

Impulsivity and cognitive distortions in pathological gamblers attending the UK National Problem Gambling Clinic: a preliminary report

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Background. Pathological gambling (PG) is a form of behavioural addiction that has been associated with elevated impulsivity and also cognitive distortions in the processing of chance, probability and skill. We sought to assess the relationship between the level of cognitive distortions and state and trait measures of impulsivity in treatment-seeking pathological gamblers.

Method. Thirty pathological gamblers attending the National Problem Gambling Clinic, the first National Health Service clinic for gambling problems in the UK, were compared with 30 healthy controls in a case-control design. Cognitive distortions were assessed using the Gambling-Related Cognitions Scale (GRCS). Trait impulsivity was assessed using the UPPS-P, which includes scales of urgency, the tendency to be impulsive in positive or negative mood states. Delay discounting rates were taken as a state measure of impulsive choice.

Results. Pathological gamblers had elevated impulsivity on several UPPS-P subscales but effect sizes were largest (Cohen's $d > 1.4$) for positive and negative urgency. The pathological gamblers also displayed higher levels of gambling distortions, and elevated preference for immediate rewards, compared to controls. Within the pathological gamblers, there was a strong relationship between the preference for immediate rewards and the level of cognitive distortions ($R^2 = 0.41$).

Conclusions. Impulsive choice in the gamblers was correlated with the level of gambling distortions, and we hypothesize that an impulsive decision-making style may increase the acceptance of erroneous beliefs during gambling play.

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Introduction

Gambling is a recreational activity that becomes disordered in approximately 0.9% of the British population using DSM criteria (Wardle *et al.* 2010). There is extensive clinical and pathophysiological overlap between pathological gambling (PG) and the substance use disorders (Potenza, 2006; Frascella *et al.* 2010), prompting a probable reclassification of PG among the addictions in the forthcoming DSM-V (Mitzner *et al.* 2010; Bowden-Jones & Clark, in press). PG is thought to arise through a combination of biological, social and psychological risk factors (Blaszczynski & Nower, 2002; Sharpe, 2002). One of the defining features of

gamblers' cognition is the tendency to overestimate the chances of winning, due to variety of cognitive distortions in the processing of chance, skill and probability (Ladouceur & Walker, 1996; Clark, 2010). Indeed, it is unclear whether these distortions have an obvious parallel in substance use disorders (Xian *et al.* 2008). Using psychometric measures of gambling distortions, such as the Gambling-Related Cognitions Scale (GRCS; Raylu & Oei, 2004a) or the Gambling Beliefs Questionnaire (GBQ; Steenbergh *et al.* 2002), several studies have reported elevated levels of distorted cognitions in individuals with disordered gambling compared to those without gambling problems (Miller & Currie, 2008; Emond & Marmurek, 2010; Myrseth *et al.* 2010). These cognitions are attenuated by treatment (Breen *et al.* 2001), and higher baseline scores predicted poorer outcome in a Gambler's Anonymous programme (Oei & Gordon, 2008).

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Studies using personality measures and neurocognitive tests have also highlighted changes in impulsivity in PG. Scores on the Barratt Impulsivity Scale and the Eysenck Impulsivity Venturesomeness Empathy (IVE) scale reliably increased in case-control studies (Blaszczynski *et al.* 1997; Petry, 2001*b*; Nower *et al.* 2004; Lawrence *et al.* 2009*a*), and prospective studies have confirmed that high impulsivity during adolescence predicts later gambling problems (Vitaro *et al.* 1999; Slutske *et al.* 2005). Rather than being a unidimensional construct, impulsivity is being increasingly viewed as a constellation of traits, including a lack of planning or forethought, reduced perseverance and the seeking of novel or intense sensory experiences (Evenden, 1999; Verdejo-Garcia *et al.* 2008). Recent research has also identified a fourth impulsivity component, labelled 'urgency': the tendency to engage in impulsive acts during intense mood states. This construct was initially identified by Whiteside & Lynam (2001) using a composite of the Barratt and Eysenck scales and the Zuckerman Sensation Seeking Scale, and subsequent work by Cyders, Smith and colleagues (Cyders & Smith, 2008*b*) has distinguished positive and negative aspects of urgency. The urgency construct is profoundly relevant to gambling behaviour, as it is known that many gamblers are motivated to gamble to alleviate states of depression, stress or boredom (Jacobs, 1986), but simultaneously, positive mood (perhaps associated with hypomania or dramatic wins) may also prompt gambling sprees (Cummins *et al.* 2009; Lloyd *et al.* 2010). Although positive and negative urgency are moderately correlated and both are related to a range of risky behaviours (Cyders & Smith, 2008*b*), there are some differential effects. Positive urgency predicted longitudinal increases in gambling behaviour across university (Cyders & Smith, 2008*a*), and changes in risk taking and alcohol consumption following positive mood induction (Cyders *et al.* 2010), whereas negative urgency is associated with bulimic symptoms (Anestis *et al.* 2007) and tobacco cravings (Billieux *et al.* 2007).

