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Multidimensional Examination of Impulsivity in Relation to Disordered Gambling

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Abstract

Impulsivity has been consistently associated with pathological gambling (PG), but the diversity of definitions and measures of impulsivity has led to ambiguity with regard to which indices are independently relevant. Toward clarifying this relationship, the current study examined indices from an array of commonly-used impulsivity measures in relation to PG severity in an adult community sample of frequent gamblers (*N* = 353). These included both survey assessments and behavioral tasks. Using a factor analytic approach, four latent factors were identified among 19 indices and were designated *reward sensitivity*, *punishment sensitivity*, *delay discounting*, and *cognitive impulsivity*. All four latent variables were positively and independently related to PG severity, albeit at a trend level for cognitive impulsivity in a combined model. These findings reveal four generally independent domains of impulsivity that are related to PG severity, clarify which assessment measures aggregate in each domain, and illustrate the importance of measurement specificity in studying impulsivity in relation to PG and other psychiatric disorders.

Keywords

Pathological Gambling; Impulsivity; Delay Discounting; Urgency; Reward Sensitivity; Punishment Sensitivity; Addiction

Pathological gambling (PG) is a psychiatric disorder characterized by persistent maladaptive patterns of gambling behavior, including gambling to relieve negative affect, chasing losses, lying to others about gambling involvement, and a preoccupation with gambling (American Psychiatric Association [APA], 2000) Although the prevalence of PG is relatively low, with lifetime estimates of .4-2% (Petry, 2005; Petry, Stinson, & Grant, 2005), PG is associated with significant impairment, including family discord and domestic violence (Shaw, Forbush, Schlinder, Rosenman, & Black, 2007), criminal behavior (Meyer & Stadler, 1999; Turner, Preston, Saunders, McAvoy, & Jain, 2009), and suicidality (Hodgins, Mansley, & Thygesen, 2006; Kausch, 2003; Maccallum & Blaszczynski, 2003; Petry & Kiluk, 2002). Nosologically, PG was classified as an Impulse Control Disorder (APA, 2000), but has been combined with substance use disorders in DSM 5 (APA, 2012). Akin to other addictive disorders, the etiology of PG is complex and multifarious, including genetic, developmental,

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learning, and personality factors (Blaszczynski & Nower, 2002; Lobo & Kennedy, 2009; Maclaren, Fugelsang, Harrigan, & Dixon, 2011). It is also similar to other forms of addiction insofar as it exists on a continuum of disordered gambling, with PG reflecting impairment above a given threshold (Strong & Kahler, 2007).

Among the diverse etiological contributions, greater propensity toward impulsivity is one of the most robust characteristics associated with PG. For example, in categorical designs, numerous studies have revealed significant differences between individuals with PG and control groups on a variety of impulsivity measures (e.g., MacKillop, Anderson, Castelda, Mattson, & Donovick, 2006b; Michalczuk, Bowden-Jones, Verdejo-Garcia, & Clark, 2011; Petry, 2001). Moreover, two recent meta-analyses have found these group differences to be of medium effect size and statistically robust across studies (MacKillop et al., 2011; MacLaren et al., 2011). Similarly, in continuous designs, indices of impulsivity have been significantly positively associated with PG severity (e.g., Alessi & Petry, 2003; Cyders & Smith, 2008a; MacKillop, Anderson, Castelda, Mattson, & Donovick, 2006a). Of course, these cross-sectional studies cannot address directionality (i.e., whether impulsivity contributed to PG or vice versa), but recent studies using longitudinal designs suggest a causal etiological role (Auger, Lo, Cantinotti, & O'Loughlin, 2010; Cyders & Smith, 2008a; Pagani, Derevensky, & Japel, 2009; Shenassa, Paradis, Dolan, Wilhelm, & Buka, 2012; Vitaro, Arseneault, & Tremblay, 1999). For example, Shenassa et al. (2012) found that children exhibiting impulsivity, as measured by psychologist's rating of behavioral impulsivity during a battery of cognitive, sensory, and motor tasks, at age 7 experienced a threefold increase in risk for developing gambling problems during adulthood and, in a sample of college freshmen, Cyders and Smith (2008a) found that impulsivity, as measured by the UPPS-P Scale, prospectively predicted increases in gambling over the course of the academic year.

