



Schizophrenia patients demonstrate a distinctive pattern of decision-making impairment on the Iowa Gambling Task

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Abstract

Although dorsolateral prefrontal cortex (DLPFC) abnormalities in schizophrenia are well established, several lines of evidence suggest the orbitofrontal cortex (OFC) may also be dysfunctional in this disorder. We examined the performance of schizophrenia patients and nonpatient controls on the Iowa Gambling Task [Cognition 50 (1994) 7], a decision-making task sensitive to OFC damage that involves a series of selections from four decks of cards that vary in their reward/punishment profiles. Patients also completed neuropsychological tests assessing DLPFC functions and clinical symptom assessments. The schizophrenic patients demonstrated a pattern of impaired performance that differed both from healthy controls and from the “non-conservative” pattern typically found in patients with OFC lesions. The patients selected from the two card decks that had low frequency and high magnitude punishments significantly more often than the decks with high frequency and low magnitude punishments. Performance on the task was not strongly related to tests sensitive to DLPFC dysfunction but was correlated with negative symptoms. Results suggest that individuals with schizophrenia display a pattern of compromised decision-making that is somewhat distinct from that found in OFC lesion patients and that may be linked to certain clinical symptoms.

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1. Introduction

Abnormalities involving the frontal lobes have long been postulated to be central to the pathophysiology of schizophrenia. Investigations of frontal lobe integrity have focused predominantly on the dorsolateral prefrontal cortex (DLPFC) and abnormalities in this region have been extensively documented in schizophrenia (Weinberger and Berman, 1996). How-

ever, the prefrontal cortex is structurally and functionally diverse, and abnormalities in schizophrenia may extend to other frontal regions, including the orbitofrontal cortex (OFC). Indeed, it has been argued that pathological processes involving either the OFC or the DLPFC may be differentially associated with specific clinical and behavioral characteristics of schizophrenia (Pantelis and Brewer, 1995).

Evidence of OFC abnormality in schizophrenic patients comes from structural (Convit et al., 2001; Crespo-Facorro et al., 2000; Goldstein et al., 1999; Pantelis et al., 2003) and functional (Bertollo et al., 1996; Crespo-Facorro et al., 2000; Quintana et al.,

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2003) neuroimaging studies as well as neuropathological findings (Meador-Woodruff et al., 1997). Schizophrenia patients also perform poorly on traditional neuropsychological tasks believed to be sensitive to processes associated with the OFC. Deficits on olfactory identification tasks have been extensively documented in schizophrenia (see Moburg et al., 1999). Additionally, deficits on object alternation tasks are sometimes found in schizophrenia patients (Siedman et al., 1995; but see Abbruzzese et al., 1995) as well as their nonpsychotic relatives (Faraone et al., 1999).

Recent advances in clinical neuroscience indicate that the OFC also plays a critical role in complex decision-making processes (see Krawczyk, 2002; Rolls, 1999). Patients with acquired damage to the OFC exhibit striking deficits in real-life decision making, especially in social or emotional decision-making, in the context of generally well-preserved intellectual functioning. It has been postulated that these patients are unable to apply their knowledge to social decision-making contexts because of their inability to “somatically mark” an internal representation of a situation with a positive or negative valence based on previous experience (Damasio, 1996).

Bechara et al. (1994) developed an experimental paradigm, the Iowa Gambling Task, intended to simulate real-life decision making processes believed to be associated with the OFC in the way it factors uncertainty, reward, and punishment. Subjects are asked to draw cards one at a time from any one of four decks (A–D). Each card selection results in winning an amount of hypothetical money while after some selections subjects are also required to pay a penalty. However, the frequencies and magnitudes of wins and losses associated with each deck are not revealed to the subject and must be learned through experience. Two of the decks (A and B) are “disadvantageous” or risky in that they involve high immediate gains and occasionally even higher penalties, and picking from these decks ultimately results in a net monetary loss. The other two decks (C and D) are “advantageous” in that they involve low immediate gains and occasionally low penalties, and the more conservative strategy of picking from these decks results in a net gain. The goal of the task is to maximize winnings on an initial loan of hypothetical money across 100 trials.