Impulsivity can also be assessed in the laboratory using a variety of neurocognitive tasks. The delay discounting paradigm assesses impulsive choice by presenting a series of decisions between a smaller reward available soon (or immediately), and larger rewards available after a longer delay (Bickel & Marsch, 2001; Reynolds, 2006). Indifference points obtained from varying one of the decision parameters (e.g. the delay to the larger reward) can be fitted to a hyperbolic discounting curve, allowing derivation of a parameter k that indicates the steepness of the discounting function. Impulsive subjects show enhanced preference for the smaller immediate rewards and steeper discounting of delayed outcomes (i.e. higher k values), and

several studies have described such a tendency in treatment-seeking and community groups with disordered gambling (Petry, 2001*a*; Alessi & Petry, 2003; Dixon *et al.* 2003; Ledgerwood *et al.* 2009).

Although impulsivity and gambling-related cognitive distortions have been described in pathological gamblers, the links between these constructs has received minimal attention. In an undergraduate sample comprising a range of gambling problems, the Eysenck Impulsivity score predicted higher scores on the GBQ (MacKillop *et al.* 2006), and a similar relationship was reported between Barratt scores and a measure of cognitive distortions that apply across many forms of psychopathology, such as personalization of negative events and all-or-none thinking (Mobini *et al.* 2007). We reasoned that an impulsive style of decision making may increase a gambler's tendency to accept erroneous beliefs about gambling over more 'rational' alternative interpretations that reflect more accurately the nature of chance. As such, the primary focus of the present study was to assess the degree of coupling between gambling-related cognitive distortions and state and trait indices of impulsivity, in participants with PG. Gamblers were recruited through the National Problem Gambling Clinic in London, which is the first (and only) National Health Service treatment facility for gambling in the UK. Given the limited treatment facilities for gambling prior to the opening of the clinic in 2008, there are few data available on the clinical characteristics and preferred forms of gambling of treatment-seeking gamblers in the UK, and it is vital to study gambling at a national level given the pronounced cultural and legislative heterogeneity in gambling practices across countries (Raylu & Oei, 2004*b*). A secondary objective was therefore to replicate prior findings, primarily from Australian and North American studies, of increased levels of gambling distortions, self-reported impulsivity, and discounting of delayed rewards in PG.

Method

Participants

Pathological gamblers ($n=30$) were recruited from the National Problem Gambling Clinic (28 males, two females; mean age = 40.1 years, *S.D.* = 12.3, range 21–60) and compared with community-recruited healthy controls (28 males, two females; mean age = 35.8 years, *S.D.* = 12.2, range 19–60). The protocol was approved by the Cambridge Local Research Ethics Committee (09/H0305/77) and all volunteers provided written informed consent. Participants were reimbursed for their time and travel expenses. The two groups did not

differ in age ($t=1.33$, $p=0.187$), years of education ($t=1.42$, $p=0.160$) or errors committed on the National Adult Reading Test (NART; Nelson & Willison, 1991), which provides an estimate of verbal IQ ($t=1.31$, $p=0.190$). Inclusion criteria for the PG group were: DSM-IV diagnostic criteria for PG, and age 18–60 years. PG was confirmed using the Massachusetts Gambling Screen (MAGS; Shaffer *et al.* 1994), which indexes the DSM-IV criteria, in conjunction with a score of ≥ 8 on the Problem Gambling Severity Index (PGSI; Ferris & Wynne, 2001). Exclusion criteria for both groups were: history of neurological illness, previous psychiatric hospitalization, current pharmacotherapy and significant physical illness. Among the controls, 27 had a PGSI score of 0 and had never gambled; two scored 1 on the PGSI and one scored 2.