However, the ostensible coherence in the preceding findings belies several significant limitations and challenges in the current empirical literature. Chief among these is the multiplicity of definitions and measures used in the conceptualization and assessment of impulsivity (de Wit, 2009; Evenden, 1999). Early conceptions of impulsivity focused on unidimensional definitions (e.g., Eysenck & Eysenck, 1978), but subsequent refinement of these aspects of personality has revealed several related but nonetheless putatively distinct elements (Patton, Stanford, & Barratt, 1995; Whiteside & Lynam, 2001). For example, two commonly used measures are the Barratt Impulsivity Scale (Patton et al., 1995), which fractionates impulsivity into three domains, and the UPPS-P impulsivity scale (Cyders et al., 2007; Whiteside & Lynam, 2001), which fractionates impulsivity into five domains. The UPPS-P represents a novel approach to the study of impulsivity, arguing for a variety of trait-based pathways to impulsive behavior that can be best understood from a basic personality trait perspective. More specifically, impulsive behavior can result from elevation or depression on a variety of general personality domains. These include neuroticism, such as acting impulsively when encountering strong negative affect (i.e., negative urgency); extraversion, such as acting impulsively when experiencing strong positive affect (i.e., positive urgency); impulsivity in the pursuit of risk, reward, or novelty (i.e., sensation seeking); and conscientiousness, such as acting impulsively because of difficulty coping

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with boredom, fatigue, or stress (i.e., lack of perseverance), or because of difficulties considering possible consequences prior to initiating a behavior (i.e., lack of premeditation).

In addition to a variety of self-report trait measures of impulsivity, a host of decision-making tasks have also been developed to tap focal aspects of impulsive or risky decision-making. These include delay discounting tasks (e.g., Petry, 2001) that assess impulsivity as preference for smaller immediate rewards at the expense of larger delayed rewards (i.e., capacity to delay gratification); the Balloon Analogue Risk Task (e.g., Lejuez et al., 2002), which assesses reward preferences under conditions of uncertainty; and the Georgia Gambling Task (e.g., Goodie, 2005), which assesses levels of confidence and risk acceptance under conditions of uncertainty. More problematic still is that these diverse measures have varying levels of overlap, as some exhibit high magnitude correlations with each other while others are entirely unrelated. Illustrating this, in a recent review, Miller and Lynam (2013) found highly variable associations among UPPS-P indices (rs = −.11-.60) as well as high variability in relation to other personality measures of impulsivity (rs = .07-.93), clearly ranging from negligible to high magnitude associations. Similarly, recent meta-analyses have found only modest overlap between impulsivity-related personality measures and behavioral tasks (Cyders & Coskunpinar, 2011).

Varying degrees of overlap among these impulsivity questionnaires and tasks presents two problems. First, studies using measures that are independent of one another might each report significant relationships in the same terms (e.g., greater impulsivity in one group versus another), leading to an appearance of mutual confirmation that is spurious because the measures are unrelated. Second, when indices are related, it is necessary to disentangle relationships that are independently robust from those that are a function of assessment or content overlap. In other words, although refining the construct of impulsivity in multidimensional terms reflects progress in the field, the resulting diversity of available measures and their varying levels of overlap have created conceptual and substantive ambiguity in the empirical literature. These issues are further compounded by the fact that most studies use only one or two measures in this domain, creating manifold opportunities for ‘third variable’ confounds, in which a significant relationship between two variables is in fact a spurious artifact of a more relevant, but unmeasured, third variable. Thus, when considering the various domains of impulsivity, these limitations make it difficult to characterize which of the elements are independently associated with PG. By analogy, within the genus of impulsivity, the current literature makes it difficult to tell which species are truly related to PG.

Three other methodological issues further contribute to ambiguity in this area. First, many of the studies to date use PG screens, such as the South Oaks Gambling Screen (Lesieur & Blume, 1987), rather than clinical diagnostic assessment. As with most screening measures, PG screens have been found to correlate significantly with diagnostic assessments, but also overestimate severity and exhibit less robust psychometric properties (Cox, Enns, & Michaud, 2004; Fortune & Goodie, 2010), making them useful in their intended capacity as screening tools, but suboptimal for studying the clinical condition. Second, intellectual functioning and income have been independently associated with both PG (Auger et al., 2010; Vitaro et al., 1999) and measures of impulsivity (Forbush et al., 2008; Shamosh et al., 2008), but these variables have not been systematically examined in the context of understanding the nature of the relationships between impulsivity-related traits and PG. This is particularly important in the case of income because some measures of impulsivity directly examine reward preferences using decision-making about financial rewards, for example delay discounting (MacKillop et al., 2006b; Petry, 2001) and the Balloon Analogue Risk Task (Lejuez et al., 2002). Third, a common limitation of a large proportion of existing studies is the use of convenience samples of college students as analogues for adults with PG. Although college gambling is itself potentially important (Blinn-Pike, Worthy, & Jonkman, 2007), it is not clear whether the observed relationships generalize to clinically diagnosed adults with PG.

