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Executive functioning in Asian pathological gamblers

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Two decades of neuropsychological research on predominantly Caucasian problem gamblers has unveiled significantly poorer performance on several domains of executive functioning (EF) relative to healthy controls. However, contradictory findings are widespread and evidence that pathological gamblers (PGs) are ‘impaired’ remains inconclusive. The study examined multiple facets of EF in 30 male, PGs seeking outpatient treatment in Singapore and 30 matched controls. CANTAB® tests of planning and organization/problem-solving, set-shifting, working memory and reflection impulsivity, were administered alongside the Barratt Impulsiveness Scale, Cognitive Failures Questionnaire and Dysexecutive Questionnaire. No significant group differences were found on any of the EF performance parameters, with performance falling in the healthy, unimpaired range for both groups. PGs did, however, report significantly greater impulsivity, everyday cognitive failures and symptoms of the dysexecutive syndrome. Exploratory analysis on a subgroup of PGs addicted to non-strategic gambling activities revealed poorer EF performance than among those addicted to strategic gambling activities. The findings suggest an absence of EF deficits despite higher trait impulsivity in Asian, predominantly strategic PGs. Hence, psychological interventions such as CBT and treatment approaches that emphasize the use of self-monitoring and informed decision-making to reduce impulsive behaviours should be suited to this population.

Keywords: strategic; pathological gambling; executive functioning; reflection impulsivity; Asian

Introduction

Pathological gambling is estimated to affect 0.4 to 1.2% of the adult population in western cultures such as the USA and New Zealand (Abbott & Volberg, 1996; Hodgins, Stea, & Grant, 2011), and between 0.8 to 1.8% in Asia including Hong Kong, Macau, Singapore and South Korea (Fong & Ozorio, 2005; National Council on Problem Gambling, 2011; Park et al., 2009; Wong & So, 2003). The persistent, maladaptive nature of gambling behaviours (e.g. chasing losses) may reflect poor self-regulation/monitoring arising from deficits in executive functioning, e.g. mental inflexibility, impulsiveness or impaired reward pathways leading to poor decision-making (see Goudriaan, Oosterlaan, de Beurs, & van den Brink, 2004; Van Holst, van den Brink, Veltman, & Goudriaan, 2010 for reviews). However, the neuropsychological literature pertaining to executive functioning (EF) among pathological gamblers (PGs) is largely inconclusive.

Studies have reported significantly poorer EF performance among PGs relative to control samples on tests of planning (Goudriaan et al., 2006; Ledgerwood et al., 2012;
Rugle & Melamed, 1993), set-shifting/cognitive flexibility (Forbush et al., 2008; Goudriaan, Oosterlaan, de Beurs, & van den Brink, 2006; Grant, Chamberlain, Schreiber, & Odlaug, 2012a; Kalechstein et al., 2007; Marazziti et al., 2008; Odlaug, Chamberlain, Kim, Schreiber, & Grant, 2011), working memory (Forbush et al., 2008; Leiserson & Phil, 2007), impulse control/inhibition (Forbush et al., 2008; Goudriaan et al., 2006; Grant et al., 2012a; Kalechstein et al., 2007; Lawrence, Luty, Bogdan, Sahakian, & Clark, 2009; Odlaug et al., 2011; Potenza et al., 2003; Roca et al., 2008) and reflection impulsivity (Lawrence et al., 2009). However, there exists much contradictory evidence, with several studies reporting the presence of only selective EF deficits and otherwise normal EF, e.g. in set-shifting (Cavedini, Riboldi, Keller, D’Annucci, & Bellodi, 2002), planning (De Ruiter et al., 2009) and working memory (Lawrence et al., 2009). Our knowledge on the nature and extent of EF impairment in PGs is further hampered by the diversity in sampling methods (e.g. problem gambling duration, severity, length of abstinence, gambling subtypes, the presence of psychiatric/substance co-morbidity) and measures of EF (e.g. different tests and respective outcome performance parameters) used across the studies. The greatest convergence of findings comes from studies examining decision-making using the Iowa Gambling Task (IGT) (Brevers et al., 2012; Forbush et al., 2008; Goudriaan, Oosterlaan, de Beurs, & van den Brink, 2005; Lakey, Goodie, & Campbell, 2007; Ledgerwood et al., 2012; Linnet, Rojskjer, Nygaard, & Maher, 2006; Power, Goodyear, & Crockford, 2012; Roca et al., 2008). The IGT (Bechara, Damasio, Damasio, & Anderson, 1994) has been regarded as the most widely used and ecologically valid measure of decision-making, yet its complexity and high loading on multiple underlying cognitive processes (e.g. visual searching, working memory, updating, inhibiting previously learned disadvantageous responses and reversal learning) is well documented (Del Missier, Mäntylä, & de Bruin, 2012; Fellows & Farah, 2005; Van Holst et al., 2010). Up to 30% of healthy controls have been reported to elicit poor performance on this task (Li, Lu, D’Argembeau, Ng, & Bechara, 2010) with normal performance also observed in PGs (Brand et al., 2005; Tanabe et al., 2007). Furthermore, factor analysis of IGT performance revealed higher loadings on attentional than on EF domains (Gansler, Jerram, Vannorsdall, & Schretlen, 2011). Thus, IGT does not provide an indication of where specific executive deficits exist and the extent of their severity. Most studies conclude that PGs exhibit EF deficits based on statistically significant differences in task performance between PGs and controls, yet raw scores indicate that performance rarely falls in the ‘clinically impaired range’ (i.e. on or below the fifth percentile – equivalent to a score of more than 1.64 standard deviations (SDs) below healthy controls). Therefore, the extent to which PGs show clinically meaningful EF deficits remains unclear. Problem gambling is particularly prevalent among members of certain races, e.g. Chinese, both in Asian countries and among Asian immigrants in countries such as Australia, Canada and the US (Loo, Raylu, & Oei, 2008; Oei & Raylu, 2007), yet all neuropsychological research on PGs to date has been restricted to western (predominantly Caucasian) populations. This gap in the knowledge base should be addressed so that we can tailor psychological treatment approaches to accommodate cognitive weaknesses and capitalize on cognitive strengths, in order to enhance treatment effectiveness.

