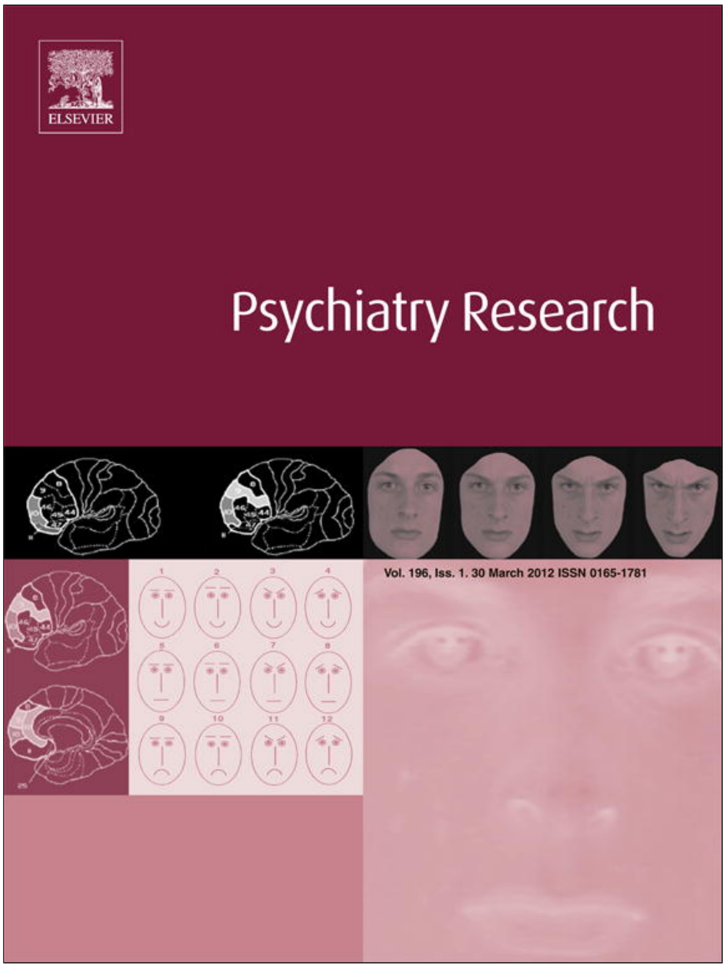
ELSEVIER
Psychiatry Research
Vol. 196, Iss. 1. 30 March 2012 ISSN 0165-1781

Psychiatry Research 196 (2012) 15–19

Contents lists available at SciVerse ScienceDirect

Psychiatry Research

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

Cognitive decision modelling of emotion-based learning impairment in schizophrenia: The role of awareness

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A R T I C L E I N F O

Article history:
Received 21 April 2011
Received in revised form 15 July 2011
Accepted 24 August 2011

Keywords:
Schizophrenia
Decision-making
Iowa Gambling Task
Awareness
Formal cognitive modelling

A B S T R A C T

Individuals with schizophrenia often lack insight or awareness. Resulting impairment has been observed in various cognitive domains and, recently, linked to problems in emotion-based learning. The Iowa Gambling Task (IGT) has been used to assess emotion-based decision-making in patients with schizophrenia, but results have been inconclusive. The current study further investigates emotion-based decision-making in schizophrenia by elucidating the unique contribution of awareness. Twenty-five patients with schizophrenia and 24 healthy controls were assessed with a modified version of the IGT recording awareness at regular intervals. Symptom assessment, medication and medical history were recorded for the clinical group. Patients with schizophrenia underperformed on the IGT compared to controls. Subjective awareness levels were significantly lower in the schizophrenia group and were associated with hallucination severity. Cognitive decision modelling further indicated that patients with schizophrenia had impaired attention to losses, compared to controls. This parameter was positively correlated with awareness. We also found that positive symptoms altered awareness levels and suggest that this disruption may contribute to sub-optimal decision-making. Overall, a lack of awareness may be an important aspect in understanding impaired social cognitive functioning and emotion-based learning observed in schizophrenia.

