGS, and then assessed the extent to which performance on two judgment and decision-making tasks, the Georgia Gambling Task (Goodie, 2003) and the Iowa Gambling Task (Bechara, Damasio, Damasio, & Anderson, 1994), related to higher reports of gambling pathology. In a sample of frequent gamblers, we found strong psychometric support for the DSM-IV conception of pathological gambling as measured by the DIGS, predictive relationships between DIGS scores and all cognitive performance measures, and significant differences in performance measures between individuals with and without pathological gambling. Analyses using suggested revisions to the pathological gambling threshold (Stinchfield, 2003) revealed that individuals meeting four of the DSM-IV criteria aligned significantly more with pathological gamblers than with non-pathological gamblers, supporting the suggested change in the cutoff score from five to four symptoms. Discussion focuses on the validity of the DSM-IV criteria as assessed by the DIGS and the role of cognitive biases in pathological gambling.

Keywords Pathological gambling · DSM-IV criteria · Georgia Gambling Task · Iowa Gambling Task · Overconfidence

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Introduction

For some time, there has been a divergence between research and clinical practice in how pathological gambling (PG) is conceptualized and measured. In clinical application, the diagnosis first appeared in the DSM-III (APA, 1980), and it has been developed further in subsequent DSM editions. Empirical research, however, has relied more heavily on prominent measures such as the South Oaks Gambling Screen (SOGS; Lesieur & Blume, 1987), which do not comport directly with the standards established in the various editions of DSM. Even though the list of DSM-IV PG criteria is not exhaustive of all possible symptoms (Lesieur & Rosenthal, 1991), and these criteria are imperfect standards of gambling pathology, they have advantages over the SOGS, such as a higher degree of classification accuracy for treatment-seeking pathological gamblers (Stinchfield, 2002, 2003; Stinchfield, Govoni, & Frisch, 2005). Despite criticisms of the SOGS (e.g., Ladouceur et al., 2000; Stinchfield, 2002), it has proven a useful tool in PG research. Perhaps as a consequence of the utility of the SOGS, though, relatively little empirical research has addressed the specific DSM-IV diagnostic criteria. This situation has begun to change in recent years (e.g., Ladouceur, Ferland, Poulin, Vitaro, & Wiebe, 2005; Stinchfield, 2003), but a research-based understanding of the performance of the DSM-IV criteria remains incomplete.

As such, we had three purposes in the current research. First, we sought to analyze the psychometric properties, including the reliability and construct validity, of the Diagnostic Interview for Gambling Severity (DIGS; Winters et al., 2002), a screen with questions adapted directly from the DSM-IV criteria for PG. Second, we extended the validity evaluation of the DSM-IV criteria by examining the extent to which PG symptom scores related to performance on two judgment and decision-making tasks, the Georgia Gambling Task (GGT; Goodie, 2003) and the Iowa Gambling Task (IGT; Bechara et al., 1994). Finally, we sought to contribute to the discussion of possible revisions to the pathological gambling threshold (Stinchfield, 2003) by examining the score at which increased cognitive biases that are characteristic of gambling-related pathology are evident.

Psychometric Properties of the DSM-IV Criteria for PG

To date, psychometric examinations of PG measures based on the DSM-IV criteria have been generally favorable. Stinchfield (2003), for example, reported a reliability (Cronbach's [1951] α) of .98 for a DSM-IV-based PG measure, which is more than adequate by the standards that prevail in the field (Nunnaly, 1978). Empirical research also has revealed some support for a single-factor structure encompassing the ten criteria (Stinchfield et al., 2005; Winters et al., 2002). There are, however, notable exceptions to this. For example, using the DSM-IV-based NORC Diagnostic Screen (NODS), Toce-Gerstein, Gerstein, and Volberg (2003) found that chasing loaded onto its own factor. However, these examinations of the factor structure of measures designed to assess the DSM-IV criteria have been limited to principal components analyses, which are generally suitable for exploratory research. Given that empirical support for the concept of PG is well accepted, a necessary next step is to subject DSM-IV-based data to a confirmatory factor analysis (CFA). This is appropriate in light of the established theoretical framework concerning PG, and beneficial because there is less subjective interpretation of factor structures (Lance & Vandenberg, 2002; Vandenberg & Lance, 2000). Accordingly, one purpose of the current research is to examine the psychometric properties of the DIGS items as a measure of the DSM-IV criteria using a CFA, the use of which affords the opportunity to assess the extent to which the interrelationships among the DSM-IV criteria are dependent upon the latent construct of PG, in a theory based, deductive manner.

Issues of Diagnostic Criteria

A discussion is also underway regarding the most useful diagnostic threshold for gambling-related pathology. The current DSM-IV (APA, 2000) standard is that if five or more out of 10 specified symptoms are evident, the diagnosis of PG is assigned; otherwise, no diagnosis is given. Researchers have proposed possible revisions to this current standard, however. For example, upon finding a considerable increase in classification accuracy between treatment-seeking and non-treatment-seeking gamblers, Stinchfield (2003) concluded that the cutoff criterion for the PG diagnosis could be reduced from five symptoms to four. Importantly, Stinchfield's findings also align with recommendations put forth by Impulse Control Disorders subcommittee (Bradford, Geller, Lesieur, Rosenthal, & Wise, 1996; Lesieur & Rosenthal, 1998).

Others have expressed the need for additional diagnostic categories beyond the current dichotomous system. Shaffer and Hall (1996), for example, noted that individuals meeting 1–4 PG criteria are still experiencing gambling-related problems, and suggested the sub-threshold diagnostic label *level-2 gamblers*. In this vein, Toce-Gerstein et al. (2003) bisected the dichotomous categories of 1–4 and 5–10, and distinguished among five discriminant categories of scores: 0, 1–2, 3–4, 5–7, and 8–10. Although not especially parsimonious, this type of taxonomy may best reflect the continuous nature of gambling involvement. It also points to a fundamentally altered conceptualization of gambling pathology that is continuous rather than discrete.