The goal of the current study was to clarify the relationship between impulsivity and PG severity. The study also aimed to address common limitations of previous studies by recruiting an adult community sample, characterizing PG severity with a semi-structured clinical diagnostic interview, and fully integrating the role of intellectual functioning and income into the study. We used factor analysis as a general framework to clarify the interrelationships among the indices and, in turn, to generate factors reflecting latent commonalities. These latent factors were then examined in relation to PG severity. We hypothesized that numerous significant individual-level associations between the impulsivity indices and PG severity would be present, as previously observed, but that the factor analytic approach would permit a more integrative and coherent perspective.

METHOD

Participants

Participants were recruited using flyers, newspaper advertisements, and word of mouth from the Athens, GA community. Eligibility criteria were: a) adult (i.e., age 18+); b) frequent gambling (i.e., at least weekly); c) adequate literacy (i.e., 9+ grade education); and, d) self-reported ability to use a computer. A total of 368 individuals enrolled but 15 individuals were excluded for missing data and low effort (i.e., low discounting response consistency, suggesting random responding), resulting in a total sample of 353 participants. Sample characteristics are provided in Table 1 and can be modally described as low-income males in their mid-thirties, of whom approximately half were white. Severity of PG was relatively high, with 23% exhibiting zero symptoms (88% male), 46% exhibiting between one and four symptoms (subclinical PG status; 80% male), and 31% meeting criteria for PG (5+ symptoms; 70% male).

Assessment

Diagnosis, Intellectual Functioning, and Demographics

Structured Clinical Interview for Pathological Gambling (SCI-PG; Grant, Steinberg, Kim, Rounsaville, & Potenza, 2004): The SCI-PG is a semi-structured clinical interview assessing DSM IV symptoms of PG over the past year. Participants were assessed by MS-level Research Assistants, trained by Drs. MacKillop and Miller, licensed clinical psychologists. A symptom count was used as a continuous index of PG severity (e.g., MacKillop et al., 2010).

Shipley Institute of Living Scale (SHP; Zachary, 1991): The SHP is a brief validated assessment of intellectual functioning and generates overall, verbal, and abstraction scores. As verbal and abstraction performance were highly correlated (r = .66, p <.001), the overall score was used.

Demographics: All participants completed a comprehensive demographic assessment.

Self-report Inventories

UPPS-P Impulsivity Inventory (Cyders et al., 2007; Whiteside & Lynam, 2001): The UPPS-P is a 59-item self-report measure of the following five impulsivity related traits: a) (negative) Urgency: difficulty inhibiting urges and cravings when experiencing strong negative affect; b) (lack of) Perseverance: propensity to give up on challenging tasks; c) (lack of) Premeditation: propensity to not dedicate sufficient deliberation or forethought; d) Sensation Seeking: propensity to seek out novel and exciting experiences; and e) Positive Urgency: difficulty inhibiting urges and cravings when experiencing strong positive affect.

Barratt Impulsivity Scale (BIS; Patton et al., 1995): The BIS is 30-item self-report measure of impulsivity that captures the following three domains: a) Attentional Impulsivity: difficulty dedicating adequate attention to a task; b) Motor Impulsivity: propensity to act rashly without forethought; and c) Nonplanning Impulsivity: failure to adequately plan ahead.

Sensitivity to Reward/Sensitivity to Punishment Questionnaire (SPSRQ; Torrubia, Avila, Molto, & Caeras, 2001): Developed to assess Gray’s dimensions of impulsivity and anxiety (Gray, 1982), the SPSRQ is a 48-item self-report measure that assesses sensitivity to reward and sensitivity to aversive outcomes (punishment).

Behavioral Inhibition Scale/Behavioral Activation Scale (BIS/BAS; Carver & White, 1994): Also based on Gray’s (1982) conception of impulsivity, the BIS/BAS scales use 20 self-report items to measure regulation of motivation for appetitive outcomes and motivation to avoid aversive outcomes. The Behavioral Inhibition Scale is unidimensional but the Behavioral Activation Scale comprises three subscales of reward responsiveness, fun-seeking, and drive.

Behavioral Tasks

Balloon Analogue Risk Task (BART; Lejuez et al., 2002): The BART is a computerized risk-taking task that permits participants to electronically inflate balloons. Each increment of inflation earns a unit of financial reward but also increases the risk that the balloon will pop, resulting in all money gained for a trial to be lost. Monetary outcomes were hypothetical. Over 30 trials, the primary dependent variable for the BART is the average number of pumps per un-popped balloon (total = 30; i.e., adjusted average).