1. Introduction

The influence of a number of the cardinal features of schizophrenia on emotion-based learning has been extensively investigated with the Iowa Gambling Task (IGT; Bechara et al., 1994; Ritter et al., 2004; Turnbull et al., 2003; Evans et al., 2005; Shurman et al., 2005; Cella et al., 2009; Larquet et al., 2010). In the IGT, participants select cards from four decks associated with variable levels of monetary reward and loss (Bechara et al., 1994). Two of the decks (A and B) result in frequent immediate high gain per choice (e.g., £100), but produce high-magnitude losses of differing frequencies depending on the deck, leading to a cumulative long term loss (i.e., termed “the disadvantageous choice”). The remaining two decks (C and D) typically result in lower immediate rewards, (e.g., £50), but also generate lower magnitude losses at the same frequency of punishment as decks A and B, resulting in a cumulative long-term gain (i.e., termed “the advantageous choice”). A key feature of learning on the IGT is the gradual adjustment to the affective consequences of reward and punishment, as participants initially sample cards from all of the decks before showing, by around the second block of 20 trials, a choice preference for the advantageous decks (Dunn et al., 2006; Cella et al., 2007; Dymond et al., 2010a).

The performance of individuals with schizophrenia on the IGT has been largely inconclusive. Some studies (e.g., Cavallaro et al., 2003; Ritter et al., 2004; Evans et al., 2005; Rodríguez-Sánchez et al., 2005) have shown that patients perform at levels comparable to healthy participants, while other studies (e.g., Shurman et al., 2005; Turnbull et al., 2006; Lee et al., 2007; Martino et al., 2007) have shown that patients with schizophrenia perform disadvantageously compared to healthy controls. A range of factors such as the influence of medication, comorbid diagnoses, and the heterogeneity of symptoms within the diagnosis of schizophrenia itself may have contributed to these findings (Dunn et al., 2006; Sevy et al., 2007).

An under-examined issue that may partly account for the inconclusive findings is the role of subjective experience or awareness of the deck contingencies of reward and punishment (Maia and McClelland, 2004, 2005; Evans et al., 2005). Advantageous decision-making on the IGT is assumed to originate with the aid of unconscious biassing signals arising from the body (Damasio, 1996; cf. Dunn et al., 2006). That is, advantageous emotion-based learning is said to occur before individuals are able to verbalise or otherwise show awareness of which decks result in net profit and which in net loss (Bechara et al., 1997; Bechara, 2004). Evans et al.

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doi:10.1016/j.psychres.2011.08.015

(2005), however, found that patients with schizophrenia showed relatively normal levels of learning on the IGT, comparable to that of healthy, educationally matched controls, and also evidenced high levels of rapidly developing awareness of which decks were "good" and which were "bad". These authors systematically assessed participants' subjective experience levels during the task by asking them, every 20 trials, to use a 10-point scale to "give each deck of cards a score, based on how good or bad you feel they are" (2005, p. 659), where *0 = very bad* and *10 = very good*. Patients' awareness scores were consistently above chance, at levels higher than their behavioural performance, and were a significantly greater predictor ($p < 0.01$) of their IGT performance than that of the controls ($p < 0.05$; Evans et al., 2005). Regular, systematic recording of subjective experience ratings of the relative goodness and badness of the decks may indicate greater awareness of deck contingencies during IGT performance in patients with schizophrenia.

The findings of Evans et al. (2005) are noteworthy, particularly as lack of awareness is often observed in people with schizophrenia and assumed to impair cognitive functioning, including executive functions and working memory (Shad et al., 2006; Simon et al., 2006; Toplak et al., 2010; Gilleen et al., 2011), that may be important in achieving advantageous decision-making (Brand et al., 2007; Dretsch and Tipples, 2008). It is also possible that the form of intensive, systematic assessment of subjective experience used by Evans and colleagues served to orient participants' attentional resources towards the outcomes of each deck. Support for this view comes from applied-developmental research showing that a symbol labelling intervention in which participants are taught to label the good and bad decks, in a manner resembling how awareness is measured, facilitates advantageous IGT performance in young children and individuals with learning disabilities (Garon and Moore, 2007; Dymond et al., 2010b). In sum, the findings of impaired awareness and insight that have been reported on the IGT may represent a direct behavioural measure of the more general awareness of deficit that clinicians experience with this patient group (Gilleen et al., 2011).