Underlying Cognitive Dimensions of PG

In addition to diagnostic criteria and other clinical symptoms associated with PG, a comprehensive understanding of PG requires knowledge concerning the basic mental processes that contribute to it. For example, examinations of cognitive biases exhibited with various numbers of symptoms could provide relevant information to the discussion of thresholds in assessing gambling pathology. Although cognitive biases are not themselves symptoms of gambling pathology, they are widely acknowledged to contribute to various PG symptoms and to PG as a whole (e.g., Bechara, 2001; Ladouceur, 2004; Ladouceur et al., 2003; Petry, 2005; Raylu & Oei, 2002, 2004; Toneatto, 1999; Toneatto, Blitz-Miller, Calderwood, Dragonetti, & Tsanos, 1997; Toneatto & Ladouceur, 2003; Toneatto & Millar, 2004). For example, building on research showing that addictive disorders are marked by a myopic focus on immediate reward leading to insensitivity for future consequences, Bechara (2001) proposed that performance on the IGT is likely related to PG. A sizable roster of cognitive illusions occurs more frequently among probable pathological gamblers than among social gamblers (Baboushkin, Hardoon, Derevensky, & Gupta, 2001). Among these, the illusion of control, and a belief that luck, perseverance or both will eventually lead to winning (Steenbergh, Meyers, May, & Whelan, 2002) may be especially relevant to developing gambling-related pathology (Raylu & Oei, 2002, 2004; Toneatto, 1999). Indeed, Ladouceur and colleagues (e.g., Ladouceur, 2004; Ladouceur et al., 2003; Toneatto & Ladouceur, 2003) report extensive evidence in support of the conclusion that judgmental biases, such as the degree of belief in one's erroneous perceptions while gambling, are pivotal variables in determining the severity of gambling outcomes.

Moreover, Goodie and colleagues (e.g., Camchong, Goodie, & McDowell, in press; Goodie, 2005; Lakey, Goodie, & Campbell, in press) provide evidence that gambling pathology is associated with overconfidence, risk seeking, and diminished discrimination between bets on events over which one has or does not have control, in studies using the GGT and IGT. For example, in a sample of frequent poker and other card players, Lakey et al. (in press) found that biases concerning overconfidence, propensities for accepting risky bets, and a myopic focus on reward all related to higher degrees of gambling-related pathology, independently of each other and of card playing frequency. Although Lakey et al.'s reliance on frequent card players limits the generalizability of their findings to all gamblers, their results nonetheless suggest that performance on the GGT and IGT, and the judgmental and risk-taking biases these tasks assess, are important to PG. Accordingly, we use these two measures in the current study in order to examine the extent to which cognitive biases are associated with varying degrees of gambling pathology.

The Current Research

In order to further the research-based understanding of the DSM-IV criteria for PG, in the current study we first analyze the psychometric properties of the DIGS as a measure of the DSM-IV criteria. Second, in an effort to understand more fully the relation between cognitive biases and PG, we relate frequent gamblers' performance on basic measures of judgment and decision-making, as assessed with the GGT and IGT, to their gambling problems, as measured by the DIGS. Finally, we draw from evidence regarding cognitive biases to contribute to the discussion of the optimal placement of the cutoff score for PG diagnoses.

Method

Participants

Participants (N = 660) were students at the University of Georgia, who completed this study for partial fulfillment of psychology course research requirements. All participants responded to a recruiting message seeking individuals who gamble frequently. Participants in this sample have a variety of opportunities to gamble including (but not limited to) state-sanctioned draw and scratchcard lotteries, access to local poker and other card games, and internet gambling sites, and they reside within relatively short-driving distance of casinos. Two hundred and two of the participants (30.6%) were female, and 458 were male (69.4%). Their ages ranged from 18 to 28 (M = 19.23 years, SD = 1.32). This sample was 88.3% Caucasian. It also included 5.0% who identified as Black or African American, 3.9% as Asian or Asian American, and 2.7% as Hispanic or Latino.

Measures

Diagnostic Interview for Gambling Severity (DIGS; Winters et al., 2002)

In the current study, we assessed participants' levels of PG with the DIGS, which is a screen for pathological gambling. The benefit of this measure is that the assessment of gambling-related pathology is accomplished with direct reference to DSM-IV symptoms. The DIGS includes two questions relating to each classification criterion. For example, the two items concerning sensation seeking through gambling participation include ''*Have you had periods when you needed to increase your frequency of betting in order to obtain the same excitement*?'', and ''*Have you ever needed to gamble with increasing amounts of money or with larger bets in order to obtain the same feeling of excitement*?''. Following the common structure of psychiatric diagnostic interviews, participants assign responses to one of three prompts (*Very True*, *Somewhat True*, *and False*). We assigned a point towards a total gambling-related pathology score for a response of *Very True* or *Somewhat True* for either or both of the two questions referencing a particular DSM-IV criterion, with possible scores ranging from 0 to 10.

The DIGS also includes questions concerning the frequency with which participants engage in eleven specific gambling modalities (e.g., *Bowled, shot pool, or played golf for money?*; *Bet on the outcome of a sporting event?*). These items refer to gambling activity in the past year, and participants respond using a 5-point scale (ranging from *None At All* to *Daily*). We attributed a literal value to these responses and converted them to yearly gambling experiences (e.g., *Daily* = 365). We summed the values for each modality so that higher totals reflect greater total gambling frequency. Prior research also demonstrates considerable differences in gambling frequency between recreational gamblers and those seeking treatment, with treatment-seeking individuals markedly more likely to gamble at least weekly (Stinchfield & Winters, 2001; see also Productivity Commission, 1999). Accordingly, we coded as frequent gambling modalities those items to which participants indicated gambling at least *weekly*. We summed these values as well so that higher totals reflect participation in a larger number of frequent gambling activities.