The current study set out to examine multiple aspects of EF, including cognitive flexibility (set-shifting), planning, working memory, and decision-making (reflection impulsivity), through neuropsychological test performance and self-reported measures of cognitive functioning among a sample of Asian PGs. The study also set out to explore whether EF differed according to main problem gambling activity, since research comparing the performance of PGs addicted to purely luck-based (non-strategic) gambling
versus more skills-influenced (strategic) gambling is limited (Goudriaan et al., 2005; Grant et al., 2012a) and inconclusive. Addressing some of the shortcomings of earlier research, it compares the performance of PGs to controls matched demographically on age, race and education, and also extends knowledge on the associations between neuropsychological performance and self-reported measures of impulsivity, cognitive failures and the dysexecutive syndrome.

Method

Participants and procedures

The clinical sample comprised 30 adult outpatients from the National Addictions Management Service (NAMS, Singapore) who had been assessed by a psychiatrist and met at least five items of the DSM-IV-TR criteria for Pathological Gambling. Inclusion criteria were: (1) primary diagnosis of Pathological Gambling; (2) aged 21–60; (3) able to understand and converse in English. An a priori power analysis was conducted based on a single earlier study at time of design (Lawrence, 2009), whereby a minimum sample of 15 was required in each group to achieve at least 80% power to detect a medium-sized difference with a .05 two-sided significance level. Suitable patients were referred by clinicians to a researcher, who then completed the neuropsychological assessment and interview with patients in a single session on their second or third visit to the clinic. Only 2 out of 32 (6%) referred patient declined participation due to lack of interest. Thirty controls matched to patients’ age, gender, ethnicity and education level were recruited through the hospital staff and their relatives and friends via word of mouth and email advertisements. All matched controls scored less than 8 points on the Problem Gambling Severity Index (PGSI) (Ferris & Wynne, 2001), with a mean score of 0.2 (with one scoring 3, which falls in the moderate-risk for problem gambling range). Exclusion criteria for both samples included: problematic alcohol use, illicit drug use in the past year, current use of antipsychotics or benzodiazepines, history of head injury with loss of consciousness exceeding five minutes, and other severe mental illnesses including psychotic disorder and/or neurological diseases. Control subjects completed the self-reported and neuropsychological measures at the clinic. The study protocol was approved by the National Healthcare Group (Singapore) ethics review board (Protocol no.: A/10/245). Written informed consent was obtained for all participants.