Georgia Gambling Task (GGT; Goodie, 2003): In the GGT, participants first completed a confidence calibration task by answering 50 two-alternative general knowledge questions and assessing their confidence in each answer using a 50–100% scale. The primary dependent variable, overconfidence, was calculated as the difference between average confidence and accuracy across the question set (i.e., the discrepancy between estimated accuracy and actual accuracy).

Delay Discounting Task (DDT; Kirby, Petry, & Bickel, 1999): The DDT used 27 dichotomous choices between smaller immediate rewards available at the end of the session or larger rewards available in the future after a delay. The 27 items comprised three sets of nine items assessing small, medium, and large magnitude delayed rewards (~$25, ~$50, ~ $85, respectively), permitting the assessment of three hyperbolic temporal discounting functions using imputation based on choice profile (Kirby et al., 1999). Actual rewards were provided via an approach that has been validated for this DDT (Kirby et al., 1999). Specifically, participants were informed they would have the opportunity to receive one of their responses on the task. They were given a six-sided die and informed that if they rolled a six, they would receive a randomly-selected outcome from their choices.

Procedure

Prospective participants completed a telephone screen and eligible individuals were scheduled for a three-hour assessment. Participants first received comprehensive instructions about the study and its procedures and then completed informed consent. The assessment protocol followed, including the semi-structured clinical interview, self-report measures, and behavioral tasks. Of note, self-report inventories were administered electronically and counterbalanced by participant. The SHP and behavioral tasks were interspersed among inventory assessment to avoid single modality fatigue. At the conclusion of the session, participants received compensation for their time ($30), an explanation of the goals of the study, and referrals to community gambling treatment resources. All procedures were approved by the University of Georgia Institutional Review Board.

Data Analysis

Based on evidence that PG severity is unidimensional (Strong & Kahler, 2007), all analyses used a continuous analytic approach. The analyses first examined zero-order interrelationships between variables using Pearson's product-moment correlations (*r*s). In order to identify latent aggregations of variables, exploratory factor analysis was conducted using principal axis factoring (PAF) with direct oblimin (oblique) rotation of all the indices of impulsivity (Russell, 2002). The solution was interpreted based on three criteria: 1) observed scree plot discontinuity; 2) parallel analysis of a bootstrapped random dataset with the same sample and variable parameters (Horn, 1965); and 3) the minimum average partial (MAP) test (Velicer, 1976). In the case of parallel analysis, eigenvalues from the analysis were compared to the 95th percentile for the randomly generated dataset (O'Connor, 2000). In the case of the MAP test, the best solution was defined as the number of factors that generates the smallest average squared correlation, reflecting the smallest amount of unsystematic variance (O'Connor, 2000). Finally, items were considered to significantly load on a factor based on a pattern matrix loading of .40 (Stevens, 2002). Latent factor scores were generated via regression and examined in relation to PG severity using Pearson's correlations and hierarchical linear regression. Specifically, to identify the uniquely associated variables, hierarchical multiple regression was performed with SHP total and income in a first block and the latent variables in successive blocks based on zero-order magnitude of association with PG severity. This was applied iteratively, using Δ^2 to determine whether a variable was retained in the model (e.g., Murphy & Mackillop, 2012). Thus, the final linear combination only incorporated variables that were uniquely associated with PG severity. Variables that were not aggregated into latent variables were added last using the same inclusion criterion. For all analyses, statistical significance was defined $p <.05$, with trends being $p <.10$, and effect sizes are reported as *r*and β. All analyses were conducted using SPSS v.21 (IBM, Armonk, NY).

RESULTS

Zero order correlations are presented in Table 2. Consistent with previous studies, the majority of the indices exhibited significant associations with PG severityand also both intellectual functioning and income. As expected, significant high-magnitude associations were present among the indices of delay discounting, which were also associated with BART, GGT, intellectual functioning, and income, but largely unrelated to the personality-based impulsivity measures. Indices from the UPPS-P, BIS, BIS/BAS, and SPSRQ were frequently significantly correlated with one another but at highly varying levels of magnitude. These indices were often significantly associated with intellectual functioning, albeit at modest levels, but not with income.