Georgia Gambling Task (GGT; Goodie, 2003)

The GGT is designed to assess both overconfidence and risk taking. It begins with a confidence calibration task (Fischhoff, Slovic, & Lichtenstein, 1977) in which participants answer two-alternative general knowledge questions and then assess their confidence in each answer using a 7-point scale (ranging from *50–52%* to *98–100%*). Confidence is assessed such that, for example, among answers in which a participant expresses 80% confidence, 80 out of every 100 should turn out to be correct. If this is achieved, the average confidence over all trials equals the proportion of questions answered correctly. Overconfidence is calculated as the difference between average confidence and overall accuracy over all trials (which equals zero in the case of idealized calibration). In the second phase of the GGT, participants are offered a bet for points on each answer, which has zero expected value if participants' confidence was well-calibrated (i.e., confidence equal to accuracy), negative expected value if participants were overconfident (i.e., confidence greater than accuracy), or positive expected value if participants were underconfident (i.e., confidence less than accuracy). Overconfidence most often prevails, so that more betting usually implies fewer points won. In sum, two factors contribute to lower point totals in the GGT: overconfidence and greater bet acceptance. Accordingly, we obtained three performance measures from the GGT: overconfidence, bet acceptance, and total points. Overconfidence, bet acceptance, and points earned on the GGT all have been related to gambling pathology among non-treatment-seeking college students (Goodie, 2005) as well as frequent poker and other card players (Lakey et al., in press).

Iowa Gambling Task (IGT; Bechara et al., 1994)

Bechara et al. (1994) designed the IGT to assess myopic focus on gambling-related wins. The IGT is a contingency card choice task with four simulated decks of cards from which to choose. There are 100 total trials, divided into five blocks of 20 trials. Each choice results in a simulated monetary gain, or a monetary gain coupled with a loss. Two of the decks provide large wins, which sometimes are accompanied by even larger losses, resulting in a negative expected value. The other two decks are both less risky and more advantageous in that they provide smaller gains that are coupled intermittently with even smaller losses, resulting in a positive expected value. Initially, Bechara et al. (1994) found that patients with damage to their ventromedial prefrontal cortex displayed continual maladaptive choices from the bad decks, in contrast with non-lesioned controls who learned over the course of the task to avoid those decks. This area of the prefrontal cortex allows for successful somatic feedback resulting from a large loss, which among non-lesioned participants serves to preclude future behaviors that would elicit similar aversive responses (Bechara, Damasio, Tranel, & Damasio, 1997; Bechara, Damasio, & Damasio, 2000a; Bechara, Tranel, & Damasio, 2000b). Accordingly, normal populations typically choose the bad decks to a considerable degree in early blocks, but then learn predominantly to avoid the risky decks in later blocks. Populations such as frontal lobe lesion patients, on the other hand, begin with comparably high levels of bad choices in the early blocks, and perseverate in choosing from the less advantageous decks in later blocks. Because the early trials are considered learning stages during which all populations respond similarly, in the current investigation, we used the total number of times that participants chose from the risky decks in the final three blocks of 20 trials (i.e., Blocks 3, 4, and 5) as the primary variables of interest from this measure. We also examined the total number of times participants chose from the risky decks over all 100 trials as a secondary measure of performance on this task, as the aggregation of suboptimal decisions can compound to yield adverse effects. The IGT has been used to identify similar indiscriminate focus on reward among individuals showing risky behaviors, including substance addicted patients (Bechara & Damasio, 2002; Bechara, Dolan, & Hindes, 2002), HIV patients who contracted the disease through intravenous drug use or risky sexual behaviors (Hardy, Hinkin, Levine, Castellon, & Lam 2006), and frequent card players (Lakey et al., in press).

Procedure

After providing informed consent, all participants completed a basic demographic questionnaire assessing their age, gender, and ethnicity, and the DIGS (Winters et al., 2002). Next, we administered the GGT (Goodie, 2003) and IGT (Bechara et al., 1994) in counterbalanced order across participants via computer. After completion of these measures, we fully debriefed and thanked all participants for their participation.

Data Analysis Overview

We explored the DSM-IV PG criteria in three ways. First, we assessed the psychometric properties of the DIGS as a measure of the DSM-IV criteria, including examinations of its reliability and its factor structure using a CFA. These analyses support inferences regarding the reliability and factorial validity of the DIGS as a measure of the diagnostic criteria and the unitary construct of gambling pathology. Second, we sought to relate performance on basic cognitive measures of judgment and decision-making reflected in the GGT and IGT to gambling pathology more rigorously than has been done in prior studies. We accomplished this by relating judgmental biases to DIGS scores and gambling frequency variables. We also analyzed the relationships between DIGS scores and judgmental biases using the dichotomous (i.e., presence or absence of PG) diagnostic categories of DSM-IV. Finally, to obtain evidence regarding the optimal placement of the PG cutoff, we examined the pattern of cognitive biases exhibited by participants with the pivotal DIGS scores of three, four, and five, searching for evidence to bear on the discussion of whether four or five is the most appropriate cutoff score for the diagnosis of PG.

Results

Descriptive Statistics

Descriptive statistics and correlations are found in Table 1. Among these gamblers, 275 (41.7%) did not participate in any single gambling modality weekly or more frequently; 306 (46.4%) participated in 1 or 2 gambling modalities at least weekly; and 79 (11.9%) participated in more than two gambling modalities at least weekly. The mean DIGS score among these frequent gamblers was 3.70 ($SD = 2.42$). Seventy-two (10.9%) had a DIGS score of 0; 146 (22.1%) scored 1–2; 220 (33.3%) scored 3–4; 167 (25.3%) scored 5–7; and 55 (8.3%) scored 8–10. Hence, and as can be seen in Table 2, we obtained a robust range of degrees of gambling involvement and gambling problems. Males' ($N = 458$; $M = 3.80$, $SD = 2.32$) and females' ($N = 202$; $M = 3.50$, $SD = 2.61$) average DIGS scores were not significantly different ($t(658) = 1.41$, $p > .05$).

Psychometric Analyses

Reliability Analyses

Cronbach's (1951) alpha (α) for the 20 DIGS items was .90. Thus, the DIGS items displayed adequate internal consistency. We also examined the reliability of the ten DSM-IV PG criteria, which was again favorable ($\alpha = .80$). Taken together, both the DSM-IV criteria and the items employed by the DIGS to derive these criteria are reliable indicators of gambling involvement and problems.