Measures

Self-reported

All participants were administered the South Oaks Gambling Screen (SOGS) (Lesieur & Blume, 1987) to measure problematic gambling behavior, and the Hospital Anxiety and Depression Scale (HADS) (Zigmond & Snaith, 1983) to determine the level of anxiety and depression experienced in the past week. Self-reported personality and cognitive measures included the Barratt Impulsiveness Scale (BIS; Patton & Stanford, 1995) as a measure of impulsive personality traits, the Cognitive Failures Questionnaire (CFQ; Broadbent, Cooper, FitzGerald, & Parkes, 1982) to assess individual cognitive lapses and slips, and the Dysexecutive Questionnaire (DEX; Wilson, Alderman, Burgess, Emslie, & Evans, 1996) which assesses behaviour associated with dysexecutive syndrome, emotional, and behavioural problems, and gives a comprehensive picture of commonly reported symptoms that are described in layman’s terms (Chan, 2001). On these three scales, a higher score reflects greater impulsivity or cognitive dysfunction (i.e. poorer functioning).
Neuropsychological battery

The neuropsychological battery comprised only non-verbal tests: Raven’s Progressive Matrices (RPM) as a measure of fluid intelligence (generating an estimated full scale intelligence quotient FSIQ) and five computerized cognitive paradigms from the Cambridge Neuropsychological Test Automated Battery (CANTAB®). Both tools have been validated in diverse populations and have the advantage of not being cultural or language sensitive; which is important since English is not necessarily the primary spoken language in Singapore. Nevertheless, all participants demonstrated sufficient proficiency in both understanding and speaking English, were able to follow verbal instructions, completed the self-reported measures, and most (24/30) were under 45 years of age and hence received British education locally.

The CANTAB battery included the Motor Screening Test (MOT) to introduce the touch-screen interface, and four subtests of EF [i.e. Stockings of Cambridge (SOC), Intra-extra Dimensional Set-shift (IED), Spatial Working Memory (SWM) and Information Sampling Test (IST)]. These subtests were selected on the basis that they tap into relevant aspects of EF which may underlie poor planning, impulsivity and rigidity in thought processing, often seen in PGs.

The SOC is a measure of planning and organization, and is analogous to the Tower of London Test (Shallice, 1982). The examinee is presented with two displays (three stacks each) containing coloured balls. The goal is to move the balls in the lower display to match the arrangement of balls in the top display, using the least number of moves. Performance parameters include time taken (in seconds) to plan the moves (i.e. mean initial thinking time), time taken to complete the task after the first move has been made (i.e. mean subsequent thinking time) and the number of moves made to complete each task.

IED is a measure of mental flexibility (set-shifting) and is analogous to the Wisconsin Card Sort Test (WCST; Berg, 1949; Grant & Berg, 1948). It features rule acquisition and reversal, visual discrimination, attentional set formation/maintenance, shifting and flexibility of attention. On this task, two artificial dimensions are used and the examinee must learn the correct dimension by trial and error with feedback. After six correct responses, the stimuli/rule changes. The shift in rule is initially intra-dimensional (i.e. within one relevant dimension), then later extra-dimensional (i.e. switches to a new dimension where the previous one becomes irrelevant). The most commonly used performance parameters are completed stages and total number of errors made during the intra and extra-dimensional shift stage.

The SWM test is a measure of ability to retain spatial information and manipulate remembered items in working memory. This self-ordered search task also assesses heuristic strategy, and is a sensitive measure of frontal lobe functioning. The examinee is presented with a number of boxes and must touch each box in turn to discover where a blue token is hidden (a search). They are informed that once the token is found, that box will not contain another within that search set. At each stage the number of boxes presented increases to a maximum of eight boxes in total, whereby both the colour and position of boxes change in each trial. Performance parameters used are between-search errors (forgetting errors) which are committed when a box previously opened and emptied of a blue token is revisited during a search, and strategy score, i.e. the ability to adopt a consistent search sequence with a novel box, and total errors.

The IST is a measure of reflection impulsivity and decision-making. The examinee is presented with 25 boxes which reveal one of two colours when selected. The examinee must decide which is the dominant colour by opening as many boxes as desired to reveal
the colour. There are two conditions: the ‘fixed reward’ condition (ISTf) has no penalty for opening more boxes, thereby increasing the certainty of choosing the correct colour to win points; in the ‘reward conflict’ (ISTd) condition 10 points are deducted with each box opened, thus opening fewer boxes increases potential for larger rewards yet also implies that a greater extent of uncertainty is tolerated before making a decision, indicating greater reflection impulsivity. The most commonly used overall performance parameters are number of boxes opened and \(P(\text{correct})\) i.e. the probability of the subject being correct at the point of decision based on the information revealed on a trial-by-trial basis (see Lawrence et al., 2009 for the formula). Order of IST condition was counterbalanced across participants.

**Analyses**

Demographic and clinical data between PGs and control subjects were compared. Mean and standard deviation (SD) were calculated for continuous variables; frequencies and percentages for categorical variables. Normality of continuous data was checked using the Shapiro-Wilks test. Differences between PGs and matched controls were explored using student’s \(t\)-tests for continuous variables and Chi-square analysis for categorical variables. Pearson’s correlations were performed to examine the relationships between the EF subtests and self-reported cognitive functioning (DEX & CFQ); subsequently between self-reported cognitive functioning, self-reported impulsivity (BIS) and problem gambling severity score (SOGS). All statistical analyses were conducted using PASW 18.0 statistical package, with statistical significance conclusions made at \(p < .05\).

