Progress in Neuro-Psychopharmacology & Biological Psychiatry 57 (2015) 52–59

Contents lists available at ScienceDirect

Progress in Neuro-Psychopharmacology & Biological Psychiatry

journal homepage: www.elsevier.com/locate/pnp

Deficits in emotion based decision-making in schizophrenia; a new insight based on the Iowa Gambling Task

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ARTICLE INFO

Article history:
Received 13 February 2014
Received in revised form 3 October 2014
Accepted 16 October 2014
Available online 24 October 2014

Keywords:
Decision-making
Iowa Gambling Task
Schizophrenia

ABSTRACT

Background: Defective decision-making is a symptom of impaired cognitive function observed in patients with schizophrenia. Impairment on the Iowa Gambling Task (IGT) has been reported in patients with schizophrenia, but these results are inconsistent among studies.
Methods: We differentiated subjects based on whether they expressed certainty at having deciphered an advantageous strategy in the course of the task. We investigated this impairment using the IGT in patients with schizophrenia and performed analysis different to standard advantageous decks minus disadvantageous decks in all 100 card choices, [C+D]–[A+B](1–100). We examined the effects on behavior after receiving a big penalty.
Results: Results were dependent on participants utilizing with or without certainty, the best strategy for positive gain. Schizophrenic patients without certainty failed to show card choice shift, from disadvantageous to advantageous decks. Differences in card choices on the IGT were clearly shown between patients with schizophrenia and normal controls by the use of improvement from block 1 to blocks 3–5, [C+D]–[A+B]([41–100]–[1–20]) ($P < 0.001$), rather than by the composite value of blocks 3–5, [C+D]–[A+B](41–100) ($P = 0.011$). The deficit of emotion-based learning in schizophrenia without uncertainty were related to scores on the SANS and S5 attention. In addition, S1 affective flattering and S4 anhedonia–asociality were also related to these deficits. For a while, normal controls showed a smooth shift from disadvantageous to advantageous decks after big penalties, with or without a certainty for strategy. However, patients with schizophrenia failed to show switching from disadvantageous to advantageous decks, even after big penalties, under the same conditions.
Conclusions: Our results highlight certainty of strategy and behavior after a big penalty, as two points of difference between patients with schizophrenia and normal controls in the accumulation of net scores.

1. Introduction

Uncertainty about how choices lead to outcomes is important in decision-making. Since healthy individuals continually face a trade-off between options that promise safety and others that offer an uncertain potential for a jackpot, understanding how the brain responds to information about uncertainty and risky choice is critical (Platt and Huettel, 2008; Rushworth and Behrens, 2008). Decision-making is affected by various factors such as perceptual information, internal emotional cues, and social cues (Gazzaniga et al., 2009).

The Iowa Gambling Task (IGT) measures the emotional aspect on decision-making under ambiguity (Bechara et al., 1994), and simulates real-life decision-making in conditions of reward and punishment and of uncertainty (Bechara et al., 2005). As the task is constructed so that picking cards from advantageous decks result in maximum profit, subjects need to overcome an initial attraction to high-payoff decks with subsequent big punishments.

Patients with schizophrenia showed impairments on the IGT, but the results are not consistent among studies (Bellani et al., 2009; Sevy et al., 2007). Some studies showed clear differences in chronological card selections by 20 card blocks, between normal controls and patients with schizophrenia (Kester et al., 2006; Kim et al., 2009; Nakamura et al., 2008; Premkumar et al., 2008; Shurman et al., 2005), whereas others found no differences (Evans et al., 2005; Rodriguez-Sanchez et al., 2005; Sevy et al., 2007; Turnbull et al., 2006). Patients with schizophrenia showed learning on the IGT (Ritter et al., 2004; Wilder et al., 1998).

It is worth considering subjective awareness of card choice during the IGT. Recent studies showed that performances were comparable between normal controls and patients with schizophrenia, and that scores correlated with an awareness of which decks were good or bad, in both groups (Cella et al., 2012; Evans et al., 2005). Impaired awareness on

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http://dx.doi.org/10.1016/j.pnpbp.2014.10.007
0278-5846/

neuropsychological tests was reported to be multiply determined (Gilleen et al., 2011). Certainty for advantageous card selections was sufficient to guide better performances on the IGT in normal controls (Maia and McClelland, 2004). Normal healthy subjects develop a preference for the good decks [C + D] over the bad decks [A + B] in the course of task, even if they do not necessarily develop the best strategy (Bechara et al., 2005). Thus, normal subjects shift their card choice from bad to good decks either implicitly or explicitly. We hypothesized that discrepancies between studies using the IGT in schizophrenia, may be explained by specific factors, namely certainty for an advantageous strategy and the effects of big penalties on card choices. In addition, we propose that these factors may be related to negative symptoms in schizophrenia. In this study, we examined the uncertainty involved in the IGT test, when performed by patients with schizophrenia. Additionally, we analyzed the effects of big penalties on emotion-based learning.

Generally, the composite value based on the difference in chosen numbers from good decks and from bad decks, [C+D]–[A+B], is for the typical analysis of IGT. We propose that inconsistent research results for IGT may be due to evaluation methodology using the composite score, [C+D]–[A+B] (Buelow and Suhr, 2009). We hypothesized that schizophrenia related impairment on the IGT could be due to differences in the degree of impact by a big punishment from deck B. To address this, results were analyzed using the composite value in blocks 3–5, [C+D]–[A+B](41–100)(Gansler et al., 2011; He et al., 2010). Additionally, this impairment could be due to improvements from block 1 to blocks 3–5, [C+D]–[A+B]([41–100]–[1–20]) (Kang et al., 2010). Furthermore, we examined the improvement of scores after the 1st and 2nd big penalties from deck B with or without certainty of strategy.