In a series of studies using the Iowa Gambling Task (see Bechara et al., 2000b), patients with OFC damage were found to persistently choose primarily from the disadvantageous decks throughout the task whereas healthy and non-orbitofrontal brain-damaged (e.g., DLPFC lesions) control groups learned to favor the advantageous decks. However, the orbitofrontal patients' performance on tasks believed to be sensitive to DLPFC damage, including the Wisconsin Card Sorting Test (WCST; Heaton, 1993) and a delayed response task, was essentially normal, supporting the regional specificity of the Iowa Gambling Task. Bechara and colleagues attribute the deficit shown by orbitofrontal patients to an inability to attach a negative valence to their learned experience, with patients basing their decisions on immediate consequences instead of anticipating the future.

Three studies have examined the performance of schizophrenic patients on the Iowa Gambling Task and have produced somewhat mixed findings. Wilder et al. (1998) found that a small sample of inpatients ($n = 12$) demonstrated a pattern of performance that was not typical of either OFC patients or healthy controls, selecting more frequently from decks B and D. This pattern was interpreted, however, as “normal” due to the finding that the non-psychiatric controls in this study demonstrated the same atypical pattern. Beninger et al. (2003) found that 18 patients on atypical antipsychotics demonstrated impairments similar to OFC patients, selecting more frequently from the disadvantageous decks and showing little evidence of learning to select from advantageous decks across blocks of trials. In contrast, 18 patients on typical antipsychotics did not significantly differ from controls, who demonstrated the pattern typical of non-clinical samples. Ritter et al. (2004) found that 20 male outpatients with schizophrenia or schizoaffective disorder earned less money and selected more frequently from the disadvantageous than advantageous decks as compared to controls. In addition, patients selected significantly more frequently from the disadvantageous deck B than deck A and, in contrast to the pattern found in OFC patients, demonstrated evidence of learning to shift to the advantageous decks across the task but at a considerably slower rate than controls.

Despite inconsistencies across these studies, it is noteworthy that performance on the Gambling Task

did not appear to be strongly related to performance deficits on tasks measuring other aspects of cognitive functioning. All three studies administered the WCST (Heaton, 1993), a task believed to tap “executive” functions associated with the DLPFC on which schizophrenia patients commonly show impairment. The two studies directly correlating indices from the Gambling Task with WCST scores found no significant relationships (Ritter et al., 2004; Wilder et al., 1998) while the third found that patients with impaired Gambling Task performance performed worse than controls on several indexes from the WCST, but did not examine correlations between the two measures (Beninger et al., 2003). Performance on the Gambling Task was also not significantly associated with general intellectual ability (Ritter et al., 2004; Wilder et al., 1998), list learning (Wilder et al., 1998) or short-term verbal retention (Beninger et al., 2003).

While studies to date suggest that decision-making functions associated with the OFC are compromised in schizophrenia, additional research is required to confirm and clarify the nature of this deficit. In the current study, we examined the performance of stabilized schizophrenic outpatients and healthy controls on the Iowa Gambling Task to clarify further whether schizophrenic patients demonstrate impairment similar to OFC patients and whether their performance on this task can be differentiated from their performance on tasks sensitive to DLPFC dysfunction, including visuospatial working memory and “executive” functions. We addressed several methodological issues raised by earlier studies using this task that may help characterize performance deficits in schizophrenia, including examinations of performance across blocks of trials and of selection from individual card decks. In addition, we compared the performance of recent-onset and chronically ill patients in light of evidence of stage of illness differences on a different gambling task that is also sensitive to orbitofrontal lesions (Hutton et al., 1998) and the performance of patients on typical and atypical antipsychotic medications (Beninger et al., 2003).

We also examined clinical symptom correlates of performance on the Gambling Task within the schizophrenic patient group. Although the one study that directly examined relationships between Gambling Task performance and clinical symptoms found no significant associations (Ritter et al., 2004), neuro-

imaging studies of the OFC in schizophrenia suggest this region may be associated with negative symptoms (Wolkin et al., 2003) and social dysfunction (Chemerinski et al., 2002). In line with these findings, as well as considerable evidence of impairment in emotional and social behaviors associated with damage to the OFC in both animals and humans (e.g. Krawczyk, 2002; Rolls, 1999), we predicted that disadvantageous choices on the Gambling Task would correlate with negative symptoms but would not significantly correlate with positive symptoms.