**Results**

**Demographic and clinical characteristics and gambling behaviour**

PGs were predominantly Chinese, with a mean age of 37.1 years and had received an average of 12 years of formal education. There were no significant demographic differences (i.e. age, race, education level or marital status) between PGs and matched controls (MCs) (see Table 1), except for significantly higher employment rates among controls. The primary problematic gambling activity for PGs was sports (\(n = 14\)), followed by card games (\(n = 9\)), gambling machines (\(n = 4\)), dice games (\(n = 1\)),

| Demographic and self-report clinical measures for PGs and matched controls (MC). |
|---------------------------------|---------------------------------|------------------------------|----------------|
| **Age** | 37.1 (± 8.9) | 37.2 (± 11.7) | 0.06\(^{t}\) | 0.951 |
| **Male** | 30 (100) | 30 (100) | - | - |
| **Chinese** | 27 (90) | 27 (90) | 0.00\(^{c}\) | 1.000 |
| **Education** | | | | |
| Above secondary | 20 (66.7) | 22 (73.3) | 0.32\(^{e}\) | 0.573 |
| Years of formal education | 12.4 (± 2.0) | 12.0 (± 2.4) | 0.74\(^{t}\) | 0.454 |
| **Married** | 16 (53.3) | 17 (56.7) | 0.07\(^{e}\) | 0.795 |
| **Employed** | 22 (73.3) | 29 (96.7) | 6.41\(^{c}\) | 0.011 |
| **HADS** | | | | |
| Anxiety | 8.8 (± 5.7) | 4.7 (± 3.8) | 3.32\(^{t}\) | 0.002 |
| Depression | 7.4 (± 5.2) | 3.8 (± 3.0) | 3.34\(^{t}\) | 0.001 |
| SOGS | 13.4 (± 2.8) | 1.2 (± 2.6) | 17.42\(^{t}\) | 0.000 |

*Note: Statistical test used for comparisons: \(^{t}\) -test, \(^{c}\)Chi-square.*

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mahjong \((n = 1)\), and lotteries \((n = 1)\). Based on existing literature dichotomizing gambling activities into two categories: strategic and non-strategic gamblers \(\text{(Grant, Odlaug, Chamberlain, & Schreiber, 2012b; Odlaug et al., 2011; Potenza et al., 2001)}\), most PGs \((n = 25)\) in this study were strategic gamblers \(\text{(i.e. with a primary gambling problem in soccer, horse betting, card/dice games or mahjong)}\), whereby the outcome of games played can potentially be influenced by the application of knowledge, skills, or decisions made by the gambler. The remaining five were non-strategic gamblers \(\text{(i.e. with a primary gambling problem in electronic gaming machines or lotteries)}\) whereby outcomes are purely luck-based/random or the gambler has no or minimal influence on the outcome. Mean gambling days in the past month was 15.0 \(\text{(SD 10.8)}\) and the median debt amount due to gambling was S$32,500, with only two reporting that they had no debts at the time of interview. The mean SOGS score for PGs was 13.4 \(\text{(SD 2.8)}\) which is indicative of pathological gambling among Chinese gamblers \(\text{(Tang, Wu, Tang, & Yan, 2010)}\). This was significantly higher than the mean score of 1.2 \(\text{(SD = 2.6)}\) among controls \(\text{(}\ p < .001\text{)}\) which falls in the non-problem gambling range. Although one control scored in the lifetime probable pathological gambling range \(\text{(i.e. 10)}\), their PGSI score and self-report confirmed the absence of any gambling problem in the past year. Patients met an average mean of 7.1 \(\text{(SD 1.2)}\) out of 10 of DSM-IV-TR criteria for PG. Three PGs presented with comorbidities; two with adjustment disorder and one with both depression and generalized anxiety disorder. Whilst two PGs were in receipt of SSRI antidepressants \(\text{(fluvoxamine)}\), the low dosages \(\text{(i.e. 50 or 100 mg)}\) taken only at night \(\text{(for their sedative effect)}\) were considered unlikely to negatively affect cognitive functioning \(\text{(Biringer, Rongve, & Lund, 2009)}\). Seven PGs reported having a psychiatric history, and 10 \(\text{(33.3\%)}\) reported having made a previous suicide attempt and a further 11 \(\text{(36.7\%)}\) reported suicidal ideations but no previous attempts. PGs obtained significantly higher scores on both subscales of the HADS, indicating greater anxiety and depression \(\text{(see Table 1)}\).