Confirmatory Factor Analysis

We used LISREL 8.72 (Jöreskog & Sörbom, 2005) to test three alternative CFA models of interrelationship among the DIGS items, which appear in Fig. 1. Because the DIGS is structured to include two items for each of the ten DSM-IV criteria, Model A (Fig. 1a) was a 10-factor model in which each DIGS item was specified as loading on a first-order factor (FOF) that represented its corresponding DSM-IV criterion. As these criteria are correlated, the correlations among these FOFs were freely estimated. Model B (Fig. 1b) proposed that the correlations among the FOFs in Model A could be accounted for by their common dependency on a second-order factor (SOF), conceptualized as a generalized

Table 1 Correlations among DIGS scores, IGT and GGT performance, and gambling frequency variables

Measure	1	2	3	4	5	6	7	8	9	10
1. DIGS total	—									
2. IGT: Block 3	.17**	—								
3. IGT: Block 4	.22**	.69**	—							
4. IGT: Block 5	.23**	.55**	.72**	—						
5. IGT: total	.23**	.80**	.86**	.83**	—					
6. GGT: overconfidence	.18**	.11**	.11**	.10**	.15**	—				
7. GGT: bet acceptance	.20**	.12**	.14**	.09*	.15**	.08*	—			
8. GGT: points	−.23**	−.16**	−.17**	−.11**	−.17**	−.56**	−.31**	—		
9. Frequency total	.36**	.01	.02	.04	.05	.05	.16**	−.06	—	
10. Modalities total	.36**	.04	.01	.05	.03	.03	.19**	−.13**	.62**	—
Mean	3.70	7.28	7.33	7.24	42.82	.06	.63	−25,050	119.90	.99
SD	2.42	4.58	5.60	5.70	16.38	.07	.15	23,467	137.94	1.13

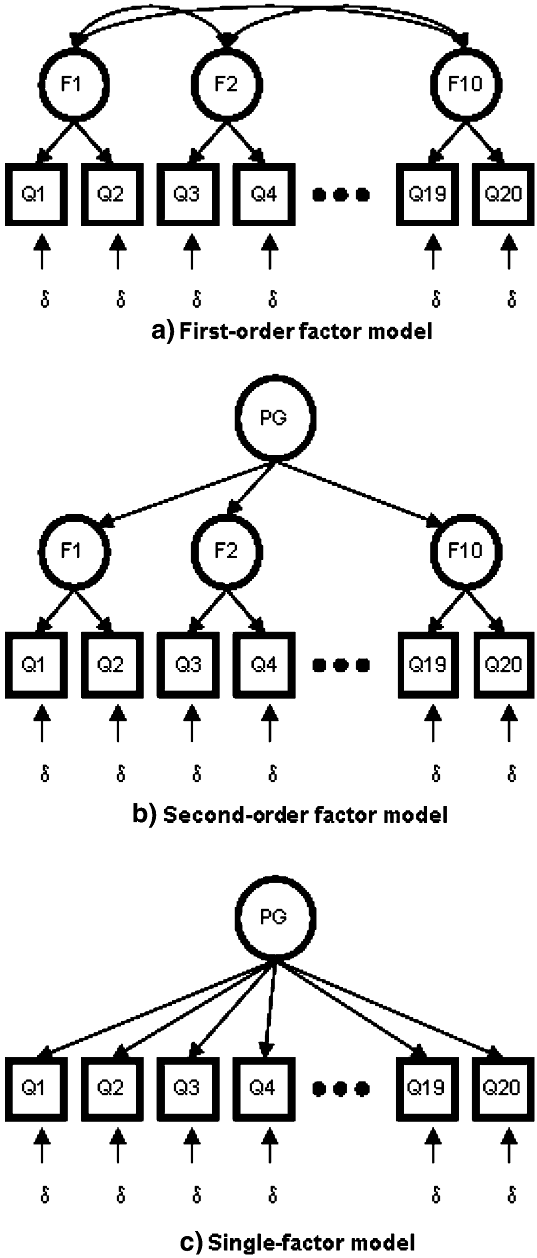
Note. DIGS = Diagnostic Interview for Gambling Severity; IGT = Iowa Gambling Task risky decks chosen; GGT = Georgia Gambling Task; Frequency total = total frequency of gambling experiences reported for the previous year; Modalities total = number of gambling modalities in which participants gambled at least weekly

*$p < .05$, **$p < .01$

Table 2 Frequency of gambling participation by the specific gambling modality based on DIGS score

	DIGS PG score											
	All	0	1	2	3	4	5	6	7	8	9	10
N Total	660	72	56	90	110	110	69	58	40	35	14	6
% of Total	100%	10.9%	8.5%	13.6%	16.7%	16.7%	10.5%	8.8%	6.1%	5.3%	2.1%	.9%
Participates in gambling modality at least weekly												
Cards with friends	243	7	18	28	39	44	19	33	23	18	8	6
Sports betting	177	5	12	35	25	39	19	13	12	19	5	3
Non-card betting (e.g., bowling)	101	1	4	8	12	23	9	13	16	11	2	2
Lottery	77	1	3	3	11	16	12	13	11	4	2	1
Slots	19	1	–	–	2	1	5	2	3	3	2	–
Dice 13	–	–	–	–	6	–	3	2	1	–	1	
Bingo	6	–	–	–	–	–	–	–	4	1	–	1
Stocks	6	–	–	–	1	4	–	–	–	–	–	1
Cards at a casino	6	–	–	–	–	–	2	3	1	–	–	–
Animal betting	5	1	–	–	1	–	–	–	1	2	–	–
Tabs	4	–	–	–	–	–	1	2	–	1	–	–
Number of frequent gambling activities at least weekly												
0	275	60	32	33	51	38	29	17	6	6	3	–
1 or 2	306	11	24	51	51	49	32	33	21	21	9	4
3 or more	79	1	–	6	8	23	8	8	13	8	2	2

Fig. 1 Pathological gambling models tested using confirmatory factor analyses of the DSM-IV criteria as assessed by the DIGS



gambling pathology factor. Finally, Model C (Fig. 1c) proposed only a generalized gambling behaviors factor, which in effect represents the idea that while the DIGS items indeed measure gambling problems, the ten DSM-IV criteria are not clearly differentiated or distinct from one another.

