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Impairment in flexible emotion-based learning in hallucination- and delusion-prone individuals

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ABSTRACT

Deficits in emotion-based learning are implicated in many psychiatric disorders. Research conducted with patients with schizophrenia using one of the most popular tasks for the investigation of emotion-based learning, the Iowa Gambling Task (IGT), has largely been inconclusive. The present study employed a novel, contingency-shifting variant IGT with hallucination- and delusion-prone university students to determine whether previous findings were due merely to the presence of psychosis. Following initial screening of a sample of 253 students (mean age = 20.13 years, S.D. = 3.27), 28 high (10 male, 18 female) and 27 low (12 male, 15 female) hallucination-prone and 27 high (7 male, 20 female) and 26 low (11 male, 15 female) delusion-prone individuals completed the contingency-shifting variant IGT. Results showed no significant differences between the performances of high and low hallucination- and delusion-prone individuals during the original phase of the task. Differences only emerged following the onset of the contingency-shift phases, with individuals high in hallucination- and delusion-proneness having impaired performance compared with low hallucination- and delusion-prone individuals. Overall, the present findings demonstrate that impairments associated with hallucination- and delusion-proneness are specific to the shift phase of the contingency-shifting variant IGT, which supports previous findings with patients with schizophrenia.

1. Introduction

Deficits in *emotion-based learning* or *emotional decision-making* are implicated in several psychiatric disorders, including schizophrenia (e.g., Lawrence et al., 2006; Martino et al., 2007; Must et al., 2006; Sevy et al., 2007). The evidence from research conducted using the Iowa Gambling Task (IGT; Bechara et al., 1994, 2000) with patients with schizophrenia is, however, largely inconclusive. Some studies (Evans et al., 2005; Ritter et al., 2004) have shown that patients perform at levels comparable to healthy participants, while other studies (Lee et al., 2007; Martino et al., 2007; Shurman et al., 2005) have shown that patients with schizophrenia engage in disadvantageous decision-making compared to healthy controls. In seeking to explain these findings, it is important to acknowledge the contribution of factors such as the relatively small sample sizes, the influence of medication, comordid diagnoses, and the heterogeneity of symptoms within the diagnosis of schizophrenia itself (Dunn et al., 2006; Sevy et al., 2007).

Recently, Turnbull et al. (2006) suggested that people with schizophrenia might not show consistent deficits on the IGT because the original task does not adequately tap flexibility in emotion-based learning. Until now, researchers have relied on tasks that separately index set-shifting and reversal learning ability to infer the role of flexible emotion-based learning in IGT performance, with a number of studies showing that people with schizophrenia perform relatively poorly (Pantelis et al., 1999; Waltz and Gold, 2007). Recently, Rodriguez-Sanchez et al. (2005) reported that first episode schizophrenia patients have unimpaired IGT performance, yet have impaired performance on one of the most widely used measures of executive functioning and set-shifting ability: the Wisconsin Card Sorting Test (WCST; see also Prentice et al., 2008). These authors also found that performance on the IGT was not correlated with WCST performance. Lee et al. (2007) reported impaired IGT performance and, similar to Rodriguez-Sanchez et al. (2005), an absence of correlations between WCST ability and IGT performance. Lee et al. (2007) also found that performance on the Simple Reversal Learning Task (SRLT; Fellows and Farah, 2003) was impaired in people with schizophrenia, relative to healthy controls, but was not associated with performance on the IGT in either of the groups. Both the Rodriguez-Sanchez et al. (2005) and Lee et al. (2007) studies failed to find correlations between set-shifting ability, as measured by the WCST, and reversal learning ability, as measured with the SRLT, and IGT performance.

Turnbull et al. (2006) recently developed a novel, contingency-shifting version of the IGT. In the contingency-shifting version, the reinforcement contingencies of the card decks were shifted following initial exposure to the original IGT trials such that card decks that had previously been advantageous became disadvantageous, and vice versa.

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Turnbull et al. (2006) compared a group of patients with schizophrenia who were classified as either high or low in positive and negative symptomatology with a healthy control group. Results showed that patients high in positive and negative symptoms initially learned at levels comparable to the healthy controls during the original IGT, supporting some previous studies (e.g., Rodriguez-Sanchez et al., 2005; Ritter et al., 2004). During the contingency-shift phase of the task, however, those patients high in negative symptoms exhibited markedly poorer performance in adjusting to the changing contingencies relative to both healthy controls and those patients high in positive symptoms, suggesting that deficits associated with schizophrenia are specific to the shift phases. In this way, the contingency-shifting variant IGT may be useful for research on emotion-based learning in the schizophrenia spectrum because it adds a cognitive component consistently shown to be impaired in schizophrenia (Waltz and Gold, 2007).