2. Methods

2.1. Subjects

Thirty-nine stable schizophrenic outpatients recruited from the UCLA Aftercare Research Clinic and the West LA VAMC Schizophrenia Research Unit participated in this study. The diagnosis of schizophrenia was established using the Structured Clinical Interview for DSM-IV (SCID; First et al., 1996) and a comprehensive review of medical records. Patients with a history of substance use disorder, as determined by the SCID, were excluded. Additionally, patients with neurologic and medical disorders known to influence cognitive functioning were excluded. All interviewers who completed diagnostic interviews and symptom assessments were trained to a criterion level of reliability and participated in an ongoing quality assurance program within the Diagnosis and Psychopathology Unit of the UCLA Clinical Research Center for the Study of Schizophrenia (Robert P. Liberman, M.D. principal investigator; also see Nuechterlein et al., 1992). Regarding antipsychotic medications, 29 patients were taking stable dosages of atypical antipsychotics (risperidone, olanzapine or clozapine), 5 were taking stable dosages of typical antipsychotics (haloperidol or fluphenazine), 2 were taking an atypical and a typical antipsychotic, and 3 were in a double-blind medication trial (typical vs. atypical) for which medication data was not available. Patients who were prescribed anticholinergic medications did not take these adjunctive medications during the 24-h preceding testing.

The nonpatient control group consisted of 10 individuals who were recruited through flyers posted in the

local community. Controls were screened for psychotic, mood and substance use disorders using the SCID as well as for history of head injury with significant loss of consciousness (greater than 5 min) or neurologic disorder. Table 1 presents demographic information for both groups and symptom characteristics of the schizophrenia patients. The groups did not significantly differ in terms of age, sex, ethnicity or marital status (all p 's > 0.05). The groups did not differ significantly in terms of parental education, although the patient group had significantly less education than controls.

2.2. Procedures

All participants completed the decision-making task and tests of DLPFC functions in a single testing session. Clinical symptom assessments were conducted for patients in the schizophrenia group on the same day that testing occurred.

2.2.1. Decision-making task

All participants completed the computerized version of the Iowa Gambling Task (Bechara et al., 1994, 2000b). Participants are told that they will be making a long series of selections, one at a time, from four

decks of cards on a computer screen. They are informed that they may switch from deck to deck as often as they wish and that the overall goal of the game is to maximize profit on a loan of \$2000 of "play money." Participants are also informed that they can make a profit and win money over time if they learn to select cards from the "good" decks and avoid the "bad" decks. After turning each card, the subject receives an amount of money. However, on some cards the subject receives money but also pays a penalty. Specifically, turning any card from deck A or B yields \$100 and turning any card from deck C or deck D yields \$50. In deck A, the penalties are frequent and range from \$100 to \$350, while in deck B the penalties are infrequent but of larger magnitude (\$1250). By picking preferentially from decks A and B, subjects will incur a net loss over time. In deck C the penalties are frequent and range from \$25 to \$75, while in deck D the penalties are infrequent but of larger magnitude (\$250). By picking preferentially from decks C and D, a subject will incur a net gain over time. A total of 100 trials are completed, though subjects are not informed of the exact number of trials. Test performance is typically measured by the total numbers of cards selected from decks A and B versus C and D, as well as total money earned.

2.2.2. Tests related to DLPFC functioning

Participants completed two tests of cognitive functions known to activate the DLPFC. First, participants completed the computerized version of the WCST (Heaton, 1993), a commonly used measure of concept formation and flexibility of abstract thought. In this task, participants are required to sort cards according to several different dimensions (color, form, number); the sorting principle must be deduced from verbal feedback provided by the computer. Once a particular response mode is established (i.e., 10 consecutive correct responses), a new sorting principle (concept) is instituted without warning and must be deduced by the participant. Measures of performance included the numbers of categories completed and perseverative errors.