CFA results in Table 3 show that although the chi-square (χ^2) statistic for Model A was statistically significant, all other goodness-of-fit indices (GFIs) surpassed accepted criteria

Table 3 CFA model goodness-of-fit

Model	*df*	χ^2	SRMSR	RMSEA	CFI	TLI	χ^2/df	RFI
1 First-order factor: Model A	125	342.18*	.034	.049	.98	.96	2.74	–
1 vs. 2	35	201.90*	–	–	–	–	–	.99
2. Second-order factor: Model B	160	544.08*	.050	.059	.96	.95	3.40	–
1 vs. 3	45	864.10*	–	–	–	–	–	.91
3. Single factor: Model C	170	1206.28*	.071	.097	.89	.87	7.09	–

Note. *df* = model degrees of freedom; SRMSR = standardized root mean squared residual; RMSEA = root mean squared error of approximation; CFI = comparative fit index; TLI = Tucker-Lewis index; RFI = relative fit index. $^*p < .05$

for good model fit, even the more stringent standards suggested recently by Hu and Bentler (1998, 1999; i.e., SRMSR $\leq .08$; RMSEA $\leq .06$; CFI and TLI $\geq .95$). Results for Model B indicate that while its χ^2 statistic was also significant, it too fit the data very well. As Model B is a special case of (i.e., nested within) Model A, performing a $\Delta\chi^2$ test of the difference in overall fit of these models to the data is appropriate. This reflects a test of whether the more parsimonious Model B incurs a significant worsening in model fit, or whether it fits the data (nearly) as well as the less parsimonious Model A. As Table 3 shows, the $\Delta\chi^2$ was statistically significant, which provides an argument that, at least from one statistical standpoint, Model A fits better than Model B. However, there are four equally potent arguments that Model B is the preferred model. First, the overall GFIs for Model B (the more parsimonious model) are nearly identical to those of the less parsimonious Model A. Second, the relative fit index[1] (RFI), which provides a relative proportion of variance (ranging from 0 to 1) accounted for by a more parsimonious model as compared to a competing, less parsimonious model, was .99, indicating that the overall fits of Models A and B were almost identical. Third, the greater number of degrees-of-freedom for Model B indicates that it is more parsimonious than Model A, and is thus the preferable model given that the two models provide functionally equivalent explanatory power. Finally, from a theoretical and practical standpoint, Model B provides empirical confirmation that these DSM-IV criteria, as measured by the DIGS, are all dependent upon their relation to the superordinate PG second order factor.

Model C also is nested within Model A, and represents a test of the hypothesis that the 20 DIGS items load directly onto a second-order generalized gambling behavior factor, without regard to their representation on each of the DSV-IV criteria posited by Model A (and Model B). Thus, a comparison between Model A and Model C tests the validity of the 10 factors representing the DSM-IV criteria posited by Model A. The GFIs for Model C reported in Table 3 indicate that it provided a poor fit to the data. In addition, the $\Delta\chi^2$ comparing Model C's fit to that of Model A was statistically significant, and the lower RFI (.91) indicates that Model C provided a significantly worsening in fit to the data as well.

Collectively, these analyses support Model B, which simultaneously gives credence to the validity of the DIGS as a measure of the ten DSM-IV criterion factors, and attests to the validity of the DSM-IV conception of PG in showing that the interrelationships among these 10 factors are summarized parsimoniously as loading on a generalized PG factor

[1] We computed RFI as $\mathrm{RFI} = 1 - \frac{\chi^2_{\mathrm{Restricted}}/df_{\mathrm{Restricted}} - \chi^2_{\mathrm{Unrestricted}}/df_{\mathrm{Unrestricted}}}{\chi^2_{\mathrm{Null}}/df_{\mathrm{Null}} - \chi^2_{\mathrm{Unrestricted}}/df_{\mathrm{Unrestricted}}}$, where χ^2 refers to the maximum likelihood χ^2 statistic, *df* = model degrees of freedom, ''restricted'' refers to the more restricted model under comparison (e.g., Model 2), ''unrestricted'' refers to the less restrictive model (e.g., Model 1), and ''null'' refers to the null model.

without compromising model fit or explanatory power. Stated differently, Model B supports the conclusions that the ten DSM-IV criteria as assessed by the DIGS are distinct from one another (as Model A does), but also shows that it is legitimate to combine these items together to capture an overall PG score. Model B's estimates of the loadings of the DIGS items on the ten FOFs were high ($M = .68$, $SD = .11$) as were the loadings of the FOFs on the SOF ($M = .77$, $SD = .15$).[2]

Cognitive Biases and DSM-IV Criteria Analyses

The results showing the seven cognitive performance criteria from the GGT and IGT as a function of DIGS scores are presented in Figs. 2 and 3. We analyzed these data in three ways. We first assessed the correlations among DIGS, performance criteria, gambling frequency, and gambling modalities. Then, we examined differences between pathological and non-pathological gambling groups using currently accepted DSM-IV cutoff criteria. Finally, we addressed whether a cutoff score of five or four better discriminates among levels of cognitive biases.

Analysis 1—Correlations Among the DIGS, Cognitive Performance Measures, and Gambling Variables

There was a significant correlation between DIGS scores and all seven cognitive performance measures and the two measures of gambling behavior, in the direction of worse cognitive performance and more frequent gambling behavior for individuals scoring higher on the DIGS. More specifically, in the GGT, DIGS scores correlated directly with both overconfidence ($r = .18$, $p < .01$) and bet acceptance ($r = .20$, $p < .01$), and inversely with total points earned ($r = -.23$, $p < .01$). In the IGT, DIGS scores significantly correlated with the number of risky deck choices in each block of interest (Block 3: $r = .17$, $p < .01$; Block 4: $r = .22$, $p < .01$; Block 5: $r = .23$, $p < .01$). The increasing correlations observed across blocks of the IGT are consistent with the increasing differences typically observed between normal and clinical populations as learning takes place. DIGS scores also correlated with the overall total of risky deck choices on the IGT ($r = .23$, $p < .01$). Finally, DIGS scores related to greater gambling frequency ($r = .36$, $p < .01$), as well as the number of modalities in which participants reported gambling at least weekly ($r = .36$, $p < .01$). Thus, individuals reporting greater gambling-related problems report more frequent gambling, as well as engaging frequently in more types of gambling activities.