In the EFA, scree plot discontinuity, MAP, and parallel analysis all indicated a four factor solution, accounting for just over half of the total variance (50.53%). The observed eigenvalues and parallel analysis-derived eigenvalues are presented in Table 3, as are the factor loadings. The four factors cleaved into relatively clear conceptual aggregations, although GGT and BART did not load on any of the factors. The first factor, comprising the Behavioral Activation Scale indices, sensitivity to reward, sensation seeking, positive urgency, and Barratt motor impulsivity scale was labeled *reward sensitivity*. The second factor comprised the discounting indices and was labeled *delay discounting*. The third factor, comprising lack of premeditation, lack of perseverance, non-planning, and attentional impulsivity, and was labeled *cognitive impulsivity* (distinct from the cognitive distortions that contribute to PG outside of an impulsivity framework; Goodie & Fortune, in press). The fourth factor comprised behavioral inhibition, sensitivity to punishment, and negative urgency, and was designated *punishment sensitivity*. In this latter case, as all factor loadings were negative, its absolute value was used for ease of interpretation in subsequent analyses (e.g., high values reflecting high sensitivity to punishment).

In zero-order correlations (Table 4), all four factors were significantly associated with PG severity. In addition, intellectual functioning and income were significantly associated with the delay discounting and punishment sensitivity latent variables. In hierarchical regression (Table 5), income again was non-significantly associated with PG severity, but all the other coefficients were statistically significant, except for reward sensitivity, for which the coefficient was a statistical trend. Performance on the GGT and BART did not significantly incrementally improve the model (*p*s>.80). Intellectual functioning was inversely associated with PG severity, but reward sensitivity, delay discounting, cognitive impulsivity, and punishment sensitivity were all positively associated with PG severity. The combined model accounted for 23% of the variance in PG severity.

DISCUSSION

The goal of the current study was to examine the relationship between an array of indices of impulsivity and PG severity. As predicted and consistent with previous studies (e.g., Alessi & Petry, 2003; Atkinson, Sharp, Schmitz, & Yaroslavsky, 2011; Cyders & Smith, 2008a; Goodie, 2005), initial examination revealed that a variety of these measures and tasks were significantly associated with PG severity. Indeed, sixteen of the nineteen indices were nominally significantly associated with PG severity. Furthermore, when considered together, many of these relationships were a function of interrelationships among the measures, also as predicted. The factor analytic approach clarified the interrelationships among the measures and their relationships to PG severity. A four factor solution was clearly supported across criteria and was highly interpretable, with clear conceptual overlap among the indices. Specifically, the resulting four-factor model suggests that the distinct elements of impulsivity that are most relevant to PG severity are temporal myopia (impulsive discounting); oversensitivity to both rewarding and punishing outcomes; and a propensity for inattention, failure to plan ahead, and lack of perseverance. The latent factors were modestly related to each other, but were all significantly associated with PG severity both in individual and regression-based analyses, albeit with a trend-level association for cognitive impulsivity in the combined model. Together, the latent factors were associated with approximately a quarter of the total variance, suggesting that these domains are substantially related to PG severity. These findings suggest that these four core facets of impulsivity are independently related to PG severity and that it is important to provide adequate coverage of each of these domains in future studies.

Although not the primary focus of the study, there are several collateral findings that bear mentioning. First, an explicit focus of the study was to incorporate intellectual functioning and income to understand these relationships and, consistent with previous studies, significant relationships were present between those variables and both the manifest indices and latent factors. Another finding of interest was the general lack of associations between the tasks and self-report inventories. This is consistent with Cyders and Coskunpinar’s (2011) recent meta-analysis, which came to the same conclusion and suggests that although these measures are often thought of as measures of impulsivity or risk taking, they are largely distinct from one another. At the opposite end of the spectrum, because of the high correlations, there has been active discussion about whether positive and negative urgency are meaningfully different from one another (Cyders & Smith, 2008b; Miller & Lynam, 2013; Murphy & MacKillop, 2012). In this case, although the two are again highly correlated, differential latent factor loading suggests that there is utility in treating these aspects of affective reactivity separately.

These findings are also highly compatible with those in another recent study investigating the latent structure of multiple impulsivity measures. Meda et al. (2009) examined the interrelationships among indices from five self-report inventories (BIS/BAS, Barratt Impulsivity Scale, Padua Inventory, Zuckerman Sensation Seeking Scale, and SPSRQ) and two behavioral tasks (BART, experiential discounting tasks) using PCA and found support for a five factor solution. These were termed Self-Reported Behavioral Activation, Self-Reported Compulsivity and Reward/Punishment, Self-Reported Impulsivity, Behavioral Temporal Discounting and *Behavioral Risk-Taking*. Despite quite different samples (healthy adults and at-risk/active drug users) and non-overlapping batteries, these factors are notably similar to the current findings. Similarly, Reynolds et al. (2008) examined the latent structure of two-self-report measures and several laboratory tasks, finding higher correlations between the self-report measures than the laboratory measures, and three independent latent factors: *Impulsive Decision-making*, *Impulsive Inattention*, and *Impulsive Disinhibition*. Although these studies are not definitive, it is fairly clear that there is meaningful latent overlap among the multiplicity of self-report impulsivity measures and that task-based indices are distinct from the questionnaire-based indices.