The PG participants were recruited as a convenience sample, and comprised three subgroups in terms of their treatment profile: 15 gamblers (50%) were tested prior to receiving any treatment, seven (23%) were currently receiving treatment and eight (27%) had recently completed a 10-session course of cognitive behavioural therapy (CBT). In the PG group, the presence of other current and lifetime diagnoses of mental illness was assessed by a semi-structured interview using the ICD-10, in conjunction with the computerized version of the Mini International Neuropsychiatric Interview (e-MINI; Medical Outcome Systems, USA) (Sheehan *et al.* 1998). Any discrepancies between these measures were resolved through discussion with the lead psychiatrist (H.B.J.) and further review of the medical records. Ten cases met current or lifetime diagnoses of major depressive disorder (six current, four lifetime). Two cases recorded current generalized anxiety disorder. For substance use disorders, one case met lifetime cannabis dependence, one case lifetime alcohol dependence, and two cases current alcohol dependence. The healthy controls recorded no lifetime or current mental health problems on the e-MINI screen.

The various forms of gambling that were played were assessed with a modified version of item 1 from the South Oaks Gambling Screen (SOGS; Lesieur & Blume, 1987); in addition, the PG participants were asked which form they considered most problematic for them. Sixty per cent of the PG group considered fixed odds betting terminals (FOBTs) to represent their problematic form of gambling. The other preferred games were sports betting (16%), internet poker or blackjack (7%), slot machines (10%), and casino games (7%). Convergent data were obtained from games played once a week or more (SOGS item 1) (individual participants may endorse more than one form, so the total does not sum to 100%): gaming machines (59%),

betting on horses (52%), lottery (41%), sports betting (38%), card games (24%), casino games (17%), bingo (7%), bowling/pool (7%) or stock market (3%). In examining the relationship status of the participants, the modal status in the PG group was single (50%), 30% were in a steady relationship, 13% were married and 7% were divorced. Among controls, the modal status was married (47%), with 23% single, 17% in a steady relationship, 10% divorced and 3% widowed. Both groups were predominately of British nationality (PG: 97%; controls: 88%). Employment status was similar in both groups; in the PG group, 61% were employed full time, 7% students, 10% self-employed, 3% retired and 17% unemployed. In the controls, 43% were employed full time, 17% students, 3% self-employed, 17% unemployed and 13% in part-time employment. The PG group rated the largest amount of money gambled in a single day, on a four-point scale: £10–£100 (6%), £100–£1000 (17%), £1000–£10 000 (60%), over £10 000 (17%). Current level of debt ranged from £0 to £80 000: 23% had no debt due to bail-out; in the gamblers with current debt, this debt ranged from £600 to £80 000 (mean £25 557).

Procedure

All participants attended a single test session in a quiet laboratory or treatment room, where they completed a cognitive assessment and questionnaire measures of clinical and personality measures.

Kirby Monetary Choice Questionnaire (MCQ; Kirby *et al.* 1999)

The MCQ is a measure of delay discounting comprising 27 hypothetical choices between a smaller reward available immediately *versus* a larger reward available at some point in the future (e.g. 'Would you prefer £15 today or £35 in 13 days?'). The larger reward varies across three levels of magnitude: small (£25–£35), medium (£50–£60) and large (£75–£80), deriving three k values that were averaged for the overall discounting rate. Given that the k parameter assumes an underlying hyperbolic discounting curve, an area under the curve (AUC) value was also extracted for each participant, as a parameter that is neutral to the underlying discounting function (Myerson *et al.* 2001).