Analysis 2—Differences between Pathological and Non-pathological Gambling Groups

We next dichotomized DIGS scores according to their DSM-IV classifications, with scores of 0–4 representing non-pathological gambling and 5–10 representing pathological gambling. These tests provided support for the current DSM-IV cutoff, as non-pathological gamblers were significantly closer to optimal responding than pathological gamblers on all seven cognitive performance measures. Indeed, as can be seen in Table 4, pathological gamblers were more overconfident, accepted more risky bets, and scored fewer points on

[2] Following recommended practice (James, Demaree, & Mulaik, 1986), we converted factor loadings to z-scores, averaged them, and then backtransformed the M and SD of the zs to the loadings reported here. Complete CFA results are available from the 3rd author.

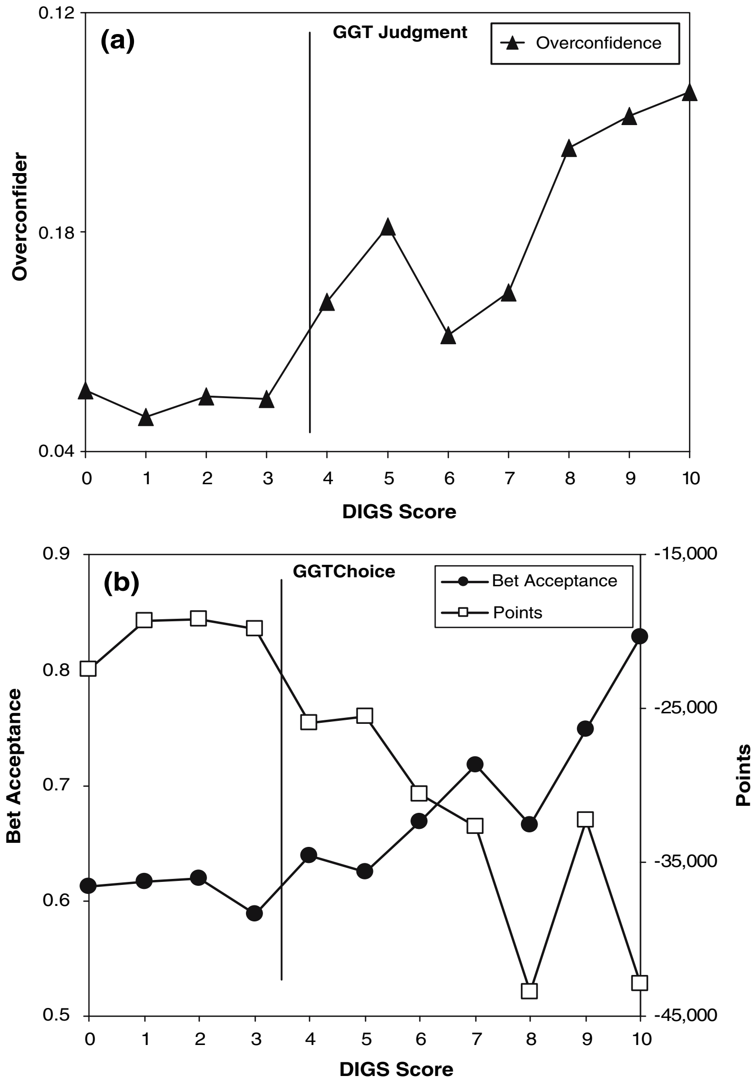


Fig. 2 Average performance at each level of PG on (**a**) GGT Overconfidence, and (**b**) GGT Bet acceptance and total points earned

the GGT (all *t*s(658) $\geq$ 4.20, *p*s < .01). Pathological gamblers also chose more from the less advantageous decks in Block 3, Block 4, Block 5, and in the aggregate (all *t*s(658) $\geq$ 3.38, *p*s < .01). Finally, individuals with PG also reported gambling more frequently as well as engaging in more gambling modalities frequently (both *t*s(658) $\geq$ 6.67, *p*s < .01), which provides an empirical, ''real-world'' check of the differences in gambling involvement between pathological and non-pathological gamblers.

Following the precedent of Stinchfield (2003) and others, we repeated these dichotomous analyses using a DIGS score of four, rather than five, as the cutoff. As can be seen in Table 4, gamblers endorsing more problems performed worse on all measures on the GGT

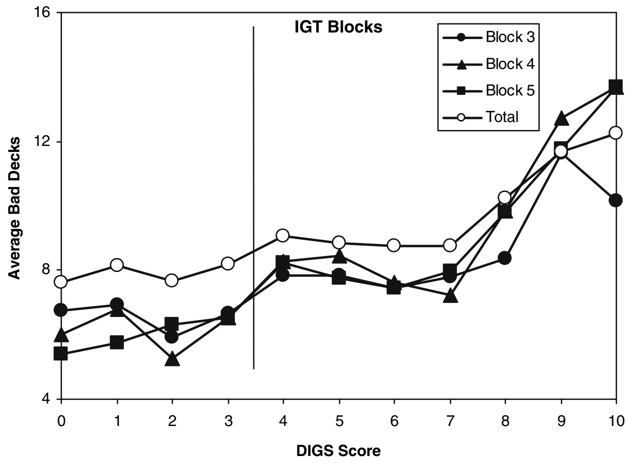


Fig. 3 Average performance at each level of PG on IGT risky deck choice at Block 3, Block 4, Block 5, and total

Table 4 Discriminant analyses of GGT and IGT performance criteria, gamblingfrequency, and gambling modalities using different cutoff scores