The present study sought to systematically investigate the role of subjective awareness in emotion-based learning in patients with schizophrenia. In so doing, we sought to extend clinical research employing the IGT to an identification of the specific components that may characterise impaired or unimpaired learning through the use of cognitive decision model parameters (i.e., Busemeyer and Stout, 2002; Yechiam et al., 2005, 2007). The Expectancy Valence (EV) model is a formal cognitive model used to dissociate cognitive, motivational and behavioural processes underlying performance on decision-making tasks such as the IGT (Yechiam et al., 2005, 2007). Three parameters can be derived from the EV model: attention to the gains and losses associated with deck selections ("attention"), attention to recent outcomes relative to past outcomes ("learning"), and response consistency between choices and expectancies over time ("response-choice consistency"). Premkumar et al. (2008) found that the learning parameter, not choice consistency or attention, differentiated the impaired performance of patients with schizophrenia on the IGT, relative to a group of healthy controls. They suggested that the three EV model parameters correspond to dissociable features of deck selection and that findings with the learning rate parameter were consistent with reports of marked memory deficit seen with patients with schizophrenia that is known to be important in emotion-based learning (Heinrichs and Zakzanis, 1998). Alternatively, Kester et al. (2006) found that only the attention parameter differentiated the impaired performance of a small sample of adolescent patients with schizophrenia on the IGT, compared to healthy adolescents. The dissociable component of attention indicates a hypersensitivity to immediate rewards often observed in those at risk of psychopathology and substance abuse (Kumra et al., 2005). Thus, in these and other studies, the EV model has proven useful in highlighting the specific cognitive processes underlying the poor performance of clinical groups (e.g., Yechiam et al., 2005; Kester et al., 2006; Premkumar et al., 2008; Bass and Nussbaum, 2010; Yechiam et al., 2010).

The present study sought to extend these findings by identifying the dissociable components underlying the IGT performance of patients with schizophrenia and healthy controls in a task that regularly assessed subjective awareness. Moreover, we sought to investigate the role of symptom severity in moderating advantageous IGT performance.

2. Method

2.1. Participants

Twenty-five outpatients who met DSM-IV criteria for schizophrenia and 24, age- and sex-matched healthy controls were recruited. Diagnoses were confirmed via the *Structured Clinical Interview* (First et al., 1998). Patients were on stable doses of atypical antipsychotic medication, with no less than a month from the last prescription change, and all stated that medication compliance had been optimal in the 2 weeks prior to the study. More than half of the patients ($n = 15$) received additional psychotropic medication, most frequently benzodiazepine. The control group was selected from the local community based on age, sex, and education, and all were free of psychotropic medication and did not have any history of mental illness. Additional exclusion criteria for patients and controls were: no history of neurological disorders or medical conditions known to influence cognition, and past or present substance abuse problems. Demographic data are presented in Table 1.

The local National Health Service Research Ethics Committee approved the study. All participants were compensated for their time.

2.2. Materials

2.2.1. Psychotic Symptom Rating Scale

The Psychotic Symptom Rating Scale (PSYRATS; Haddock et al., 1999). The PSYRATS is a 17-item scale, administered via interview, assessing the multidimensional features of delusions and auditory hallucination in patients with schizophrenia. The PSYRATS provides two sub-scale scores: Auditory Hallucinations and Delusions.

2.2.2. Scale for the Assessment of Negative Symptoms

The Scale for the Assessment of Negative Symptoms (SANS; Andreasen, 1982). The SANS is a 20-item scale assessing negative symptoms associated with schizophrenia.

Table 1
Participant characteristics. Differences were tested with either a *t*-test or Chi square test as appropriate; *p* values are reported.

	Schizophrenia ($n = 25$)	Controls ($n = 24$)	t or χ^2
Age, years, mean (S.D.)	39.24 (10.54)	35 (10.51)	$t(47) = 1.41$ $p = 0.166$
Sex (male/female)	15/9	11/14	$\chi^2(1) = .214$ $p = 0.432$
Education (years)	13.4 (2.12)	15.38 (1.76)	$t(47) = -3.53$ $p = 0.001$
Ethnicity			
White	25	23	$\chi^2(1) = 1.06$ $p = 0.47$
Other	0	1	
Employment			
Unemployed	23	0	$\chi^2(1) = 45.99$
Working	0	20	$p < 0.0001$
Student	2	3	
Retired	0	1	
Cigarettes per day, mean (S.D.)	13.01 (2.59)	4.84 (.99)	$t(47) = 5.42$ $p < 0.0001$
Last hospitalisation (weeks), mean (S.D.)	75.36 (75.38)		
Age of onset, mean years (S.D.)	23.04 (6.33)		
Illness duration, years, mean (S.D.)	16.44 (8.96)		
Psychiatric hospitalisation	5.12 (4.88)		
CBT for psychosis	16		
PSYRATS Auditory Hallucinations, mean (S.D.)	16.16 (13.4)		
PSYRATS Delusions, mean (S.D.)	7.52 (6.31)		
SANS total (S.D.)	30.52 (25.9)		

The items are grouped into five complexes: affective flattering, alogia, avolition-apathy, anhedonia-asociality and attentional impairment, and yields one total score.

