Executive Functions in Pathologic Gamblers Selected in an Ecologic Setting

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Background: Recent studies have reported deficits in measures of decision making in pathologic gamblers (PGs) suggesting an involvement of the prefrontal cortex in the pathophysiology of this disorder. As only 7% to 12% of PGs are thought to seek treatment, most of the studies have relied on few specifically selected groups of PGs recruited from psychiatric units who were undergoing or seeking treatment and therefore their results are poorly representative of the general PG population.

Methods: The present study compared decision making and executive functions among 11 PGs who were selected from an ecologic setting and 11 healthy controls.

Results: The PG group selected fewer advantageous cards on a decision-making task, the Iowa Gambling Task, and made more commission errors on the Go-No Go task, a test of inhibitory control, compared with controls.

Conclusions: The impairments in decision making are similar to those previously reported in individuals with prefrontal lesions and treatment-seeking PGs. PGs also presented impairment in tasks of inhibitory control suggesting an involvement of the prefrontal cortex in the pathophysiology of pathologic gambling (PG). The deficits in decision making and inhibition of irrelevant information observed in this study may have distinct but additive effects upon the development of PG behavior.

Key Words: pathologic gambling, decision making, executive function, prefrontal cortex, inhibitory control

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Pathologic gambling (PG) is an increasing Diagnostic and Statistical Manual of Mental Disorders (DSM-IV) impulse-control disorder characterized by excessive gambling behavior, which has negative consequences on interpersonal relationships, finances, and occupational function.[1] Preliminary studies have begun to measure neuropsychologic functioning in PG individuals using laboratory testing[2–4] with particular interest in measures of decision making like the Iowa Gambling Task (IGT),[5] which assess the preference for 'risky' decisions associated with short-term benefits but long-term negative consequences.

Deficits on the IGT in PG groups have been reported by Cavedini et al[2] and Goudriaan et al,[3] who interpreted their findings in terms of orbitofrontal cortex dysfunction in PG, relying on highly selected PG patients who were undergoing or seeking treatment. As PG often do not seek treatment,[6] in the present study we recruited gamblers from an ecologic setting (a casino in Buenos Aires) arguing that our findings would be more representative of the general PG population.

Recent findings have begun to question the exact nature of behavioral deficits on the IGT. Besides the demand on emotional decision-making, optimal IGT performance also requires other executive functions[7] and the processes measured by the IGT implicate a distributed network of prefrontal, subcortical and posterior brain regions, besides the orbitofrontal cortex.[8,9] In the present study, we evaluated the decision-making processes in PG subjects, together with additional measures of executive function–which do not involve reward and response cost–including a test of response inhibition, to assess the relationship between decision-making deficits and broader executive ability in a group of pathologic gamblers (PGs) recruited in an ecologic setting.

MATERIALS AND METHODS

PGs who fulfilled the DSM-IV diagnosis criteria (n = 11) and nongambling control subjects (n = 11) were recruited. PG individuals were recruited at a gambling casino located in the province of Buenos Aires. The selection criteria for PGs were as follows: (1) meet the DSM-IV criteria for PGs; (2) SOGS (South Oaks Gambling Screen[10]) score greater than 5 to indicate probable PGs; (3) absence of psychosis or a major psychiatry comorbility; and (4) no documented head injury or seizure disorder. Eighteen gamblers were randomly screened, of which 11 met the inclusion criteria. After an interview, subjects who fulfilled the inclusion criteria were invited to participate in the study. All patients provided informed consent and underwent a neuropsychiatric examination.

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Normal controls were recruited through local advertisement. No control subject had a personal history of neurologic or psychiatric disorder. Both groups were screened for depression with the Beck Depression Inventory (BDI) and also for alcohol and substance abuse. The 3-item version of the AUDIT[11] was used to evaluate alcohol consumption and all participants were paid for their participation in the study.

Neuropsychologic Battery

Addenbrooke's Cognitive Examination[12]

A short-screening test of general cognitive functions that evaluates 6 cognitive domains: orientation, attention, memory, language, verbal fluency, and visual-spatial skills.

IGT[5]

The IGT encourages subjects to pick cards from 4 decks and grants different degrees of reward and punishment to assertive decisions and errors (specifically, winning and losing abstract points). Two 'risky' decks yield greater immediate wins but very significant occasional losses. The other two 'conservative' decks yield smaller wins but negligible losses that result in net profit over time.