	Using 5–10			Using 4–10			% Change in η^2
	t	*p*	η^2	*t*	*p*	η^2	
GGT							
Overconfidence	4.20	**	.026	4.64	**	.032	23.1%
Bet acceptance	4.66	**	.032	4.66	**	.032	0.0%
Total points	5.40	**	.042	5.43	**	.043	2.4%
IGT							
Block 3	3.38	**	.017	4.27	**	.027	58.8%
Block 4	4.34	**	.028	5.62	**	.046	64.3%
Block 5	3.89	**	.022	5.23	**	.040	81.8%
Total	4.09	**	.025	5.22	**	.040	60.0%
Frequency	7.85	**	.086	8.24	**	.093	8.1%
Modalities	6.67	**	.063	8.12	**	.091	44.4%

Note. GGT = Georgia Gambling Task; IGT = Iowa Gambling Task; Frequency = frequency of gambling experiences reported for the previous year; Modalities = number of gambling modalities in which participants participated at least weekly; η^2 = variance accounted for by each variable

** $p < .01$

and IGT (ts(658) $\geq$ 4.21, ps < .01) and reported more frequent gambling and more gambling modalities (ts(658) $\geq$ 8.12, ps < .01). Moreover, the variance accounted for (eta-squared, η^2) in each measure increased by including scores of four among pathological rather than non-pathological gamblers, with the exception of GGT bet acceptance, for which variance accounted for was unchanged. These increases were relatively small in absolute magnitude, but represented considerable proportional increases. The median relative increase in variance accounted for was 44.4%.

Analysis 3—Judgmental Biases, Gambling Frequency, and Cutoff Analyses Using the DSM-IV Criterion Count

For each of the seven performance criteria from the GGT and IGT, as well as the two frequency variables, we examined the average change from each DIGS score to the next. In considering whether four or five represents the better cutoff score, the important question is whether individuals scoring four are more similar to those scoring three, or to those scoring five. Consequently, we performed *t*-tests between individuals scoring three ($N = 110$) and those scoring four ($N = 110$), and between individuals scoring four and those scoring five ($N = 69$), on the seven GGT and IGT performance criteria as well as the total gambling frequency and frequent (i.e., weekly) modality variables.

The results are rather stark. These differences between individuals scoring three and those scoring four were statistically significant for all seven cognitive performance criteria. Specifically, the change from three to four DSM-IV criteria was associated with significantly greater overconfidence ($t(218) = 2.15$, $p < .05$) and risky bet acceptance ($t(218) = 2.41$, $p < .01$), and thus significantly lower point totals ($t(218) = 2.14$, $p < .05$). These effects on the GGT can be seen in Fig. 2. On the IGT, for which effects can be seen in Fig. 3, significant differences were observed in Block 3 ($t(218) = 1.88$, $p < .05$), Block 4 ($t(218) = 2.28$, $p < .05$) and Block 5 ($t(218) = 2.16$, $p < .05$). Total bad deck choices were also significantly different ($t(218) = 1.84$, $p < .05$). Finally, when compared to those scoring three, individuals scoring four also gambled significantly more frequently ($t(218) = 3.60$, $p < .01$) and reported engaging in a greater number of gambling modalities frequently ($t(218) = 2.63$, $p < .01$).

These results stand in marked contrast to analyses between individuals scoring four and those scoring five. On six out of the nine comparisons, individuals scoring five actually performed more optimally than those scoring four; on the other three measures, those scoring four outperformed individuals scoring five. However, and perhaps most importantly, none of the differences were statistically significant (all ts$(177) \leq 1.50$, all ps $> .05$). Consequently, in the current discussion of whether the best cutoff in a dichotomous system is four or five, the present results suggest that the cognitive biases that accompany PG support a cutoff score of four.

Discussion

In this study, we sought to evaluate the DSM-IV PG criteria, first by assessing the psychometric properties of DIGS as a measure of these criteria, and then examining their relation to cognitive biases. Toward this end, we assessed the reliability of the DIGS and then conducted a CFA, which allowed us to ascertain the extent to which the theoretical bases of the DIGS (and the DSM-IV criteria it measures) fit well within the confines of an empirical CFA examination. We then examined the extent to which performance on two judgment and decision-making tasks, the IGT and the GGT, related to higher reports of gambling pathology. In so doing, we analyzed behavioral performance with DIGS scores as a continuous variable as well as using dichotomous diagnostic categories.

In a number of ways, the present results validate the current DSM-IV conceptualization of pathological gambling. First, the results confirm that the ten DSM-IV diagnostic criteria, as well as the items the DIGS uses to assess them, are reliable indicators of gambling problems. Moreover, the CFA results simultaneously confirm that the unitary concept of PG is reasonable, that the existing criterion symptoms adequately reflect that conception (although they are assuredly not an exhaustive list of gambling pathology symptoms), and that the DIGS instrument adequately reflects those criteria. These results also provide evidence that more severe gambling outcomes accompany more frequent gambling as well as gambling in diverse gambling modalities at least weekly. In fact, the number of modalities in which participants gambled at least weekly correlated as strongly with pathology as the overall frequency of gambling. This observation may be attributable to the relatively imprecise method of measuring overall gambling frequency that we used here. However, as noted by Stinchfield and Winters (2001), the relative frequency of gambling experiences and the number of activities in which an individual frequently engages in gambling seems to be discrete indicators of pathology, and accordingly, may prove important to differentiate (Productivity Commission, 1999). This idea merits further research.

These results also provide further evidence that gambling pathology is predicted to a significant degree by cognitive biases associated with PG. In the case of GGT measures (i.e., overconfidence, bet acceptance, and points earned), this replicates earlier findings (Goodie, 2005; Lakey et al., in press). Indeed, when compared to those without PG, individuals with PG reported significantly higher confidence assessments based on their own knowledge. Moreover, individuals with PG exhibited significantly poorer calibration between their subjective confidence and their objective accuracy, which defines greater overconfidence. When this maladaptive judgmental bias is coupled with greater risk taking, individuals with PG objectively underperformed in points earned, compared to their non-PG counterparts.