This study yielded four main findings. First, consideration of certainty differentiates results on the IGT, but cannot discriminate between controls and patients with schizophrenia. Second, we were able to differentiate between the two groups using different analytical methods, particularly on the point of improvement, which is dependent on subject uncertainty. Third, the deficit of emotion-based learning in schizophrenia with uncertainty was found to be related with score on the SANS and S5 attention. In addition, S1 affective flattering and S4 anhedonia–asociality were related to these deficits. Fourth, big penalties affected learning in controls, but not in patients with schizophrenia, and this result is irrelevant to certainty.

2. Methods

2.1. Subjects

Subjects consisted of 61 patients with schizophrenia (Sz) and 50 sex- and age-matched normal control subjects (NC). All patients were recruited from the outpatient clinics of Chiba University Hospital. Control subjects with no past history of psychiatric disorders or drug dependence were recruited. Characteristics of the subjects are shown in Table 1. Patients with an IQ of less than 80 were excluded from the study. All patients met the DSM-IV criteria for schizophrenia (American Psychiatric Association, 1994) and had no other psychiatric disorders. Of the patients, 37 were diagnosed as having residual type schizophrenia and 24 as having paranoid type schizophrenia. Patients with schizophrenia were clinically stable for at least three months before the start of the study. The research was approved by the ethics committee of Chiba University Graduate School of Medicine. Written informed consent was obtained after the procedure had been fully explained.

All patients were receiving second-generation neuroleptics; namely, risperidone (n = 30, 1–12 mg), olanzapine (n = 17, 5–20 mg), quetiapine (n = 3, 400–500 mg), perospirone (n = 4, 16–48 mg), and aripiprazole (n = 7, 6–30 mg). The chlorpromazine-equivalent dose was 539 ± 331 (means ± SD) mg/day (Woods, 2003). Fourteen patients were being treated with the anticholinergic drug biperiden (mean dose of 2.2 mg/day), although anticholinergic drugs can lead to impairments in learning and memory (Silver and Geraisy, 1995).

Table 1
Characteristics and disease severity of study participants.

Variable (mean ± SD)	Normal controls (n = 50)	Schizophrenia (n = 61)	t	df	P values
Sex, male/female	33/17	33/28	1.615	1	0.203[a]
Age (years)	31.9 ± 7.8	34.3 ± 8.3	1.557	109	0.122[b]
Education duration (years)	15.4 ± 3.1	13.8 ± 2.2	3.174	109	0.002[b]
Estimated IQ[c]	110.3 ± 11.9	101.1 ± 16.2	3.343	109	0.001[b]
Age at disease onset (years)		25.0 ± 5.9			
Duration of illness (years)		9.4 ± 7.7			
Amount of medication[d]		539 ± 331			
BPRS total score		24.7 ± 9.0			
BPRS positive score		10.8 ± 5.1			
BPRS negative score		7.5 ± 3.3			
SANS total score		76.1 ± 13.9			
DIEPSS score		0.39 ± 0.33			

All values are shown as mean ± S D (range).
[a] χ^2 test.
[b] *t*-Test.
[c] Short form version of Wechsler Adult Intelligence Scale, Revised (WAIS-R).
[d] Chlorpromazine equivalent (mg).

2.2. Clinical severity

The Brief Psychiatry Rating Scale (BPRS) was used to evaluate general disease severity (Overall and Gorham, 1962). The Scale for the Assessment of Negative Symptoms (SANS) was used to evaluate negative symptoms (Andreasen, 1982). Since many cognitive functions are influenced by extrapyramidal motor side effects, the Drug Induced Extrapyramidal Symptoms Scale (DIEPSS) was used to evaluate the effects of drug-induced extrapyramidal symptoms, which could affect clinical severity (Inada et al., 2002). Intelligence quotient (IQ) scores were estimated from the information, digit span, and picture completion subscales, using the short version of the Wechsler Adult Intelligence Scale Revised (WAIS-R) (Nakamura et al., 2000; Wechsler, 1997). Age at onset, duration of illness, and duration of untreated psychosis were evaluated.

2.3. Iowa Gambling Task (IGT)

Subjects are instructed to sit facing 4 decks of cards, and to pick a card from one of the decks (A, B, C, D). They were informed that they would receive a monetary reward or penalty following card pickup, and that the goal of the game was to maximize profits. The subjects were free to pick from any deck and to switch decks at any time. The subjects are not informed prior to the task how many cards they would be required to pick up, but the task was stopped after the 100th card pickup.

Decks A and B were disadvantageous, in that as well as providing large monetary gains ($100) they also dealt occasional large losses between $150 and $350 from Deck A and $1250 from Deck B. Both of these decks led to a net loss in the long run. Conversely, decks C and D were advantageous in that they provided smaller monetary rewards ($50) but also smaller penalties, ranging between $25 and $75 from Deck C, and $250 from Deck D. Both decks lead to net gains at the end of the test. Performance is measured by the comparison of card choices from advantageous decks [C + D] and disadvantageous decks [A+B]. Typically, the composite value, [C+D] − [A+B], is used for analysis of IGT.

In this study, after completion of the task, subjects were asked whether they had deciphered the best strategy to achieve net gain,