Importantly, these findings have the potential to be applied to advancing the understanding and treatment of PG. It is important that future work on the relationships between impulsivity and PG use a multi-trait and multi-modal perspective as each of these impulsivity-related components appears to provide important and clinically useful information in the study of PG. Particularly in prospective clinical research, there is increasing evidence that delay discounting predicts poor treatment outcome (Krishnan-Sarin et al., 2007; MacKillop & Kahler, 2009; Yoon et al., 2007) and these data provide further support for examining not only discounting but all four domains implicated in PG treatment. Moreover, from a clinical standpoint, there is increasing evidence that experimental manipulations can ameliorate performance on some indices of impulsivity (Bickel, Yi, Landes, Hill, & Baxter, 2011; Black & Rosen, 2011; Hofmeyr, Ainslie, Charlton, & Ross, 2011; Rosen, Rounsaville, Ablondi, Black, & Rosenheck, 2010). As such, a treatment approach for PG that directly focuses on multiple dimensions of impulsivity may be a promising direction for the future. Currently, the most robust empirical support is for cognitive behavioral therapy (Gooding & Tarrier, 2009; Pallesen, Mitsem, Kvale, Johnsen, & Molde, 2005) and motivational interviewing (Grant, Donahue, Odlaug, & Kim, 2011; Grant et al., 2009; Larimer et al., 2011), neither of which have a direct focus on impulse control. An impulsivity-focused approach may be useful independently or in conjunction with these modalities. Finally, the current findings may contribute to understanding genetic contributions to PG. Impulsivity is increasingly examined as a candidate endophenotype (i.e., a heritable mechanistic characteristic that clarifies genetic influences on liability for a given clinical syndrome; Flint & Munafo, 2007; e.g., Eisenberg et al., 2007). As such, the four latent domains identified here are informative about the phenotypic structure of the relationship between impulsivity and PG. Further, in light of the overlapping relationships that exist within and across measures, these findings suggest that greater phenotypic coherence may be found using factor analysis to derive latent characteristics across multiple indices.

Promising though these applications may be, there are also important considerations pertaining to the current study that are reasons for caution. As noted earlier, cross-sectional studies cannot unequivocally implicate the observed relationships in the etiology of the condition. Elevations in impulsivity are putatively causally related to the development of

PG, but it is also possible that the opposite is true, that aspects of gambling behavior contribute to greater impulsivity. In addition, other ‘third variables’ cannot be conclusively ruled out in cross-sectional investigations. The existing longitudinal studies provide general support that impulsivity predates PG (e.g., Auger et al., 2010; Pagani et al., 2009; Shenassa et al., 2012; Slutske et al., 2012; Vitaro et al., 1999), but of course with the qualification that the measures are not fully comparable across those studies or to the current study. Further, the prospective study by Cyders et al. (2009) suggests some facets of impulsivity are significantly informative over time and others are not. As such, caution should used in making conclusions about causation from these findings. A priority for future work in this area will be applying a similarly fine-grained approach to understanding the role of these dimensions over time. A second consideration is that, as a relatively large battery of measures was used, Type I error rate was potentially inflated and false positive associations are possible within the results. For the primary findings, this issue is substantially mitigated because the factor analytic approach was specifically intended to reduce the number of indices into latent factors. As such, the analyses of the latent variables in relation to PG involved only a small number of variables. However, in the descriptive zero order correlation matrix, the associations that met only the nominal statistical significance criterion should be interpreted cautiously because of this issue.

A final consideration is that although the current study used a wide and diverse battery of impulsivity measures, it was not fully exhaustive. For example, two recent studies have implicated probability discounting with PG (Madden, Petry, & Johnson, 2009; Petry, 2012), which characterizes risk-taking propensity in terms of sensitivity to escalating uncertainty of reward. Another relevant measure of risk-taking is the Iowa Gambling Task (Lakey et al., 2007; Miranda et al., 2009). In addition, behavioral inhibition (i.e., capacity to suppress a prepotent response) is another behavioral index of impulsivity (de Wit, 2009) that is typically assessed using Go/NoGo or Stop Signal Tasks and was not included in the current battery. Thus, although the study carefully parsed the roles of a large number of the most commonly used impulsivity measures, there are aspects that fell beyond its scope. Related to this, although the final model accounted for approximately one-quarter of the variance in PG severity, clearly much of the variance was unexplained and other factors play an important role too. Including assessments of gambling-specific cognitive distortions (MacKillop et al., 2006a, 2006b) and social network factors (e.g., Fortune et al., 2013; Meisel et al., 2013) may provide a more complete picture in future studies.