A second mechanism helping to explain the relation between cognitive biases and gambling severity was that non-PG individuals were better able to learn mixed reward and punishment contingencies on the IGT than those scoring higher on the DIGS. These results suggest that their myopic focus on reward results from a decreased consonance between their behavior and the affective consequences that are associated with it, which comes at the expense of more adaptive decision-making strategies (Bechara et al., 1994, 1997). Akin to the bet acceptance measure of the GGT, this apparent insensitivity to future consequences seems best explained as a function of the risk attitude of individuals with PG. The current findings with regard to the IGT (each of Blocks 3–5 and Total) represent some of the first empirical support for the relationship between myopic focus on reward and PG.

Importantly, these tasks (i.e., the GGT and IGT) mimic real-world risk taking in important ways, and also capture individual differences in judgmental biases and risk-taking propensities that underlie both real-world gambling and other risky behaviors (Bechara, 2001; Bechara & Damasio, 2002; Bechara et al., 2002; Goodie, 2005; Hardy et al., 2006; Yechiam, Busemeyer, Stout, & Bechara, 2005). As such, to the extent that these measures relate to gambling pathology, they should affect both gambling behavior and risky behavior in other environments, regardless of specific context, including whether money, points, or some other task goal is at stake.

Given the success of all these cognitive measures in predicting pathology on a continuous scale, it is not surprising that they also predict PG using the current DSM-IV dichotomy of PG (i.e., DIGS score of 5–10) and absence of PG (i.e., DIGS score of 0–4). Pathological gamblers performed worse than non-pathological gamblers by all seven cognitive measures. Taken together, these cognitive biases appear to undermine gamblers' adaptive behavioral regulation, allowing for the progression from gambling as a harmless pastime to developing gambling-related pathology.

Most importantly, individuals meeting four of the DSM-IV criteria consistently align with those scoring five (and higher) on all of these same judgmental measures and in overall gambling frequency and in the number of modalities in which individuals gamble at least weekly. Conversely, those scoring four do not align with individuals reporting less severe gambling outcomes (i.e., those scoring three or less on the DIGS). Stinchfield and colleagues (Stinchfield, 2003; Stinchfield et al., 2005) have reported that the DSM-IV PG cutoff score of five discriminates well between participants who seek treatment and those who come from a general, non-treatment-seeking population. However, by combining our results with those of Stinchfield (2003), three important events appear to occur with unique reliability at the transition from three criteria to four: gambling frequency significantly increases, individuals seek treatment, and the severity of cognitive biases intensifies. These effects are not observed at other DIGS score increments. Indeed, individuals scoring 0–3 do not increasingly seek treatment, do not gamble with significantly greater frequency, and do not show progressively increasing cognitive biases. Likewise, the biases evidenced by individuals meeting five DSM-IV criteria are entirely comparable with those scoring four. From the appearance of these data, there is relatively little reason to distinguish in diagnosis between individuals scoring four and those scoring five, whereas there is considerable data to distinguish between individuals scoring three and those scoring four.

Although the present data lend support to altering the cutoff score from five to four, the idea of an additional diagnosis short of pathological gambling does not receive particular support from these data. We are not arguing that individuals with sub-threshold scores are not experiencing gambling-related problems. There is, however, scant evidence in our data of cognitive differences between individuals with no gambling-related problems (i.e., those scoring 0) and those with sub-clinical problems (i.e., individuals scoring 1–3). At the other end of the spectrum, however, the approach of Toce-Gerstein et al. (2003) in bisecting the PG range of DIGS scores among individuals scoring 5–10 receives some support from our data. It would appear in Figs. 2 and 3 that GGT overconfidence and IGT performance in general were worse among those scoring 8–10 than among those scoring 5–7. This question bears further research.

Limitations and Future Research

Our sampled population of college students who self-identify as frequent gamblers introduces important considerations. In comparison with treatment-seeking samples, it carries the disadvantage of including large numbers of participants who might not gamble exceptionally frequently or do not experience significant gambling-related problems. Because of the restricted range of age, ethnicity, education level, and income, there are limits on its generalizability, and there would therefore be value in extending our findings to broader populations. At the same time, it has the strength of including participants with sub-clinical gambling problems, and possibly some with quite severe gambling problems who nevertheless do not seek treatment. Moreover, there is inherent value to studying college students as a group (e.g., Baboushkin et al., 2001), as previous research has revealed notably high rates of gambling pathology among both youth (Shaffer & Hall 1996; Stinchfield & Winters 1998) and college student samples (Winters, Bengston, Dorr, & Stinchfield, 1998). In general, our sample included a broad spectrum of degrees of gambling involvement and gambling pathology. Because we deliberately sought frequent gamblers, however, we cannot infer prevalence rates from our observed pathology distribution.

While these results provide evidence that judgmental biases, overall gambling frequency, and the number of modalities in which individuals gamble at least weekly relate to the DSM-IV criteria as assessed by the DIGS, and that there are significant differences between individuals who show three or fewer PG symptoms and those who show four or more, there are not data concerning the amount of money spent or lost gambling. Such data would be useful in establishing other detrimental effects that accompany judgmental biases, and will be an important avenue for future research.

Because of the cross-sectional nature of the current data, our conclusions regarding the causal chain of cognitive biases contributing to PG is speculative. While it is more likely that a propensity toward maladaptive judgmental biases would influence PG outcomes than the converse (see Ladouceur, 2004; Raylu & Oei, 2002), a longitudinal examination would also be a useful avenue for further examination.

Finally, it is possible that the psychometric findings from this research are specific to the DIGS and may not replicate with different instruments. However, if PG and the DSM-IV criteria fail future confirmation by subsequent analyses using a different instrument, then the appropriate conclusion would be that the instrument, and not PG or the DSM-IV criteria, lacked validity.

Conclusions

The present results psychometrically validate the concept of PG, the symptoms that the DSM-IV adopts as criteria for PG, and the manner of probing these symptoms incorporated by the DIGS. They also demonstrate that the DSM-IV criteria are predicted significantly by all the cognitive biases we tested using the GGT and IGT. The evidence from these cognitive biases, however, offers further support to recent suggestions that the most useful cutoff score for the diagnosis of PG would be four symptoms, rather than five.

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