Participants also completed a computerized delayed match to sample task (DMST; Nuechterlein and Asarnow, 1994) designed to replicate working memory conditions of Bauer and Fuster (1976) that elicit DLPFC activation (Fuster, 1989; Goldman-Rakic, 1992). The condition used here involves watching a

Table 1
Demographic and clinical information for schizophrenia and control groups

	Schizophrenia	Control	Statistic
Age (years)	33.5 (10.1)	32.1 (4.5)	$t=0.64$
Parental education (years)	14.2 (4.0)	14.4 (2.8)	$t=0.82$
Education (years)	13.4 (1.2)	15.5 (2.4)	$t=3.11^*$
Sex (% male)	72%	50%	$\chi^2=1.17$
Race/ethnicity (%)			$\chi^2=3.37$
Caucasian	60%	51%	
Hispanic	20%	18%	
African American	20%	11%	
Other	0%	20%	
Marital status			$\chi^2=0.45$
Never married	80%	87%	
Married	10%	6%	
Divorced/separated	10%	7%	
Symptom ratings			
SAPS total	12.6 (16.4)	–	
SANS total	9.2 (4.8)	–	
PANSS cognitive organization	7.9 (3.8)	–	

Standard deviations appear in parentheses.

* $p < 0.005$.

circle on the computer monitor that is red or green and then matching the color to one of two circles, one red and one green, that appear below the “sample” after a delay. Twenty trials at 1 and 10 s delays were used, with subjects told to respond as quickly as possible to the correct circle with a corresponding button press. As all subjects were coached to make errors as rare as possible, the mean response time for correct trials was used as the primary dependent variable. The increased response time at 10 s as compared to 1 s delays was used as an index of working memory burden (Bauer and Fuster, 1976). A \log_{10} transformation was used to normalize distributions.

2.2.3. Clinical symptom assessments

Clinical symptoms in the schizophrenic patients were evaluated through semi-structured interviews using three clinical rating scales. Positive and negative symptoms were evaluated using the Scale for the Assessment of Positive Symptoms (SAPS; Andreasen, 1983a) and the Scale for the Assessment of Negative Symptoms (SANS; Andreasen, 1983b), from which total positive and total negative symptom scores were derived. In addition, symptoms of cognitive disorganization were evaluated using items from the cognitive disorganization subscale of the Positive and Negative Syndrome Scale (PANSS; Kay et al., 1987).

3. Results

3.1. Gambling Task performance

Descriptive data for performance on the Gambling Task is presented in Table 2. Patients had significantly smaller difference scores on the advantageous minus disadvantageous deck selection index and earned significantly less money than controls. Group differences in the chronological selection of advantageous versus disadvantageous cards was examined using a 2 (group) \times 5 (blocks of 20 cards) repeated-measures ANOVA and the learning curves are presented in Fig. 1. There were significant main effects for group, $F(4,44)=10.56$, $p<0.001$, and block, $F(1,47)=19.69$, $p<0.001$, and the interaction effect approached significance, $F(4,44)=2.21$, $p=0.08$. Controls selected more frequently from the advantageous decks by the end of the second

Table 2
Performance on Gambling Task and cognitive tests

	Schizophrenia	Control	<i>t</i>
Iowa Gambling Task			
Choices from advantageous minus disadvantageous decks	1.9 (18.8)	31.6 (19.4)	4.44***
Mean amount of money earned	1707.9 (531.9)	2215.0 (593.5)	2.62*
No. of cards chosen from deck A	21.6 (7.2)	15.7 (4.1)	-3.26**
No. of cards chosen from deck B	27.5 (8.8)	18.5 (6.4)	-3.03**
No. of cards chosen from deck C	23.0 (7.4)	34.0 (9.0)	4.04***
No. of cards chosen from deck D	28.0 (8.9)	31.8 (6.3)	1.20
Wisconsin Card Sorting Test			
Categories completed	3.5 (2.2)	5.7 (.7)	5.53***
Perseverative responses	28.4 (16.5)	13.8 (10.8)	-3.38**
Delayed match to sample Working memory access time	4.2 (.7)	3.5 (.5)	-2.01*

Standard deviations appear in parentheses. Working memory scores were log transformed.

* $p<0.05$.

** $p<0.005$.

*** $p<0.001$.

block and continued to do so across the remaining blocks whereas patients showed essentially no evidence of switching to a strategy of selecting from the advantageous decks. Between-group differences were statistically significant for the final two blocks of trials using a correction for multiple comparisons (p 's <0.05 by Bonferroni).