UPPS-P Impulsive Behaviour Scale (Cyders *et al.* 2007)

This is a 59-item self-report questionnaire using a Likert scale from 1 (I agree strongly) to 4 (I disagree strongly) to assess five impulsivity subscales: Negative Urgency (e.g. 'Sometimes when I feel bad, I can't seem to stop what I am doing even though it is making me feel worse'); Positive Urgency (e.g. 'When overjoyed, I feel like I can't stop myself from going

Table 1. Mean scores (s.d.) on the GRCS and UPPS-P Impulsivity Scale in the participants with pathological gambling (PG) and healthy controls

	PG	Controls	F	Cohen's <i>d</i>
GRCS				
Predictive Control	9.4 (6.2)	6.1 (2.7)	7.29*	0.75
Illusion of Control	14.4 (6.8)	4.4 (0.9)	64.3**	2.59
Interpretive Bias	14.7 (7.1)	6.2 (3.5)	34.5**	0.80
Gambling Expectancies	13.9 (6.4)	5.7 (2.5)	43.3**	1.85
Inability to Stop	11.1 (5.5)	5.9 (2.9)	21.1**	1.24
Total score	69.8 (27.7)	30.6 (10.6)		
UPPS-P				
Negative Urgency	35.6 (6.4)	24.3 (6.4)	47.2**	1.77
Positive Urgency	35.9 (8.3)	23.9 (8.1)	31.8**	1.46
(Lack of) Planning	26.6 (5.9)	23.3 (4.7)	5.58*	0.78
(Lack of) Perseverance	23.0 (5.6)	19.1 (4.3)	9.07*	0.61
Sensation Seeking	33.4 (5.9)	34.7 (6.9)	0.68	0.20

GRCS, Gambling-Related Cognitions Scale; s.d., standard deviation.
ANOVA degrees of freedom 1, 59.

* $p < 0.05$, ** $p < 0.005$.

overboard'); (lack of) Planning (e.g. 'I usually make up my mind through careful reasoning' – negative loading); (lack of) Perseverance (e.g. 'I finish what I start' – negative loading); and Sensation Seeking (e.g. 'I would enjoy the sensation of skiing very fast down a high mountain slope').

GRCS (Raylu & Oei, 2004a)

The GRCS a 23-item self-report questionnaire using a seven-point Likert scale from 1 (strongly disagree) to 7 (strongly agree) to assess five subscales: Predictive Control (e.g. 'Losses when gambling are bound to be followed by a series of wins'); Illusion of Control (e.g. 'I have specific rituals and behaviours that increase my chances of winning'); Interpretive Bias (e.g. 'Relating my winnings to my skill and ability makes me continue gambling'); Gambling Expectancies (e.g. 'Gambling makes things seem better'); and Inability to Stop (e.g. 'I'm not strong enough to stop gambling').

Statistical analysis

Statistical analyses were implemented in SPSS version 17 (SPSS Inc., USA). A natural log transformation was applied to the discounting k values, to improve suitability for parametric analysis. Visual inspection of the discounting data led to exclusion of three participants' scores on this measure (one PG, two controls), who uniformly selected the larger reward across all delay (i.e. the pre-specified delays and amounts on the MCQ failed to isolate indifference points for these participants). Group comparisons on the GRCS and

UPPS-P were performed by entering the component subscales into a multivariate ANOVA. A mixed-model ANOVA was used to compare k discounting values, with magnitude of the larger reward as a within-subjects factor. Within the PG group, Pearson's coefficients were used to assess univariate relationships between the UPPS-P, GRCS and Kirby MCQ variables, and a stepwise multiple linear regression assessed possible additive contributions of the UPPS-P and Kirby MCQ variables to predicting the level of cognitive distortions (with GRCS as the dependent variable).

Results

The PG group displayed a higher level of gambling-related cognitions ($F_{5,54} = 13.1$, $p < 0.001$), with significant differences on all of the GRCS subscales (see Table 1). On the UPPS-P, the PG group displayed elevated impulsivity ($F_{5,54} = 10.0$, $p < 0.001$), with significant differences on all subscales with the exception of Sensation Seeking (see Table 1). Effect sizes (Cohen's d) revealed stronger effects for the two urgency subscales ($d = 1.46$ – 1.77) in comparison to the narrow impulsivity subscales ($d = 0.61$ – 0.78).

Choice behaviour on the delay discounting scale was analysed using a mixed-model ANOVA of group (PG, controls) by magnitude (small, medium, large). The PG group displayed higher k values than healthy controls (main effect of group: $F_{1,55} = 8.02$, $p = 0.006$), indicating elevated impulsive choice in the PG group (see Fig. 1). All participants showed higher k values (steeper discounting) for smaller, compared to larger,

Table 2. Untransformed delay discounting measures on the Monetary Choice Questionnaire (MCQ), in the participants with pathological gambling (PG) and healthy controls

	PG	Controls
<i>k</i> score		
Large	0.0198 (0.0224)	0.0093 (0.0138)
Medium	0.0268 (0.0406)	0.0133 (0.0169)
Small	0.0398 (0.0459)	0.0192 (0.2310)
AUC value	0.503 (0.214)	0.642 (0.241)

AUC, Area under the curve.