2.3. Iowa Gambling Task (IGT)

Participants were instructed to select cards from four concurrently available decks presented on the computer screen (labelled sequentially A, B, C and D). The programme randomly determined which two of the decks were to be "advantageous" and "disadvantageous", respectively, for each participant. This was done in order to rule out location preference as a potential factor governing performance. Once determined, the positions of the decks remained unchanged until the end of the task. A loan of £1000 of virtual money was displayed at the bottom right of the screen and was updated immediately following choices with gains and/or losses. Participants always won £100 if they selected a card from the "disadvantageous" decks and always won £50 if they selected a card from the "advantageous" decks. The amount of losses varied between £150 and £350 for deck A; £1250 for deck B; between £25 and £75 for deck C; and £250 for deck D. In the case of gains, a sentence stating, "You won X! X added to your total" appeared on the screen and the amount of money won was added to the total. In the case of gains and loss, the message presented was, "You lose £1250! £1250 has been deducted from your total". This onscreen feedback was displayed for 10-s, before a 2-s ITI. Both groups received general instructions about the task that were based on Bechara et al. (2000). The task ended when 100 choices were made.

As in Cella et al. (2007), after every block of 20 choices, participants were asked to provide subjective ratings in terms of how "good" or "bad" they felt each deck to be. Ratings were made using a slider-scale from 0 to 10 (where *0 = very bad* and *10 = very good*).

2.4. Expectancy-valence (EV) model parameter estimation

The three parameters of the EV model (Busemeyer and Stout, 2002; Yechiam et al., 2005) were applied to each group's task performance (Stallen, 2006). Values of the *attention* parameter can range between 0 and 1, with lower numbers indicating lower attention to trial losses. The *learning* parameter can also range between 0 and 1, with larger values indicating stronger recency effects. Finally, with the *choice consistency* parameter, low values reflect inconsistent and erratic choices that are independent of deck expectancies.

2.5. Data analysis

The mean net score was calculated for each block of 20 trials by subtracting the number of selections of the bad decks (A and B) from the number of selections of the good decks (C and D). Mean net scores above zero are an index of advantageous performance (selecting more from the good decks) while scores below zero are an index of disadvantageous performance (selecting more from the bad decks). Similarly, mean net subjective awareness levels were calculated for every block of 20 selections by subtracting the ratings of the bad decks from the ratings of the good decks.

Mixed factor analyses of variance (ANOVAs) with contrast analyses were used to analyse decision-making performance and subjective awareness during the IGT in the two groups. Greenhouse–Geisser correction was applied when sphericity assumptions were violated. T-tests were used to identify how the specific EV parameters differed across each group performance. Multiple regression was used to investigate the role of possible predictors of IGT performance and awareness.

3. Results

3.1. IGT performance

Fig. 1 shows the mean net score performance of the schizophrenia patients and the controls during the five blocks of 20 trials. A 2 (group) × 5 (block) mixed factor ANOVA revealed a significant main effect of block, F (2.9, 138.39) = 8.87, p<0.0001, group, F (1, 47) = 18.84, p<0.0001, and a significant interaction, F (2.9, 138.39) = 9.41, p<0.0001. Within-group contrast analyses showed a significant decrease between block 2 and 3 in the schizophrenia group, F (1,24) = 4.41, p = 0.046, and a significant increase in the control group between block 1 and 2, F (1,23) = 24.9, p<0.0001. A follow-up between-group ANOVA showed a significantly higher performance level for the control group in blocks 3, 4 and 5 (all p<0.05).

3.2. IGT subjective awareness ratings

Fig. 2 shows the mean net subjective rating for both groups. A 2 (group) × 5 (block) mixed factor ANOVA revealed a significant main effect of block, F (3.37, 158.6) = 10.05, p<0.0001, group, F (1, 47) = 13.34, p = 0.001, and a significant interaction, F (3.37, 158.6) = 13.04, p = 0.009. Within-group contrast analyses showed a significant improvement in subjective ratings between block 1 and 2, F (1,23) = 4.33, p = 0.049, and block 2 and 3, F (1,23) = 11.78, p = 0.002, for the controls, and between block 1 and 2 for the schizophrenia patients, F (1,24) = 7.01, p = 0.014. A follow-up between-group ANOVA showed a significantly higher awareness level for the control group in blocks 3, 4 and 5 (p values between 0.04 and <0.0001).