Group differences on selections from individual decks were examined using a 2 (group) \times 4 (deck) repeated-measures ANOVA. There was a significant main effect for deck, $F(3,45)=11.89$, $p<0.001$, and the group \times deck interaction was also significant, $F(3,45)=7.93$, $p<0.001$. Follow-up t -tests first evaluated between-group differences on each deck. As shown in Table 2, patients selected more frequently from decks A and B and less frequently from the advantageous deck C than controls, while the groups did not differ on deck D selections (p 's <0.05 even after Bonferroni correction). Within-group contrasts to clarify the pattern of performance showed that normal subjects showed the expected significantly larger

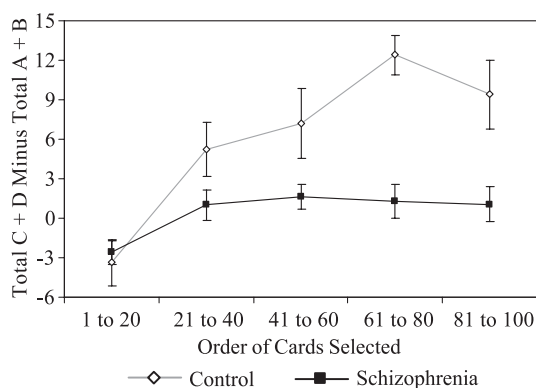


Fig. 1. Decision-making over time.

number of choices for advantageous decks ((C + D) – (A + B)), $t = 5.16$, $p < 0.001$, while schizophrenic patients did not. A contrast that evaluated the impact of high-frequency/low-magnitude punishments as compared to low-frequency/high-magnitude punishments ((B + D) – (A + C)) showed that schizophrenia patients selected less from the high-frequency/low-magnitude punishment decks $t = 3.29$, $p < 0.005$, while the normal subjects did not.

We next examined patient subgroups categorized in terms of illness chronicity, comparing patients with a relatively recent illness onset ($n = 13$, onset < 5 years) and chronically ill patients ($n = 26$). These subgroups did not significantly differ on either selections from the individual decks or the difference score between advantageous minus disadvantageous decks (all t 's < 1.87, p 's > 0.05). We also compared patients taking typical ($n = 5$) versus atypical ($n = 29$) antipsychotic medications. The difference score for the advantageous decks minus the disadvantageous decks was larger, but not significantly so, in patients taking typical ($M = 14.4$, S.D. = 22.0) than atypical ($M = 0.07$, S.D. = 17.5) antipsychotics ($t = 1.63$, $p = 0.113$). On the individual decks, there were no significant differences between patients taking typical antipsychotics (means and [S.D.'s] were: for deck A: 18.0 [8.7], deck B: 24.8 [10.3], deck C: 25.0 [11.9], deck D: 32.2 [9.0]) versus atypical antipsychotics (deck A: 22.0 [6.4], deck B: 28.0 [9.0], deck C: 22.1 [7.1], deck D: 28.0 [8.6]) (all p 's > 0.23). However, the very small number of patients taking typical antipsychotics substantially limited our statistical power to detect group differences.

3.2. Relationship between Gambling Task and DLPFC-related tasks

Tests of between-group differences on the two tasks associated with DLPFC functioning are presented in Table 2. Consistent with previous research, the schizophrenic patients completed significantly fewer categories and made more perseverative errors than controls on the WCST. Additionally, the schizophrenic patients performed more poorly than the controls on the index of working memory access time from the DMST. Thus, in the DMST, the patients were differentially slowed in the 10-s delay trials relative to the 1-s delay trials.

We next sought to determine whether performance on the Gambling Task was associated with performance on the WCST and DMST within the schizophrenia group. There were no significant correlations between Gambling Task and DMST performance (p 's > 0.05). Regarding the WCST, selections from deck D negatively correlated with perseverative errors ($r = -0.40$, $p < 0.05$). There were no other statistically significant correlations.

3.3. Relationship between Gambling Task and clinical symptoms

Correlational analyses within the schizophrenia group examined the relationship between performance on the Gambling Task and the major dimensions of positive, cognitive disorganization, and negative symptoms. Total money earned on the Gambling Task inversely correlated with negative symptoms measured by the SANS ($r = -0.39$, $p < 0.05$).¹ There were no other significant correlations with clinical symptoms (all p 's > 0.05).