Values given as mean (standard deviation).

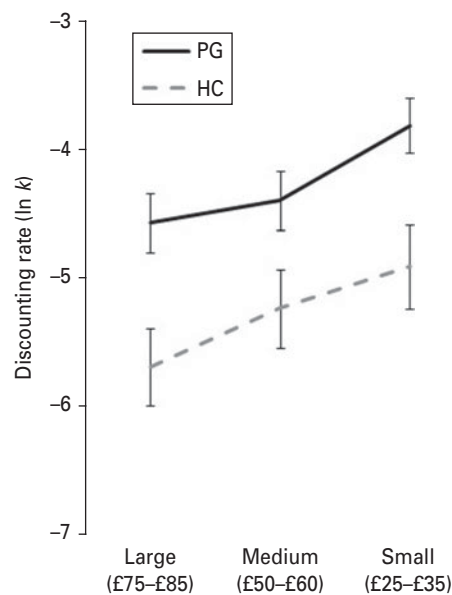


Fig. 1. Delay discounting ($\ln k$) on the Monetary Choice Questionnaire (MCQ), in patients with pathological gambling (PG) and healthy controls (HC). Errors bars indicate standard error of the mean.

delayed rewards ($F_{1,55}=23.2$, $p<0.001$). This is consistent with a typical 'magnitude effect' (e.g. Chapman, 1996), and suggests that the PG participants are using similar cognitive mechanisms for making these inter-temporal decisions to the healthy controls. There was no interaction of group by magnitude ($F_{1,55}=0.894$, $p=0.412$). In addition, the PG and healthy controls differed on the AUC measure for the discounting function ($t_{55}=2.3$, $p=0.025$), a parameter that does not assume any underlying mathematical function. The AUC values are displayed in Table 2, alongside the untransformed k scores for comparison with previous studies with the MCQ.

We examined univariate associations between delay discounting (average k), UPPS-P impulsivity and GRCS scores in the PG group. In keeping with

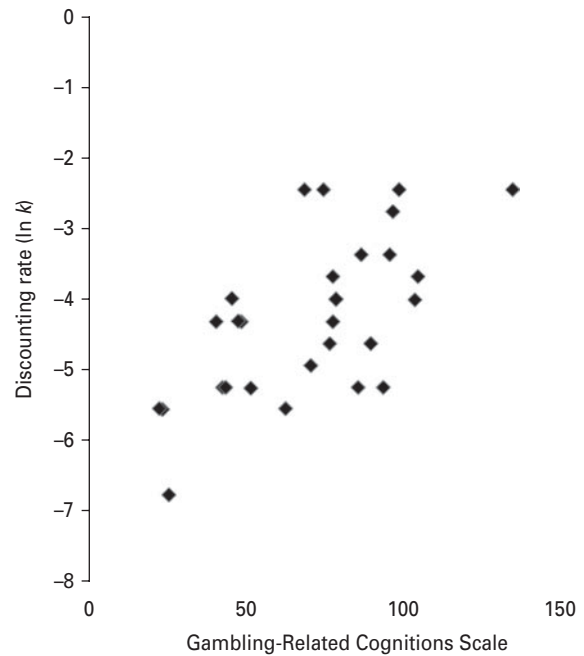


Fig. 2. Delay discounting ($\ln k$ scores, averaged across the three magnitude levels) is correlated significantly with total score on the Gambling-Related Cognitions Scale (GRCS), in the pathological gamblers.