Differentiating between emotion-based learning deficits that may reflect core pathological processes in schizophrenia and the impact of symptomatology on the reported behavioural deficits is important in understanding the emotional and cognitive determinants of psychopathology. An intriguing means of addressing this question is to examine flexible emotion-based learning with the contingency-shifting variant IGT in non-clinical samples that have elevated psychosis-proneness scores (Johns and van Os, 2001; Verdoux and van Os, 2002). Hallucination- and delusion-proneness are two of the most prominent features of psychosis-proneness that appear to be dimensionally distributed across the general population (Johns and van Os, 2001). Previous studies have investigated how measures of proneness to psychosis relate to measures of set-shifting, such as the WCST (e.g., Nieuwenstein et al., 2001; Suhr, 1997; Suhr and Spitznagel, 2001). Performance on the contingency-shifting IGT and WCST is, however, likely to be reliant on a number of relatively diverse cognitive processes, such as working memory, attention and response inhibition, and some caution is therefore necessary when interpreting previous findings. Nonetheless, it seems plausible to suggest impairment in IGT contingency-shifting performance in individuals high in hallucination- and delusion-proneness.

The aim of the present study, therefore, was to extend the findings of Turnbull et al. (2006) with the contingency-shifting variant IGT by examining the performance of non-clinical groups high on hallucination- and delusion-proneness. We hypothesised that high and low psychosis-prone individuals would not differ in their performance during the original IGT trial blocks but would differ significantly during the contingency-shifting phases.

2. Method

There were two stages to the study. First, a large cohort of students was screened to form our participant groups. Second, those participants invited for further study were tested in a laboratory and were compensated with £5.00.

2.1. Participants

Two hundred and fifty-three Swansea University students were administered the *Launay–Slade Hallucination Scale* (LSHS; Launay and Slade, 1981; Larøi et al., 2004), *Peters Delusions Inventory* (PDI; Peters et al., 1999, 2004), and several other unrelated self-report scales. One hundred and seventy-seven of these participants were female and 73 were male (3 participants did not record their gender). The mean age of this sample was 20.13 years (S.D. = 3.27). Scores on the LSHS and PDI served as the basis for inclusion in the laboratory study. Participants in the top and bottom 15% of the distribution for the PDI and LSHS total scores were placed into high and low groups for these scales, respectively. These individuals were then invited to participate in a further experimental session comprising administration of the contingency-shifting variant IGT. Seventy-four of the 92 invited participants agreed to complete the second session within 6 weeks of completing the questionnaires. This yielded a final sample of 28 high- and 27 low-LSHS participants and 27 high- and 26 low-PDI participants. There were 10 males and 18 females in the High-LSHS group, 12 males and 15 females in the low-LSHS group, 7 males and 20 females in the High-PDI group, and 11 males and 15 females in the Low-PDI group. There were no differences in either age or gender between those who declined to participate in the second session and those who did. Participants were not pre-screened for psychiatric disorders, substance abuse disorders, or use of psychotropic medication, and all were drug free at the time of testing.

2.2. Psychosis-proneness measures

2.2.1. Launay–Slade Hallucination Scale (LSHS; Launay and Slade, 1981)

Hallucination-proneness was assessed using a modified version of the LSHS (Larøi et al., 2004). The scale is composed of 16 items, scored on a 5-point Likert scale, where 0 = "certainly does not apply to me", 1 = "possibly does not apply to me", 2 = "unsure", 3 = "possibly applies to me", 4 = "certainly applies to me". Participants' total LSHS score is the sum of all the item scores. The LSHS has high internal reliability (Cronbach's $\alpha = 0.78$; Bentall and Slade, 1985; Larøi et al., 2004) and has been used as a valid indicator of psychosis-proneness in the general population (Larøi et al., 2004; Lincoln, 2007; Cella et al., 2008).

2.2.2. Peters et al. Delusions Inventory (PDI; Peters et al., 1999)

Delusion-proneness was assessed with the revised 21-item PDI (Peters et al., 2004). This measure explores lifetime prevalence of delusional ideation, using the introductory expression, "Do you ever feel as if [*some people are not what they seem to be*]?" Questions are answered on a yes-or-no basis. When a "Yes" is checked, three additional 5-point rating scales measure distress, preoccupation and conviction associated with the experience. Each "Yes" checked assigns 1 point contributing to a frequency score of reported delusional experiences (range: 0–21). All of the items checked "Yes" also contribute to distress, preoccupation and conviction scores. The final score is the sum of the selection endorsed in the rating subscales. Each subscale can range from 0 to 105. Every "No" answer on the PDI leads automatically to a 0 score for each subscale. Finally, a total PDI score is obtained by adding the frequency of positively endorsed items to all the subscale total scores. The 21-item scale has high internal reliability (Cronbach's $\alpha = 0.82$), has high test-retest reliability ($r = 0.82$; Peters et al., 1999) and has been used to screen for psychotic symptoms in clinical and non-clinical groups (Larøi and Van der Linden, 2005; Lincoln, 2007).