4. Discussion

This study sought to clarify discrepancies in the literature regarding whether individuals with schizophrenia demonstrate impairment on the Iowa Gambling Task, a neurocognitive task sensitive to OFC

¹ Inspection of the scatter plot indicated that this correlation remained significant ($r = -0.33$, $p < 0.05$) even if one possible outlier was excluded. Scatter plot available upon request.

lesions. We replicated the typical pattern of performance found among healthy individuals on this task in our control sample, who selected from the advantageous decks more frequently than the disadvantageous decks and ultimately had positive “money” gains. In contrast, the schizophrenic patients did not select more frequently from the advantageous decks, ultimately lost “money” and displayed minimal evidence of learning to select from the advantageous decks across the task. These results are broadly consistent with two of the three previous studies examining the performance of schizophrenic patients on the Iowa Gambling Task (Beninger et al., 2003; Ritter et al., 2004) and with the notion that complex decision-making processes associated with the OFC are indeed compromised in schizophrenia. However, as discussed later in this section, the pattern of choices shown by schizophrenic patients in relationship to reward and punishment frequencies is distinctive.

The pattern of impairment demonstrated by the schizophrenic patients on the Iowa Gambling Task did not appear to be attributable to several potential confounds. In contrast to the stage of illness effects found for schizophrenic patients’ performance on a different gambling task that is sensitive to OFC functions (Hutton et al., 1998), recent-onset patients did not significantly differ from chronically ill patients in the current study. The patients’ poor performance also did not appear to be solely attributable to antipsychotic medication status, as performance did not significantly differ between patients taking atypical versus typical antipsychotics. Our ability to assess the medication effects on Iowa Gambling Task performance reported by Beninger et al. (2003) was, however, limited by the small number of patients in our sample who were taking traditional antipsychotics.

The performance deficits in the schizophrenic patients on the Gambling Task did not appear to be secondary to generalized frontal dysfunction. Gambling Task performance was generally not related to the deficits on two neurocognitive tasks sensitive to DLPFC functioning. The only evidence of such an association was a negative correlation between selections from deck D and perseverative errors on the WCST. It is noteworthy that the number of deck D selections did not differ between groups, so this one correlation with WCST perseverative errors does not contribute to significant group differences in Iowa

Gambling Task performance. The general lack of association with WCST and DMST performance is consistent with previous studies of schizophrenia (Ritter et al., 2004; Wilder et al., 1998) and supports the proposal of Bechara et al. (1994, 1998) that performance on the Gambling Task is relatively independent of cognitive functions believed to be associated with the DLPFC.

There was evidence within the schizophrenia group of an association between impaired Gambling Task performance and negative symptoms. Total money earned on the Gambling Task inversely correlated with global negative symptoms, while no relationships were found between Gambling Task performance indexes and positive or cognitive disorganization symptoms. The one previous study that examined the symptom correlates of Gambling Task performance in schizophrenic patients ($n=20$) reported no significant associations with score on the SANS or subscales of the Brief Psychiatric Rating Scale (Overall and Gorham, 1962). However, an association between negative symptoms and OFC abnormalities has been reported in a structural neuroimaging study by Wolkin et al. (2003; but see Chemerinski et al., 2002) and in neuropsychological studies using tasks sensitive to OFC functioning (e.g., Brewer et al., 2001). Structural OFC abnormalities have also been found to correlate with social dysfunction in schizophrenia (Chemerinski et al., 2002), and this region has been hypothesized to play an important role in the social cognitive deficits associated with this disorder (Pinkham et al., 2003). Thus, links between OFC abnormalities and functional outcome appear to warrant further research.

While the performance of schizophrenic patients on the Iowa Gambling Task appears similar to that of patients with OFC lesions in several respects, some features of schizophrenic patients’ performance on this task may not wholly resemble the OFC pattern. Although the patients in our study demonstrated little evidence of learning to select from the advantageous decks based on feedback from their previous choices (as seen in OFC patients; Bechara et al., 2000a), this pattern has not been consistently found in previous studies. Beninger et al. (2003) found that although patients on atypical antipsychotics did not learn to adjust their choices to the advantageous decks, patients on typical antipsychotics adjusted to selecting from the advantageous decks in a manner similar to controls. In

contrast, Ritter et al. (2004) found that a sample of patients primarily taking atypical antipsychotics eventually learned to select from the advantageous decks, but did so at a much slower rate than controls. Thus, the extent to which schizophrenic patients are capable of learning to make advantageous deck selections based on the consequences of their previous actions is uncertain.