previous work (e.g. Kirby *et al.* 1999; Mobini *et al.* 2007; Koff & Lucas, 2011), moderate associations were observed between the delay discounting rates and self-reported impulsivity (UPPS-P), with the highest coefficients observed on Lack of Planning ($r=0.376$, $p=0.044$) and Lack of Perseverance ($r=0.382$, $p=0.041$). A strong correlation was observed between impulsive choice on the delay discounting scale and the level of gambling cognitions (see Fig. 2), explaining 41% of the variance in the total GRCS score. Each of the GRCS subscale correlations was statistically significant (see Table 3). In light of a previous study showing that gambling distortions are attenuated by psychological treatment (Breen *et al.* 2001), we observed no significant difference in the GRCS scores in the three PG subgroups at different stages of treatment: pre-treatment group, mean GRCS=74.6 (s.d.=20.9); during treatment group, mean GRCS=71.4 (s.d.=37.2); post-treatment group, mean GRCS=59.5 (s.d.=30.6, $F_{2,27}=0.78$, $p=0.469$). Notably, the correlation between the discount rate and the GRCS total remained highly significant after controlling for stage of treatment (partial coefficient $r=0.612$, $p=0.001$).

UPPS-P impulsivity was less clearly associated with the level of cognitive distortions in the PG group: Negative and Positive Urgency were both associated with Illusion of Control, and Positive Urgency was additionally correlated with the Gambling Expectancies and Inability to Stop subscales, and the GRCS

Table 3. Univariate correlations (Pearson's r) between the delay discounting (Kirby k ; $n=29$), Gambling-Related Cognitions Scale (GRCS) ($n=30$) and UPPS-P ($n=30$) in the pathological gamblers

	Negative Urgency	Positive Urgency	Lack of Planning	Lack of Perseverance	Sensation Seeking	Kirby k
GRCS total	0.315	0.395*	0.289	0.184	0.122	0.644**
Illusion of Control	0.492**	0.497**	0.244	0.080	0.079	0.460*
Predictive Control	0.027	0.013	0.071	0.204	0.184	0.378*
Interpretive Bias	0.196	0.177	0.306	0.250	0.267	0.525**
Gambling Expectancies	0.254	0.413*	0.231	0.100	-0.197	0.566**
Inability to Stop	0.204	0.366*	0.223	0.115	0.147	0.581**
Kirby k	0.284	0.345	0.376*	0.382*	0.113	-

* $p < 0.05$, ** $p < 0.005$.

total (see Table 3). To test whether the UPPS-P urgency scales added significantly to the discounting rates in the prediction of gambling distortions, a stepwise multiple regression model was run with the total GRCS score as the dependent variable, and the delay discounting rate, Positive Urgency and Negative Urgency as predictors. The k score was the only variable retained in the model as a significant predictor of the level of cognitive distortions ($R^2=0.415$, overall $F_{1,27}=19.1$, $p < 0.001$, $k \beta=0.64$). (The same conclusion was drawn using a hierarchical regression with the discounting rate entered at the first step and the Urgency scores entered at the second step: there was no significant change in the R^2 between the two steps; overall $R^2=0.481$.) We also explored the relationships between delay discounting (average k) and the GRCS score and UPPS-P subscales in the healthy controls. The total GRCS scores displayed moderate variability in the controls (minimum = 23, maximum = 60) and, as in the PG, impulsive choice on the delay discounting measure was predictive of the level of gambling distortions ($r=0.431$, $p=0.022$). The correlations between delay discounting and the UPPS-P subscales were not significant in the controls, although the coefficients for Negative ($r=0.20$) and Positive ($r=0.34$) Urgency, and Lack of Planning ($r=0.21$), were comparable to the strength of relationships observed in previous studies (Kirby *et al.* 1999; Mobini *et al.* 2007; Koff & Lucas, 2011).

Discussion

The present study is the first UK study to describe clinical and psychological data in treatment-seeking PG. A convenience sample of 30 gamblers recruited from the National Problem Gambling Clinic were predominantly male, well-educated (48% had entered higher education), and typically in full-time employment (61%). As expected, these gamblers participated

in a range of games, with the preferred form of gambling being FOBTs in some 60% of the sample. These gaming machines (now known as category B2 gaming machines) are characterized by high stakes, high jackpots, and a rapid rate of play, and are a relatively new arrival on the UK gambling landscape. Although the national prevalence of FOBT play was low (4%) in the 2010 British Gambling Prevalence Survey (Wardle *et al.* 2010), FOBT play was the third most common form of gambling among the problem gamblers recruited in that survey (in 9%). Our data further highlight the attractiveness of these games in a treatment-seeking group with PG.