**Neuropsychological performance**

PGs and matched controls did not differ on RPM raw scores at 50.4 \(\text{(SD = 5.4)}\) and 50.6 \(\text{(SD = 6.4)}\). Similarly, mean converted FSIQ score fell within the normal range for both groups at 98.8 \(\text{(SD = 11.0)}\) and 98.5 \(\text{(SD = 11.6)}\) respectively. No significant group differences were found in mean scores on any performance parameter on the SWM, SOC, IED or IST tests. Overall, PGs performance \(\text{(Z-scores)}\) remained within half a standard deviation of matched controls \(\text{(see Table 2)}\), indicating an absence of clinical impairment. Similarly, the performance of PGs never exceeded 1 SD below that of healthy individuals matched on age and IQ from CANTAB normative data; indicating normal/unimpaired performance. On the IST, a mixed-model ANOVA indicated a significant main effect of task condition \(\left[F(1, 56) = 9.34, p < .01\right]\), \(\text{(i.e. both groups sampled less information in the reward-conflict condition compared to the fixed-reward condition)}\), but no significant interaction was found between condition and group.

Due to the small sample size in each group, Mann-Whitney U was used to explore the differences in CANTAB performances between strategic and non-strategic gamblers. Mean scores of non-strategic gamblers suggested a trend for poorer performance on IED and SWM. This, coupled with a statistically significant increase in boxes opened and \(P\) (correct) on ISTd \(\text{(}U = 22\text{ and }27, \text{ both } p < .05\text{)}\), suggests a higher likelihood for a more conservative \(\text{(less risk-taking)}\) style of decision-making \(\text{(see Table 3)}\). Non-strategic gamblers also had a significantly higher probability of guessing the correct colour, compared to controls \(\text{(}U = 13, p < .05\text{)}\).
Self-reported cognitive functioning and impulsivity

Relative to controls, PGs obtained significantly higher scores on the self-reported measure of impulsivity (BIS) and everyday behaviours associated with the dysexecutive syndrome (DEX), but not on the measure of everyday cognitive failures (CFQ) (see Table 4).

Relationship between EF, other measures of cognitive functioning & impulsivity

No significant relationships were found between behavioural (CANTAB) cognitive performance and self-report measures of cognitive function (CFQ, DEX) and impulsivity (BIS). None of the gambling severity scores (SOGS, GSAS, days gambled/month) significantly correlated with the CANTAB measures; however, DEX and BIS were both found to significantly correlate with SOGS score (DEX: $r = 0.5$, $p < 0.05$; DEX and CFQ also had a strong correlation of $0.6$, $p < 0.001$).

Discussion

The study attempted to replicate the finding of EF deficits in PGs with an Asian sample by comparing their performance to healthy controls closely matched on demographic characteristics that influence cognitive functioning. PGs reported significantly greater

Relationship between self-reported cognitive functioning and impulsivity

Relative to controls, PGs obtained significantly higher scores on the self-reported measure of impulsivity (BIS) and everyday behaviours associated with the dysexecutive syndrome (DEX), but not on the measure of everyday cognitive failures (CFQ) (see Table 4).

Table 2. Scores on CANTAB measures for PGs and MCs.