Go-No Go Task

A computerized task that evaluates the patient's ability to inhibit the response to irrelevant information. Subjects were presented with 5 alternating abstract patterns and were instructed to press the space bar for 2 of the stimulus (targets—Go stimulus) and to withhold responding with the other 3 (No Go stimulus). There were 8 Go and 40 No Go randomly distributed stimuli. Before the test trial, a training trial was administered.

Statistical Analysis

Data were analyzed using 2-tailed t tests wherever appropriate. When the data did not show a normal distribution, a nonparametric Mann-Whitney U was calculated to compare both the groups. In such cases, Spearman rank correlation coefficient was employed. Tests were threshold at a significance level of $P < 0.05$ using SPSS 11.5 (SPSS Inc, Chicago, IL).

RESULTS

The PGs and control groups did not differ significantly in sex, age ($t_{20} = 0.047$; $P = 0.963$), educational background ($t_{20} = -0.714$; $P = 0.483$), alcohol consumption ($t_{20} = 0.000$; $P = 1$), or BDI score ($U = 35.5$; $P = 0.098$).

Neuropsychologic Findings

In terms of their background neuropsychologic function, PGs subjects had worse performance in word fluency ($U = 26.5$, $P = 0.024$) and memory ($U = 21$, $P = 0.008$). There were no significant differences between the 2 groups in backward and forward digit repetition (Table 1).

TABLE 1. Neuropsychologic Results

	PG (n = 11)	CG (n = 11)	*P*
GNG omission errors	6.82 (10.25)	2.55 (7.5)	0.314
GNG commission errors	15.34 (12.44)	0.85 (2.03)	**0.001**
GNG RT (PG n = 9)	283.98 (113.2)	410.74 (116.42)	**0.048**
ACE	90.27 (5.95)	96.91 (2.47)	0.004
MMSE	29.55 (0.52)	29.82 (0.4)	0.18
Orientation	9.82 (0.4)	10 (0)	0.147
Attention	7.82 (0.4)	8 (0)	0.147
Memory	30 (4.05)	34.09 (0.83)	**0.008**
Verbal fluency	10.36 (1.63)	12.18 (1.72)	0.024
Phonologic fluency	12.64 (2.62)	16.18 (5.27)	0.154
Categorical fluency	17 (5.44)	20.64 (3.47)	**0.009**
Language	27.36 (1.03)	27.82 (0.6)	0.152
Praxis	4.91 (0.302)	5 (0)	0.317
Digits forward	5.91 (1.14)	6.64 (1.03)	0.174
Digits backward	4.82 (0.98)	5.27 (0.79)	0.321

$P < 0.05$ is shown in bold characters.

ACE indicates Addenbrooke's Cognitive Examination; CG, control group; GNG, Go-No Go; MMSE, Mini Mental; PGs, pathologic gambler; RT, reaction time.

The performance on the IGT was examined by analyzing card selections in successive blocks of 20 cards. Confirming previous results, significant differences were found between PGs and control groups in the choice of "advantageous" decks in the last 4 blocks ($U = 27$, $P = 0.026$; $U = 27$, $P = 0.027$; $U = 11.5$, $P = 0.001$; and $U = 11.5$, $P = 0.001$; respectively). Although control subjects shifted their preference toward "conservative" decks, PGs groups failed to do so. No correlations were found between depression ($r = -0.08$, $P = 0.8$) and alcohol intake ($r = -0.12$, $P = 0.71$) nor gambling severity on the SOGS ($r = 0.03$, $P = 0.92$) and performance on the IGT in the PGs group (Fig. 1).

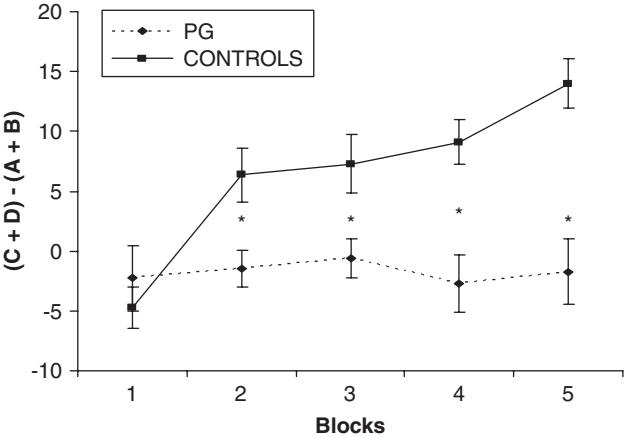

FIGURE 1. Performance of the PGs and controls on the Iowa Gambling Task, with each block (1 to 5) representing 20 sequential card choices. Net score is calculated by subtracting number of 'risky' deck selections from number of 'good' deck selections. A negative net score indicates poor decision making. Error bars indicating S.E.M. *$P<0.05$.