The major finding in the present dataset was of a relationship between impulsive choice on the delay discounting task and the level of gambling-related cognitive distortions. This was a particularly strong effect in the PG group, where discounting scores explained 41% of the variability in gambling distortions, and it was also observed at a significant level (19% shared variance) in the healthy controls. Group differences in impulsivity, and inaccurate beliefs about skill, chance and probability, are widely recognized in the literature on problem gambling, but the relationship between these putative aetiological mechanisms has received little attention. Our findings support a previous study in student gamblers (MacKillop *et al.* 2006), where the GBQ was correlated moderately ($r=0.40$) with Eysenck Impulsivity scores. We extend these findings into a treatment-seeking PG sample, and demonstrate that a state measure of impulsive choice is the stronger predictor of gambling distortions than self-reported impulsivity. This close linkage illustrates that gamblers with more 'myopic' (i.e. focused on the present) decision making and a reduced capacity to defer gratification are more susceptible to the diverse range of complex distortions that occur during play, such as beliefs in superstitions and rituals (GRCS Illusion of Control), the failure to appreciate

independence of turns (GRCS Predictive Control), and expectancies that gambling will be exciting and/or relieve negative affect (GRCS Gambling Expectancies) (Toneatto *et al.* 1997; Raylu & Oei, 2004a). Indeed, delay discounting was significantly associated with all five of the GRCS subscale scores in the PG group. Many of these distortions can also be elicited in healthy, non-problem gamblers (Clark, 2010), and we saw that discounting rates were also predictive of GRCS scores in the healthy controls. We have reported previously that individual differences on the GRCS predicted neural responses to gambling 'near-misses' in healthy non-gamblers (Clark *et al.* 2009).

We were able to replicate several group differences reported previously in Australian and North American studies. First, the PG group reported more cognitive distortions on the GRCS, with significant group differences on each of the five subscales (Raylu & Oei, 2004a; Emond & Marmurek, 2010). Prospective data do not yet exist to arbitrate whether these cognitions predate the onset of problem gambling, or occur as a consequence of long-term gambling. Second, the PG group displayed elevated impulsivity on the UPPS-P questionnaire. Significant differences were observed on the two subscales of 'narrow' impulsivity (Lack of Premeditation and Lack of Perseverance) and also on the two Urgency subscales, but the effect sizes for the Urgency subscales were considerably larger. This is the first study to differentiate Positive Urgency and Negative Urgency in treatment-seeking PG, and our findings clearly emphasize the relevance of these constructs to PG. By inference, impulsive acts in problem gamblers may predominantly arise through an interaction with current affective state, perhaps through impaired emotion regulation mechanisms (Billieux *et al.* 2010; Cyders *et al.* 2010). Although Positive and Negative Urgency scales were correlated in the present data, it remains to be seen whether positive or negative mood states represent distinct pathways to risk taking in individual gamblers (Blaszczynski & Nower, 2002). We observed no group differences in sensation seeking, consistent with some (Blaszczynski *et al.* 1986; Parke *et al.* 2004; Ledgerwood *et al.* 2009) but not all (Cunningham-Williams *et al.* 2005) previous studies in PG. This may reflect the exclusively male sample (Nower *et al.* 2004), or it is possible that sensation seeking can be decomposed further into subfactors, such as boredom proneness, some of which may be associated with PG (Fortune & Goodie, 2010). Alternatively, sensation seeking may dispose recreational engagement with gambling rather than the transition to disordered gambling, and may therefore have less relevance to adult treatment-seeking groups (cf. van Leeuwen *et al.* 2010).