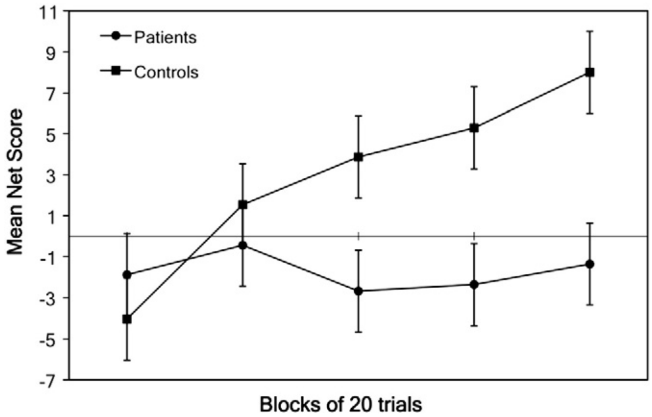

Fig. 1. Mean net IGT score for the schizophrenia patients and controls across each of the 5, 20-trial blocks. Error bars represent two standard errors.

3.3. Parameters obtained from the EV model

Independent samples t-tests were used to examine differences in the three parameters across the two groups. Two patients with schizophrenia and one control participant were excluded from these analyses, as the EV model failed to converge for these participants. Schizophrenia patients (M = 0.28, S.D. = 0.32) showed significantly greater insensitivity to losses (*attention*) compared to the control group (M = 0.52, S.D. = 0.38): t (44) = 2.32, p<0.05. There were no significant differences between the groups for the *learning* (patients: M = 0.30, S.D. = 0.37; controls: M = 0.27, S.D. = 0.39), t (44) = −.28, p>0.05, or *choice consistency* parameters (patients: M = 0.63, S.D. = 2.28; controls: M = 0.58, S.D. = 2.72), t (44) = −0.07, p>0.05.

In the schizophrenia group, mean net subjective rating was significantly correlated with the *attention* parameter of the EV model, r = 0.46, p = 0.04.

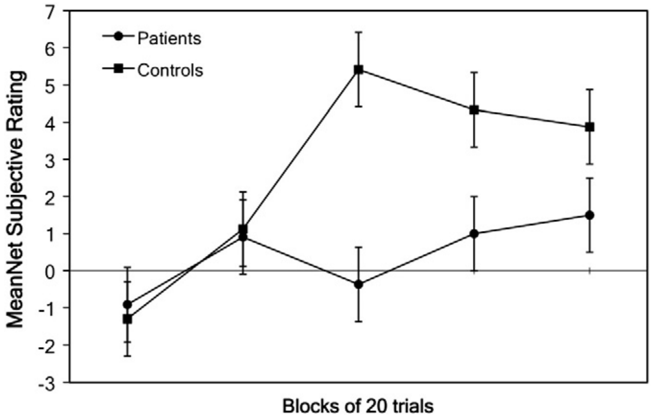

Fig. 2. Mean net IGT subjective rating for the schizophrenia patients and controls across each of the 5, 20-trial blocks. Error bars represent two standard errors.

3.4. Further investigating impairment in the schizophrenia patients

To clarify the contribution of different factors to IGT performance in patients with schizophrenia, a stepwise multiple regression model was performed. Positive and negative symptom and awareness ratings were entered in the model to predict IGT performance. The model yielded an R^2 of 0.59, F (1,21) = 29.37, $p<0.0001$, and identified subjective rating as the only significant predictor of performance (standardised $\beta=0.771$, $p<0.0001$). Correlation analysis confirmed the positive and significant relation between subjective rating and mean net score ($r=0.74$; $p<0.05$).

A further stepwise multiple regression model was carried out to clarify the contribution of symptoms to subjective rating. The model yielded an R^2 of 0.54, F (1,21) = 23.4, $p<0.0001$, and the PSYRATS hallucinations scale was found to be the only significant predictor (standardised $\beta=-0.73$, $p<0.0001$).