Acknowledging these considerations, the current study nonetheless contributes to greater clarity in understanding the relationship between facets of impulsivity in relation to PG. In a large community sample of gamblers of whom the majority exhibited clinical or subclinical levels of PG, four specific domains - temporal myopia, reward sensitivity, punishment sensitivity, and cognitive impulsivity - were found to be uniquely associated with PG severity. Further applications of these findings to longitudinal and clinical research are priorities for future work in this area.

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Table 1

Sample characteristics (*N* = 353).

Characteristic	**Mean (SD)/%/Median (IQR)**
Age	35.32 (12.34)
Sex	78.5% Male/21.5% Female
Race	
White	52.1%
African American	43.1%
Mixed Race	2.8%
Asian	1.1%
NA/NA	.6%
Other	.3%
Hispanic Ethnicity	1.4%
Income	<$15,000 (<$15,000 to $15-30,000)
Shipley – Total	50.69 (15.61)
SCID PG Symptoms	3.23 (2.84)

Note: NA/NA = Native American/Alaskan Native; SCID = Structured Clinical Interview for DSM IV; PG = Pathological Gambling

Table 2

Zero-order correlations among severity of pathological gambling, indices of impulsivity, and collateral measures of intellectual functioning and income.Correlation magnitudes ≥ |.11| are nominally statistically significant (p < .05); coefficients ≥ |.17|p < .005.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1. PGS	**1.00**																				
2. BART	−.18	**1.00**																			
3. GGT	.17	−.32	**1.00**																		
4. S-*k*	.30	−.23	.23	**1.00**																	
5. M-*k*	.27	−.28	.28	.82	**1.00**																
6. L-*k*	.26	−.32	.25	.78	.87	**1.00**															
7. BIS	.18	.04	−.04	.02	−.05	−.04	**1.00**														
8. BAS-RR	.07	.01	−.05	−.08	−.07	−.08	.23	**1.00**													
9. BAS-D	.17	−.61	.14	.14	.18	.17	.09	.53	**1.00**												
10. BAS-F	.15	−.02	.03	.01	.04	.07	.17	.50	.56	**1.00**											
11. S-P	.33	−.23	.11	.09	.10	.07	.50	.02	.11	.14	**1.00**										
12. S-R	.14	.03	.00	.03	.08	.09	.18	.26	.35	.45	.14	**1.00**									
13. NU	.28	−.03	.06	.09	.09	.05	.41	.17	.18	.31	.42	.34	**1.00**								
14. LPM	.11	.11	−.08	.03	.01	−.01	−.02	−.09	−.16	.08	−.02	.09	.25	**1.00**							
15. LPR	.10	.04	−.12	.01	−.01	−.05	.11	−.17	−.22	−.04	.20	−.03	.20	.56	**1.00**						
16. SS	−.03	.17	−.11	−.07	−.04	−.03	.00	.19	.16	.41	−.20	.32	.23	.14	−.11	**1.00**					
17. PU	.29	−.06	.08	.09	.13	.10	.23	.17	.24	.35	.35	.35	.80	.24	.19	.33	**1.00**				
18. NP	.21	.05	−.01	.10	.05	.05	.14	.04	−.06	.19	.20	.13	.39	.42	.41	.08	.32	**1.00**			
19. ATT	.25	−.03	.05	.09	.03	.06	.25	.01	.04	.22	.34	.18	.39	.37	.34	.09	.31	.48	**1.00**		
20. MOT	.14	−.01	.07	.04	.07	.05	.17	.24	.29	.51	.18	.42	.43	.32	.11	.32	.41	.31	.49	**1.00**	
21. SHP	−.30	.52	−.39	−.29	−.33	−.33	.04	.17	−.11	.06	−.36	.03	−.12	.14	−.01	.30	−.17	.08	−.04	−.01	**1.00**
22. INC	−.19	.27	−.26	−.22	−.21	−.18	.07	.03	−.07	.00	−.20	.06	−.12	.10	.03	.16	−.10	−.16	−.04	.02	.38

Notes: PGS = pathological gambling severity; BART = Balloon Analogue Risk Task; GGT = Georgia Gambling Task; S-k, M-k, L-k = Small, medium and large hyperbolic discounting functions; BIS = Behavioral Inhibition Scale; BAS = Behavioral Activation Scale; RR = Reward Responsiveness; D = Drive; FS = Fun-Seeking; S-P = Sensitivity to Punishment; S-R = Sensitivity to Reward; NU = Negative Urgency; LPM = Lack of Premeditation; LPR = Lack of Perseverance; SS = Sensation Seeking; PU = Positive Urgency; NP = Nonplanning; ATT = Attention; MOT = Motor Impulsivity; SHP = Shipley; INC = Income.