<table>
<thead>
<tr>
<th>CANTAB tasks</th>
<th>Raw scores comparisons</th>
<th>PG M ± SD</th>
<th>MC M ± SD</th>
<th>t</th>
<th>Z</th>
<th>Cohen's $d$</th>
<th>p</th>
<th>CANTAB SS</th>
</tr>
</thead>
<tbody>
<tr>
<td>SOC Problems solved in minimum move</td>
<td>$8.9 ± 1.8$</td>
<td>$8.2 ± 1.9$</td>
<td>$0.74$</td>
<td>$0.05$</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>SOC Mean subsequent thinking time(s)*</td>
<td>$8.5 ± 0.74$</td>
<td>$8.2 ± 1.9$</td>
<td>$0.40$</td>
<td>$0.10$</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>DEX: Extradimensional shift (EDS) errors*</td>
<td>$13.9 ± 12.5$</td>
<td>$5.4 ± 3.9$</td>
<td>$1.06$</td>
<td>$0.27$</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>DEX: Intradimensional shift (IDS) errors*</td>
<td>$21.0 ± 17.1$</td>
<td>$15.4 ± 11.3$</td>
<td>$0.98$</td>
<td>$0.27$</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>SWM: Total errors*</td>
<td>$14.5 ± 4.6$</td>
<td>$10.4 ± 3.7$</td>
<td>$0.90$</td>
<td>$0.27$</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>SWM: Between search error*</td>
<td>$19.4 ± 15.5$</td>
<td>$15.9 ± 11.3$</td>
<td>$1.08$</td>
<td>$0.27$</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>SWM: Total errors*</td>
<td>$21.0 ± 17.1$</td>
<td>$15.4 ± 11.3$</td>
<td>$1.06$</td>
<td>$0.27$</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>ISTf Boxes opened</td>
<td>$10.4 ± 4.2$</td>
<td>$9.1 ± 3.0$</td>
<td>$0.56$</td>
<td>$0.27$</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>ISTf P(correct)</td>
<td>$0.8 ± 0.1$</td>
<td>$0.8 ± 0.1$</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>ISTf Boxes opened</td>
<td>$11.1 ± 4.2$</td>
<td>$10.7 ± 3.9$</td>
<td>$0.59$</td>
<td>$0.27$</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>ISTf P(correct)</td>
<td>$0.8 ± 0.1$</td>
<td>$0.8 ± 0.1$</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>ISTd Boxes opened</td>
<td>$14.5 ± 4.6$</td>
<td>$12.9 ± 3.7$</td>
<td>$0.90$</td>
<td>$0.27$</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>ISTd P(correct)</td>
<td>$0.7 ± 0.1$</td>
<td>$0.7 ± 0.1$</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>ISTd Boxes opened</td>
<td>$10.4 ± 4.2$</td>
<td>$8.7 ± 3.9$</td>
<td>$0.59$</td>
<td>$0.27$</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>ISTd P(correct)</td>
<td>$0.8 ± 0.1$</td>
<td>$0.8 ± 0.1$</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td></td>
</tr>
</tbody>
</table>

*Higher score reflects poorer functioning.

Abbreviations referred to as: PG, pathological gamblers; MC, matched controls; SS, standard scores; SOC, Stockings of Cambridge task; EED, Extradimensional Shift Test; DEX, dysexecutive syndrome; SWM, Spatial Working Memory task; ISTf, Information Sampling Task 'fixed reward'; ISTd, Information Sampling Task 'reward conflict'.
impulsivity and symptoms of the dysexecutive syndrome. However, no significant group differences were found on any of the EF performance parameters, with performance falling within the healthy, unimpaired range for both groups. In addition, PGs exhibited a good understanding of the task goals by displaying within-normal range test results and successfully opening fewer boxes in the reward-conflict condition relative to the fixed-reward condition on the IST; indicating normal sensitivity to changes in reward contingencies. Whilst this is not the first study to report evidence of intact EF among PGs (Cavedini et al., 2002; De Ruiter et al., 2009; Lawrence et al., 2009), the findings are incongruent with the larger number of studies reporting evidence of at least selective EF deficits. We now consider possible explanations for this finding.

Firstly, it is unlikely that the failure to find group differences is due to inadequate statistical power, as we recruited double the minimum number of participants indicated in

Table 3. Self-report cognitive functioning and impulsivity in strategic and non-strategic PGs.

<table>
<thead>
<tr>
<th>CANTAB tasks</th>
<th>Raw scores comparisons</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Strategic PG M, ± SD</td>
</tr>
<tr>
<td>SOC Problems solved in minimum move</td>
<td>8.7 ± 1.9</td>
</tr>
<tr>
<td>SOC Mean initial thinking time(s)*</td>
<td>8.2 ± 4.8</td>
</tr>
<tr>
<td>SOC Mean subsequent thinking time(s)*</td>
<td>1.5 ± 2.2</td>
</tr>
<tr>
<td>IED Stages completed</td>
<td>8.3 ± 1.0</td>
</tr>
<tr>
<td>IED Total errors (adjusted)*</td>
<td>29.1 ± 21.6</td>
</tr>
<tr>
<td>IED Pre-EDS errors*</td>
<td>4.9 ± 2.5</td>
</tr>
<tr>
<td>IED EDS errors*</td>
<td>14.3 ± 11.3</td>
</tr>
<tr>
<td>SWM Strategy score*</td>
<td>31.7 ± 4.0</td>
</tr>
<tr>
<td>SWM Between search error*</td>
<td>18.5 ± 13.3</td>
</tr>
<tr>
<td>SWM Total errors*</td>
<td>19.8 ± 14.1</td>
</tr>
<tr>
<td>ISTf P(correct)</td>
<td>0.8 ± 0.1</td>
</tr>
<tr>
<td>ISTf Boxes opened</td>
<td>13.9 ± 4.7</td>
</tr>
<tr>
<td>ISTd P(correct)#</td>
<td>0.7 ± 0.1</td>
</tr>
<tr>
<td>ISTd Boxes opened#</td>
<td>9.6 ± 3.7</td>
</tr>
</tbody>
</table>

* Higher score reflects poorer functioning.
# p < .05

Abbreviations referred to as: PG, pathological gamblers; SOC, Stockings of Cambridge task; IED, Intra/extra Dimensional Set-shift Test; EDS, extradimensional shift; SWM, Spatial Working Memory task; IST, Information Sampling Task; ISTf, Information Sampling Task ‘fixed reward, ISTd, Information Sampling Task ‘reward conflict’.