2.3. Measure of emotion-based learning

2.3.1. Contingency-shifting variant IGT

Participants received general instructions about the task and completed a total of 220 trials of the IGT in two phases: 100 trials of the original version of the task (Phase 1; see Cella et al., 2007), followed by 120 trials of the contingency-shifting variant IGT involving three successive shifts of the reinforcement contingencies (Phase 2). In Phase 1, participants were instructed to select cards from four concurrently available blue-coloured decks (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. That is, unlike previous studies, the spatial location of the advantageous and disadvantageous decks was not restricted to the left (i.e., A and B) or right (i.e., C and D) of the computer screen. Randomly determining advantageous and disadvantageous decks at the outset of the task for every participant excludes 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 intertrial interval. This phase ended after 100 trials.

In Phase 2, three contingency-shift phases, each consisting of two blocks of 20 trials, were introduced. The onset of each unsignalled shift phase involved a progressive modification of the reward and punishment contingencies of Phase 1. The advantageous decks (C and D) were successively replaced by Decks A and D, A and B, and B and C during the three shift periods (see Fig. 1). Phase 2 ended after 120 trials.

2.4. Data analysis

For analysis of the IGT, trials were grouped in to blocks of 20: Phase 1 comprised 5 blocks of 20 trials, while Phase 2 had three shift periods, each comprising 2 blocks of 20 trials. The mean net score was calculated for each block of 20 trials by subtracting the number of selections from the good decks (A and B) by the number of selections from the bad decks (C and D). Mean net scores above zero are an index of advantageous performance (selecting more from advantageous decks) while scores below zero are an index of disadvantageous performance (selecting more from disadvantageous decks). Mixed factor ANOVAs with post-hoc tests were used to analyses of variance (ANOVAs) with high- and low-PDI/LSHS groups across blocks of trials, and differences in good-now-bad deck selections across the shift periods for the high and low groups.

3. Results

Table 1 displays the mean PDI and LSHS scores for the initial large sample, as well as for the high- and low-PDI/LSHS sub-groups. Reliability scores as established by Cronbach's alpha were 0.88 for the

Deck	Phase 1	Phase 2		
		1	2	3
A	-	+	+	-
B	-	-	+	+
C	+	-	-	+
D	+	+	-	-

Fig. 1. The good (+) and bad (−) decks during Phase 1 and each of the three contingency shift phases of Phase 2.

LSHS, 0.94 for PDI total, 0.84 for PDI distress, 0.84 for PDI preoccupation, and 0.79 for PDI conviction. In the total sample, the PDI and LSHS total scores were positively and significantly correlated ($r=0.53$, $P<0.0001$). As expected, independent samples t-tests showed that the high- and low-PDI groups significantly differed on the PDI total score, $t(51)=-14.05$, $P<0.0001$, and the high- and low-LSHS groups differed significantly on the LSHS total score, $t(53)=-22.87$, $P<0.0001$. It should be noted that the age and gender of participants did not significantly relate to performance on the IGT or scores on the PDI and LSHS, and so were not included in subsequent analyses.

Figs. 2 and 3 show Phase 1 and 2 mean net score performance for the high- and low PDI/LSHS groups, respectively. In Phase 1 of the IGT, both high and low-PDI groups showed a positive learning pattern, but there were no significant between-group differences on performance. A 2 (group) × 5 (block) mixed factor ANOVA revealed a main effect of block, $F(4, 204)=11.70$, $P<0.0001$. However, there was no significant group main effect, $F(1, 51)=1.98$, $P=0.17$, or block by group interaction, $F(4, 204)=1.73$, $P=0.15$. A similar pattern of results was shown for the high- and low-LSHS groups. In Phase 1 of the IGT, both groups showed a general increase in performance across blocks, but there were no significant group differences. A 2 (group) × 5 (block) mixed factor ANOVA revealed a main effect of block, $F(3.2, 173.32)=6.25$, $P<0.0001$. Again, there was no significant group main effect, $F(1, 53)=0.01$, $P=0.92$, or block by group interaction, $F(3.2, 173.32)=0.82$, $P=0.49$.