Table 3

Exploratory factor analysis of diverse indices of impulsivity.

	Extraction		
	Parallel Analysis	**Observed Eigenvalues**	**% Variance**
1	1.51	4.29	20.04
2	1.40	2.95	14.00
3	1.33	2.44	10.21
4	1.28	1.64	6.29
5	1.23	1.08	

	Factor Solution			
	1	**2**	**3**	**4**
BAS-RR	**0.59**	−0.11	−0.23	−0.08
BAS-D	**0.66**	0.17	−0.31	−0.09
BAS-FS	**0.78**	0.02	0.01	−0.03
UPPS - SS	**0.56**	−0.08	0.13	0.27
UPPS - PU	**0.41**	0.08	0.35	−0.29
BIS-MOT	**0.54**	0.04	0.35	−0.06
SR	**0.55**	0.04	0.08	−0.06
S-*k*	−0.03	**0.85**	0.13	0.10
M-*k*	0.03	**0.96**	0.09	0.15
L-*k*	0.04	**0.93**	0.07	0.15
UPPS - LPR	0.01	−0.01	**0.77**	0.20
UPPS - LPS	−0.25	−0.04	**0.66**	−0.10
BIS-NP	0.07	0.03	**0.59**	−0.11
BIS-ATT	0.12	0.04	**0.53**	−0.24
BIS	0.10	−0.10	0.06	**−0.53**
S-P	−0.10	0.05	0.09	**−0.87**
UPPS - NU	0.35	0.03	0.39	**−0.42**
GGT	0.01	0.32	−0.09	−0.10
BART	0.05	−0.34	0.13	0.20

Notes: Parallel analysis of a bootstrapped dataset (N = 353, 19 variables) was used to generated eigenvalues at the 95th%ile for comparison with the observed eigenvalues and suggested a four factor solution. Total variance accounted for = 50.53%. BAS- RR = Behavioral Activation Scale - Reward Responsiveness; BAS -D = Behavioral Activation Scale - Drive; BAS - FS = Behavioral Activation Scale - Fun-Seeking; UPPS-SS = UPPS - Sensation Seeking; UPPS-PU = Positive Urgency; BIS-MOT = Barratt Impulsivity Scale - Motor Impulsivity; S-R = Sensitivity to Reward; S-*k*, M-*k*, L-*k* = Small, medium and large hyperbolic discounting functions; UPPS - LPM = UPPS - Lack of Premeditation; UPPS - LPR = Lack of Perseverance; BIS - NP = Barratt Impulsivity Scale - Nonplanning; BIS - ATT = Barratt Impulsivity Scale - Attention; BIS = Behavioral Inhibition Scale; S-P = Sensitivity to Punishment; UPPS - NU = Negative Urgency; GGT = Georgia Gambling Task; BART = Balloon Analogue Risk Task.

Table 4

Associations between latent factors of impulsivity in relation to pathological gambling severity, intellectual functioning, and income.

	1	2	3	4	5	6	7
1. PG Severity	1.00						
2. Reward Sensitivity	.17**	1.00					
3. Delay Discounting	.32**	.05	1.00				
4. Cognitive Impulsivity	.20**	.18**	−0.03	1.00			
5. Punishment Sensitivity	.34**	.24**	.17**	.19**	1.00		
6. Shipley	−.30**	.09	−.42**	.07	−.36**	1.00	
7. Income	−.19**	.03	−.26**	.01	−.22**	.38**	1.00

Table 5

Hierarchical regression of latent aggregations of impulsivity variables with pathological gambling severity. Following a covariate model comprising intellectual functioning and income, latent factors were successively added and only retained based on the change in overall model fit.

Variable	Step	$R^2/\Delta R^2$	B	SE	β	*p*
Income	1		−.08	.08	−.05	0.34
Shipley	1	.10	−.03	.01	−.14	≤.05
Punishment Sensitivity	2	.06	.60	.17	.19	≤.001
Delay Discounting	3	.04	.62	.15	.21	≤.001
Cognitive Impulsivity	4	.03	.52	.15	.17	<.001
Reward Sensitivity	5	.01	.29	.15	.10	.06

Note: Overall model $R^2 = .23$.