Table 4. Self-report cognitive functioning and impulsivity in PGs and MCs.

<table>
<thead>
<tr>
<th></th>
<th>PG M, ± SD/n (%)</th>
<th>MC M, ± SD/n (%)</th>
<th>t, χ²</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIS</td>
<td>70.0 ± 14.1</td>
<td>58.8 ± 9.1</td>
<td>3.63¹</td>
<td>0.001</td>
</tr>
<tr>
<td>Highly impulsive (&gt;71)</td>
<td>13 (43.3)</td>
<td>1 (3.3)</td>
<td>13.46⁵</td>
<td>0.001</td>
</tr>
<tr>
<td>Normal (52–71)</td>
<td>13 (43.3)</td>
<td>23 (76.7)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overcontrolled (&lt;52)</td>
<td>4 (13.3)</td>
<td>4 (20.0)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CFQ</td>
<td>35.1 ± 16.9</td>
<td>29.7 ± 9.1</td>
<td>1.53¹</td>
<td>0.132</td>
</tr>
<tr>
<td>DEX</td>
<td>30.0 ± 16.3</td>
<td>18.5 ± 11.2</td>
<td>3.18¹</td>
<td>0.002</td>
</tr>
</tbody>
</table>

Abbreviations referred to as: PG, pathological gamblers; MC, matched controls; BIS, Barratt Impulsiveness Scale; CFQ, Cognitive Failures Questionnaire; DEX, Dysexecutive Questionnaire.
the a priori power calculation. Secondly, it is unlikely a consequence of having underperforming controls since their mean scores were comparable to age-matched controls in other studies (Lawrence et al., 2009; Manning et al., 2009; Yun et al., 2011), and fell within the normal range relative to CANTAB norms. Thirdly, mean PG performance fell consistently within 0.5 standard deviations of matched controls and 1 standard deviation of age and IQ-matched CANTAB norms (based on 2000 healthy individuals aged 4–90 across different IQ bands). This suggests PGs had normal planning/organization, set-shifting, and working memory and reflection impulsivity. Lastly, it is unlikely that PGs exhibited EF deficits that were simply not detected by the CANTAB tests administered, as they are analogous to traditional pencil-&-paper measures which have successfully demonstrated EF deficits with a PG population (e.g. Tower of London planning test and SOC, WCST set-shifting test and IED) and have been used in over 100 pharmacological trials and in studies that detect early signs of cognitive impairment (Sahakian & Owen, 1992). Furthermore, EF deficits have previously been reported in PGs using some of the CANTAB tests used in the current study (Lawrence et al., 2009; Odlauq et al., 2011). The neural substrates of the CANTAB tests have been examined in animal models, and, being computerized, they are more accurate, sensitive and less susceptible to human error in administration and scoring. Nonetheless, their ecological validity (e.g. reliance on an arbitrary points system) may not be sufficient to detect or activate modest executive deficiencies in a population well-accustomed to winning/losing real money. It is also possible that cultural differences may contribute to the different EF profiles observed in the current sample and PGs in western studies; however, there are no available comparison data since this is the first Asian study to report CANTAB performance among adults.

The heterogeneity of PGs is well documented in the literature, whereby different types of gambling preferences may represent different PG populations with distinct motivations, arousal levels, cognitive styles and personality characteristics (Blaszczynski & Nower, 2002; Coventry & Constable, 1999; Potenza et al., 2001). In comparison to western studies comprising predominantly PGs with problems in non-strategic gambling activities (e.g. electronic gaming machines, EGM), PGs in the current study had problems primarily in strategic gambling activities, which conceivably have greater cognitive demands. Strategic games (e.g. card games or sports betting) often require working memory and mental flexibility. With poker, for example, one needs to keep track of cards played to determine odds of receiving a certain card, reason, emotionally self-regulate (i.e. bluff), and process the opponents’ micro expressions to support complex decision-making (e.g. estimate the worth of the opponents’ hands before choosing whether to wager a bet or not). Similarly, horse racing, dog racing or football can place reasonable demands on working memory and mental flexibility in order to calculate odds and likely payouts, and rely on declarative memory in the application of using past knowledge and experiences (e.g. performance track record, absent players) to determine the probability of wins. In comparison, non-strategic gambling such as EGM and lotteries often require little more than attentional processes. In the Goudriaan et al. (2005) study, subgroup analysis of PGs found that strategic (casino) gamblers outperformed non-strategic (slot machine) gamblers on the IGT (Goudriaan et al., 2005), although recently using the CANTAB, Grant et al. (2012b) failed to find any differences in set-shifting and inhibitory control between strategic and non-strategic gamblers. Being a cross-sectional study, we cannot infer causation: whether their underlying neurobiology supports efficient EF leaving them with a predilection for strategic gambling, or whether regular recruitment of these higher-order cognitive functions during play has enabled them to stay cognitively intact. Our
exploratory but nonetheless significant finding of a more conservative game strategy among non-strategic gamblers suggests evidence of different cognitive profiles according to primary problematic gambling activity, and this should be further explored and refined in future research.