Finally, there were significant differences in delay discounting between the two groups, in addition to the individual differences seen on this measure. Both groups showed the standard 'magnitude effect' on the discounting task, such that large rewards of a relatively higher value (£75–£85) were discounted less than large rewards of a relatively smaller value (£25–£35). This is a consistent finding in the behavioural economics literature (Chapman, 1996; Green & Myerson, 2004), and, as in the original study using this measure in heroin addicts (Kirby *et al.* 1999), the magnitude effect did not interact with group status: participants with PG showed similar sensitivity to reward magnitude to the controls. Steeper discounting on the Kirby MCQ procedure replicates previous work in PG using other variants of the delay discounting paradigm (Petry, 2001a; Alessi & Petry, 2003; Dixon *et al.* 2003; MacKillop *et al.* 2006; Ledgerwood *et al.* 2009), and patients with Parkinson's disease with medication-induced PG also show steeper delay discounting than controls with Parkinson's disease on the MCQ (Housden *et al.* 2010). The discount rates in the PG group were correlated significantly with the UPPS-P subscales of 'narrow' impulsivity. This is in keeping with past personality studies in the general population, which primarily find an association with the Barratt non-planning subscale (Kirby *et al.* 1999; Mobini *et al.* 2007; Koff & Lucas, 2011). Although statistically significant in the larger studies, it is likely that this state–trait relationship is of only modest strength ($r \approx 0.3$) because of the distinct sources of variability in the two measures: one is an introspective evaluation of generalized impulsive tendencies and the other is a state measure involving a series of financial decisions.

Some limitations should be noted. First, the present sample was composed of only treatment-seeking PG, and findings may not generalize to all levels of disordered gambling (although see MacKillop *et al.* 2006), and our convenience sample included a mixture of cases tested before, during and after treatment. It was reported previously that ratings of gambling distortions are reduced by a course of psychotherapy (Breen *et al.* 2001), although such an effect was not statistically significant in our data, possibly because the CBT programme did not place a strong emphasis on the correction of specific gambling distortions. Nonetheless, the association with delay discounting remained highly significant when partialling for stage of treatment. Second, in this restricted sample we did not exclude participants with some of the common clinical co-morbidities with PG, including mood disorders and substance use disorders, which may be associated with impulsivity and discounting tendencies (Reynolds, 2006; Takahashi *et al.* 2008;

Dombrowski *et al.* 2011). We note that the rate of substance use disorder co-morbidity was relatively low compared to international data in treatment-seeking PG (Ramirez *et al.* 1983; Black & Moyer, 1998), and we did not examine the additive impact of these co-morbidities on psychological functioning (e.g. Petry, 2001a) for reasons of statistical power.

Previous studies have described associations between facets of impulsivity and gambling severity (Steel & Blaszczynski, 1998; Krueger *et al.* 2005), physiological arousal during gambling (Anderson & Brown, 1984; Krueger *et al.* 2005), and short-term treatment outcomes (Leblond *et al.* 2003; Goudriaan *et al.* 2008). The present work highlights mood-related impulsivity ('urgency') and delay discounting as especially relevant facets in gambling behaviour. The correlation between delay discounting and gambling distortions may indeed shed further light on the nature of these faulty cognitions in disordered gambling. Previous work eliciting gambling distortions with the 'think aloud' technique has reported high rates of erroneous verbalizations even in non-problematic regular players (Ladouceur & Walker, 1996; Delfabbro, 2004), and it was not until psychometric measures such as the GRCS and GBQ were developed that the elevated level of distortions in PG became evident (Raylu & Oei, 2004a; Emond & Marmurek, 2010; Myrseth *et al.* 2010). However, it remains unclear from the psychometric scales whether increased scores reflect the *frequency* of these cognitions, the *conviction* with which the beliefs are held, or the tendency to use these beliefs to justify excessive gambling (Ladouceur & Walker, 1996; Delfabbro, 2004). Measures of impulsivity, and the delay discounting paradigm most specifically, capture the conflict between short-term gratification and longer-term gains. The resolution of these inter-temporal decisions recruits neural regions, including the ventral striatum and ventromedial prefrontal cortex (McClure *et al.* 2004; Hariri *et al.* 2006; Sellitto *et al.* 2010), that are implicated in the pathophysiology of problem gambling (Potenza *et al.* 2003; Reuter *et al.* 2005; Lawrence *et al.* 2009b). These dilemmas may be analogous to the conflict that gamblers experience between the rapid acceptance of a distorted belief, *versus* a more deliberative, analytical appraisal that their recent gambling results do not reflect skill, luck or other common biases. Measures of impulsivity including delay discounting were also seen to predict more general Beckian cognitive distortions associated with psychopathology in a student sample (Mobini *et al.* 2006, 2007). Therefore, based on the link between delay discounting and GRCS scores, we hypothesize that the willingness to accept distorted gambling thoughts over more rational explanations may be a key pathological process in disordered gambling.

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Declaration of Interest

None.

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