Analyses of the deck-by-deck selections of schizophrenic patients on the Iowa Gambling Task also suggest possible differences from OFC patients. Whereas OFC patients preferentially select more frequently from both of the disadvantageous decks (A and B) and less frequently from both of the advantageous decks (C and D) (Bechara et al., 1994), the selection patterns of the schizophrenic patients in our study did not exactly correspond to this pattern. Compared to controls, the schizophrenic patients selected from the two disadvantageous decks more frequently than controls and also selected less frequently from one of the advantageous decks (deck C) but not the other (deck D). Within the schizophrenia group, the two decks that had low frequency and high magnitude punishments (B and D) were selected significantly more frequently than the two decks with high frequency and low magnitude punishments (A and C). This preferential selection of cards from decks B and D is not typical of either normal controls or OFC patients. Interestingly, Wilder et al. (1998) also found that schizophrenic patients selected more from decks B and D than decks A and C, although these findings are difficult to interpret due to the failure to replicate the typical normal pattern of performance in their control sample. There was also some indication of a preference for selecting from disadvantageous deck B over disadvantageous deck A among schizophrenic patients in the study by Ritter et al. (2004). Selections from individual decks were not examined in the study by Beninger et al. (2003).

While the distinctive pattern of deck selection found in our patient sample was not predicted, the pattern does appear sensible in terms of the reward and punishment profiles that characterize the decks that patients did and did not select, and is consistent with at least three possible interpretations. Bechara et al. (1994) propose that OFC patients preferentially select from decks A and B because they suffer from, “myopia for the future”, responding to the immediate reinforcing properties of these high monetary reward decks

while failing to adjust their behavior to the punishments associated with this strategy (possibly due to faulty somatic marking). While the schizophrenic patients also failed to adjust their disadvantageous decision-making strategies, their preferential selection of decks with large, infrequent penalties could be motivated by attraction to the relatively high ratio of reward frequency to punishment frequency associated with decks B and D. Alternatively, their selection from these decks could reflect avoidance of the relatively higher frequency of punishments associated with decks A and C. In either case, the patients’ performance seemed influenced primarily by the frequency of rewards and punishments, accompanied by a relative neglect of reward and punishment magnitudes.

A third alternative is that the pattern reflects a working memory impairment rather than an anomaly that intrinsically involves reward and punishment effects. Thus, patients may select from decks B and D because they are more likely to forget the intermittent punishments associated with these decks. The lack of association between performance on the Gambling Task and the DMST would argue against a traditional DLPFC working memory explanation. However, disruption of maintenance of affective representations in other regions, such as ventromedial prefrontal cortex (Damasio, 1996; Saver and Damasio, 1991) might contribute to the abnormal pattern demonstrated by the schizophrenic patients.

In future research, it will be important to further specify the nature of complex decision making deficits in schizophrenia. This might be accomplished by examining autonomic responses and verbal reports of patients’ decision-making strategies while performing the Iowa Gambling Task (see Bechara et al., 2000). Examination of how performance on this task is related to tasks designed to fractionate the cognitive processes that contribute to successful social/emotional problem solving may also be useful (e.g., Hutton et al., 1998). In addition, it will be important to determine whether the neural substrate of schizophrenic patients’ decision-making deficits on this task is in fact localized to the OFC (or a particular subregion; O’Doherty et al., 2001) or instead reflects dysfunction of other regions involved in decision making processes that are known to be dysfunctional in schizophrenia, such as the amygdala (Lawrie and Abukmeil, 1998) or anterior cingulate cortex (Carter et al., 2001).

This study has some limitations. First, the schizophrenic patients were taking a variety of antipsychotic medications at clinically determined dosages. The small number of patients taking typical antipsychotics and the lack of random assignment of patients to medication treatment groups limited our ability to evaluate the effects of different types of medications on decision-making processes. Second, the control group was relatively small, although we were able to replicate the typical pattern of performance on the Iowa Gambling Task found in healthy controls. Third, although little evidence was found for a relationship between performance on the Iowa Gambling Task and tasks believed to reflect DLPFC functioning, inclusion of a wider range of cognitive tasks would have allowed for a more comprehensive assessment of the specificity of deficits on this task. Despite these limitations, this study provides further evidence that complex decision-making processes are compromised in schizophrenia, possibly linked to certain aspects of the clinical picture, and may show a pattern that is somewhat distinct from that found in OFC lesion patients.

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