Nonetheless, despite an absence of behavioural differences, PGs had significantly elevated BIS scores that fell in the abnormal (highly impulsive) range. This supports the finding from earlier studies of PGs using BIS or Eysenck Personality Questionnaire as measures of impulsiveness (Brand et al., 2005; Ledgerwood, Alessi, Phoenix, & Petry, 2009; Ledgerwood et al., 2012; Leiserson & Phil, 2007). Research suggests that personality trait measures of impulsivity can be stronger predictors of PG status than neuropsychological measures of impulsivity (Forbush et al., 2008) and contribute to the severity of behavioural and psychological disturbance among PGs (Blaszczynski, Steel, & McConaghy, 1997). PGs also had a significantly higher mean score on an ecologically valid, self-report measure of executive functioning difficulties (DEX) but not everyday cognitive failures (CFQ), both of which failed to correlate with neuropsychological measures. This is the first study to report on DEX scores among PGs, and it is perhaps not surprising that self-reported EF and behavioural EF performance tell a different story. Behavioural EF assessed via neuropsychological test performance targets highly specific EF components at a single point in time. In contrast, self-reported questionnaires measure general behavioural tendencies more broadly, i.e. across a variety of situations, and are dependent on subjective perception of one’s behaviour. The DEX is based on emotional, motivational and behavioural, as well as cognitive aspects of executive dysfunctions and gives a comprehensive picture of commonly reported symptoms. This highlights patients’ insight into the everyday cognitive problems experienced in more ecological, contextual situations that may elicit decision-making biases rather than EF impairments. It has been noted that with other clinical populations, performance-based cognitive functioning only weakly correlates with the frequency and severity of self-reported cognitive functioning, except in cases of severe impairment (Benedict & Walton, 2012). Given that medium-to-strong correlations were found between DEX, BIS and SOGS score, these self-report measures could aid clinical management in the absence of neuropsychological testing to highlight those with greater vulnerability.

The current study was unique in its matching of controls and PGs on age, gender, ethnicity and education level at the recruitment phase; however, there are a number of limitations that must be considered. Whilst estimated FSIQ did not differ between the groups, its reliability is questionable since it was derived from an RPM converted score which relies on non-verbal measures in a population where English is often not the first language. A further limitation is the modest and exclusively male, treatment-seeking sample which restricts the generalizability of the findings. Furthermore, the results are limited to PGs who are able to understand, read and speak English since these were inclusion criteria for the study. Nonetheless, the findings address an important gap in the literature and provide evidence of impulsivity traits despite healthy/unimpaired executive functioning among Asian PGs.

With intact and healthy organization/planning ability, cognitive flexibility and working memory, PGs should be able to engage in, and profit from psychological therapies such as CBT, which place heavy demands on these cognitive functions. Nonetheless, it is imperative that treatment approaches target the management of impulsivity early on as self-report impulsivity score at intake has been shown to predict treatment non-completion (Leblond, Ladouceur, & Blaszczynski, 2003), and could compromise decision-making.
capacity crucial for sustained recovery. As part of the treatment process, therapists might set up self-monitoring training to help reduce impulsive responses in everyday life, encourage informed decision-making or utilize a goal setting system (e.g. goal attainment scaling/goal management training) to help their patients direct behaviour towards the desired outcome. Recently, the combination of goal management training and mindfulness based meditation were found to improve response inhibition as well as working memory and decision-making with polysubstance abusers (Alfonso, Caracuel, Delgado-Pastor, & Verdejo-García, 2011). Teaching wait-time strategies and encouraging the use of cost-benefit analysis may also prove useful in reducing impulsive decision-making with PGs. As gambling becomes more ubiquitous and accessible, understanding the cognitive profile of gamblers and how best to manage them places us in the strongest position to offer effective treatments for the small, yet increasing, proportion for whom gambling takes on a pathological or debilitating nature.

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References