In the Go-No Go task, the PGs group made significantly more commission errors than control subjects ($U = 14.5$ $P = 0.001$). There were no significant differences between groups for omission errors (no response on Go trials). Reaction time ($n = 9$) was significantly faster in PGs ($U = 23.5$, $P = 0.048$) compared with control subjects. No correlations were found among the amount of commission errors in the inhibitory control task and IGT performance, BDI depression rating, SOGS gambling severity, or alcohol intake in the PGs group. However, a significant correlation was found between diminished reaction time in the Go-No Go task and gambling severity on the SOGS ($r = -0.717$, $P = 0.03$).

It has been suggested by some authors[13] that response inhibition in Go-No Go tasks and response change in task switching may share a common mechanism and neural substrates. Examination of response switching in the IGT may provide a measure of inhibitory control that is not reflected in the IGT classical analysis. To investigate this possibility, a Mann-Whitney analysis with group as a between subjects factor and contingency (reward or net loss) was performed to investigate whether rewards or net losses resulted in change of deck choice on the consecutive trial. This analysis has been used before by Goudriaan et al[14] who found that although normal controls switched decks more often after loss than reward trials, PGs did not show this behavior. In the present study, we did not find significant differences in the percentages of switching neither after reward ($P = 0.417$) nor after loss ($P = 0.205$) between both the groups.

DISCUSSION

Decision making and inhibition deficits have been described previously in PGs individuals recruited in specialist addiction treatment facilities.[2,3,15,16] Those results may be difficult to generalize to the wider population of gamblers given that only 7% to 12% of PGs are thought to seek treatment.[6] In the present study, PGs subjects were recruited in an ecologic setting, making our results more representative of PGs general population. The PGs group exhibited impaired performance on the IGT, a measure of emotional decision making, as well as deficits in memory, verbal fluency, and response inhibition. Decision making and inhibitory deficits were not related to levels of depression or alcohol intake. The PGs group was unable to learn an advantageous strategy on the decision-making task. In addition, they made more commission errors on the Go-No Go task and showed a faster reaction time on Go trials, which are both, suggestive of impulsivity. Faster reaction times were correlated with severity of gambling. This new finding supports the diagnostic position of PGs as an impulse-control disorder.

Kertzman et al[16] recently reported Stroop deficits in PGs, suggesting impaired inhibition of responses to irrelevant information. It was suggested that decision-making deficits could be related to such inability. As has been argued before,[17] the lack of correlation between Go-No Go and decision making in the present study may suggest that these impairments may have more independent contributions to the development of gambling behavior. Clearly, the small group sizes in the present study merit caution in interpreting this effect.

Deficits on the IGT in PGs groups have already been reported,[2,3] and were interpreted in terms of orbitofrontal cortex dysfunction. We argue that the IGT is a complex task that involves a number of distinct components and in PG groups, task performance could be influenced by their extensive experience with gambling. Moreover, recent findings suggest that the IGT does not provide a behavioral index of the orbitofrontal region in isolation, but on the contrary may recruit a wider distributed network of prefrontal and subcortical regions.[9] To circumvent problems associated with the past experience of gambling scenarios, research in PGs may benefit from using more covert neuropsychologic executive tests like the Go-No Go task used in the present study. Go-No Go deficits in PGs have already been reported by Goudriaan et al.[3] However, in the present study, we used a Go-No Go task that successfully isolates the inhibitory control deficits from potential reward and punishment responses.

Impaired verbal fluency has been described in frontal patients and may also serve as a measure of executive functioning.[18–20] That is why we have searched for correlations between phonologic and semantic fluency and the inhibitory control and decision-making tasks, but no significant correlations were found.

In summary, our group of PGs recruited in an ecologic setting presented the same decision-making deficits previously reported in treatment-seeking PGs group. PGs also presented deficits in tasks of inhibitory control, which did not correlate with the decision-making impairment. Our findings support the notion that gambling addiction shares characteristics with substance abuse and other impulsive control disorders and add more evidence to the possible role of the prefrontal cortex in the pathophysiology of this neuropsychiatric disorder.

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