4. Discussion

To our knowledge, the present study represents the first investigation of subjective awareness and cognitive decision modelling of performance in emotion-based learning in patients with schizophrenia. Consistent with some of what has become a complex literature on emotion-based learning in schizophrenia (Shurman et al., 2005; Kester et al., 2006; Lee et al., 2007; Martino et al., 2007), we found that patients with schizophrenia performed below-chance and significantly worse compared to healthy controls on the IGT. The present study's findings on basic IGT performance therefore fall at the lower end of the wide range of previously reported performances. It is difficult to establish the precise reasons for this variability: options might include issues of medication and comorbid substance abuse, impulsivity, variation in age, education and levels of executive function, and differences in administration technique (Evans et al., 2004, 2005; Dunn et al., 2006; Sevy et al., 2007; Verdejo-García et al., 2008; Toplak et al., 2010).

The role of awareness has often been neglected in research on decision-making. Maia and McClelland (2004, 2005) showed that, although IGT performance is not necessarily dissociated from awareness of the deck contingencies, no specific suggestion about its possible supporting role has ever been advanced (Bechara et al., 2005). One previous investigation found relatively preserved levels of subjective experience are seen in patients with schizophrenia (Evans et al., 2005), and the investigation of this topic with patients may prove extremely fruitful — because these clinical groups, and others with psychosis, are often reported to lack insight and awareness. Naturally, the precise relationship between impairments of insight on the IGT and the disruption of insight and lack of awareness of deficit that are reported in this patient group remain topics for further investigation. However, it seems likely that while the precise forms of general versus task-specific insight/awareness may differ, there are likely to be several facets of cognitive and emotional functioning than underpin awareness on both the IGT and awareness of ability in everyday life (Dunn et al., 2006; Gilleen et al., 2011).

The present study focussed on the recording of levels of subjective experience throughout the task, and showed that the groups significantly diverged from the third block of trials onwards, with patients with schizophrenia reporting *some* (though relatively modest) growth in awareness, but significantly smaller gains than controls. Consistent with previous findings, subjective awareness correlated positively with overall performance (Evans et al., 2005). Importantly, in the schizophrenia group, subjective experience was the *only* significant predictor of IGT performance, and was also influenced by hallucination severity. This substantial role for subjective awareness in the disorder suggests that people with schizophrenia rely on emotion-based information in complex decision-making — a finding also consistent with the developing literature on the role of emotion in false belief states (Fotopoulou et al., 2004; Turnbull et al., 2004; Turnbull et al., 2005, 2006; Fotopoulou et al., 2007, 2008).

In an attempt to dissociate the cognitive, motivational and behavioural processes underlying performance on the IGT, we applied the EV model (Yechiam et al., 2005, 2007). The EV model parameters indicated that patients with schizophrenia paid significantly greater attention to losses compared to controls. No significant differences were found with the learning and choice consistency parameters. Since the attention parameter is considered to reflect working memory processes, then our findings are consistent with previous reports showing dissociation between working memory and IGT performance (e.g., Bechara et al., 1998; Hooper et al., 2004). Both the patients and the controls showed high levels of deck consistency (as referenced with the choice consistency parameter), with patients consistently showing a preference for the disadvantageous decks, and controls for the advantageous decks.

Our results support those of Kester et al. (2006), who showed the same pattern of results using the EV model with an adolescent sample with schizophrenia. Premkumar et al. (2008), however, found that patients showed poorer memory for past, relative to recent, outcomes compared to controls (*learning*), but no significant differences on other parameters. The current findings suggest that the patients are effective at initially learning the contingencies of the task that ascribe higher reward values to the 'bad' decks, but that they show greater insensitivity to the intermittent large losses that occur with these decks, relative to the control group. In other words, it suggests that patients with schizophrenia show relatively poor flexible learning in a task with a mix of reward and punishment contingencies that must be learned over time. Indeed, previous studies using a modified IGT that switches the 'good' and 'bad' decks at the completion of the standard IGT trials have supported the idea that patients with schizophrenia (Turnbull et al., 2006) and putatively healthy participants with high scores on measures of hallucination and delusion proneness (Cella et al., 2009) perform poorly when flexible learning is required.

In conclusion, we found that patients with schizophrenia underperformed on the IGT relative to controls, showed diminished attention to gains versus losses as revealed by a cognitive decision model, and that their subjective awareness levels significantly predicted behavioural performance. Further investigation of the role of subjective awareness in patient populations with psychotic experiences by, for instance, measuring subjective experience levels prior to the onset of the task, and identifying the extent to which subjective (intuitive) experiences are relied on in decision-making, and predicted by formal models, may well pay substantial dividends in understanding the nature of delusional belief states.

Acknowledgments

The authors gratefully acknowledge the assistance of staff at Cefn Coed Hospital and Ty Morris, Swansea during the conduct of this research.

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