Figs. 2 and 3 show that across Phase 2, performance between the low and high groups on the PDI and LSHS began to diverge. A 2 (group) × 6 (block) mixed factor ANOVA performed on the shift phase for high- and low-PDI groups showed a significant main effect for group, $F(1, 49)=15.24$, $P<0.001$, but no significant main effect for block, $F(3.7, 181.32)=1.19$, $P=0.3$, nor a significant interaction, $F(3.7, 181.32)=0.76$, $P=0.58$. Post-hoc t-tests showed that the high- and low-PDI groups significantly differed in mean net score across each of the six blocks (all $P<0.05$). A similar set of analyses for the high- and low-LSHS groups revealed a main effect for group, $F(1, 52)=7.70$, $P=0.008$, but no significant main effect for block, $F(4.1, 213.43)=0.49$, $P=0.75$, nor significant interaction, $F(4.1, 213.43)=1.73$, $P=0.14$. Post-hoc t-tests showed that the high- and low-LSHS groups significantly differed in mean net score across blocks 2, 3, 4, and 6 (all $P<0.05$).

3.1. Investigating response perseveration during contingency-shift phases

Performance in Phase 2 was further investigated by examining the selection of decks that were advantageous and became disadvantageous from Phase 1 to Phase 2 and during the contingency shifts of Phase 2 in both LSHS and PDI sub-groups (see Fig. 4). A mixed factor 2 (group) × 3 (shift) ANOVA conducted on the LSHS sample showed a main effect of group, $F(1, 53)=7.212$, $P<0.01$, but no significant effect of shift period, $F(2, 106)=0.96$, $P=0.39$, nor interaction $F(2, 106)=0.24$, $P=0.79$. Post-hoc tests showed that high-LSHS participants made significantly more good-now-bad selections in the second, $t(53)=-2.35$, $P=0.02$, and in the third shift periods, $t(53)=-2.01$, $P=0.05$, but not in the first shift period, $t(53)=-1.61$, $P=0.11$. A mixed factor 2 (group) × 3 (shift) ANOVA conducted on the PDI sample showed a main effect of group, $F(1, 51)=6.41$, $P<0.01$, but no significant effect of shift period, $F(2, 102)=1.10$, $P=0.34$, nor interaction, $F(2, 102)=0.02$, $P=0.98$. Post-hoc tests showed that high-PDI participants made significantly more good-now-bad selections in the third shift period, $t(51)=-1.99$, $P=0.05$, with trends towards significantly more good-now-bad selections in the first, $t(51)=-1.92$, $P=0.06$, and second, $t(51)=-1.87$, $P=0.07$, shift periods.

4. Discussion

The findings of the present study revealed no significant differences between the performance of individuals classified as high and low in delusion- and hallucination-proneness during the original IGT phase (i.e., Phase 1). Differences in performance only emerged between the groups following the onset of the contingency-shift phases (i.e., Phase 2): individuals high in delusion- and hallucination-proneness had impaired performance during all three contingency-shift sub-phases compared with low delusion- and hallucination-prone individuals. Indeed, during the shift phases, high delusion- and hallucination-prone individuals showed a general impairment in their IGT performance as evidenced by consistent disadvantageous decision-making.

Our findings that high delusion- and hallucination-prone individuals showed general impairment in IGT performance during the shift phases may be compared with those obtained from previous studies that have investigated emotion-based learning in schizophrenia patients classified on the basis of positive symptoms (i.e., symptoms relating to the presence of abnormal experiences) such as hallucinations or delusions. Ritter et al. (2004) found impaired performance during original IGT trials in patients with schizophrenia compared to a group of healthy controls, and observed that WCST performance was impaired in both groups. These authors failed to find any correlations between IGT scores and measures of negative symptoms and did not classify IGT performance in terms of negative symptoms. Measures of positive symptoms were not reported. In the only other previous study to have examined the relationship between positive symptomatology and IGT performance, Turnbull et al. (2006) employed the contingency-shifting variant IGT and found that patients with high scores on measures of positive symptoms showed Phase 1 and Phase 2 learning at levels comparable to that of controls. Thus, it would appear

Table 1
Gender ratio, mean age and mean values (with standard deviations) for LSHS and PDI subscales for high and low groups.

	Group	Male/female	Age (S.D.)	Mean PDITot	Mean PDIdis	Mean PDIPre	Mean PDICon	Mean LSHS
LSHS	All ($n=253$)	73/177	20.13 (3.27)	45.95 (30.42)	12.8 (9.27)	12.55 (9.14)	15.4 (10.16)	16.92 (10.54)
	High ($n=28$)	10/18	19.68 (1.33)	79.32 (44.52)	23.14 (13.93)	22.29 (14.19)	26.11 (14.03)	34.07 (6.29)
	Low ($n=27$)	12/15	21.96 (4.01)	24.33 (28.69)	6.70 (8.06)	6.56 (7.98)	8.31 (9.03)	4.52 (2.38)
PDI	High ($n=27$)	7/20	20.04 (2.05)	102.81 (33.54)	30.33 (10.59)	28.52 (11.77)	33.59 (10.15)	27.52 (11.32)
	Low ($n=26$)	11/15	21.73 (4)	9.23 (5.39)	2.46 (1.55)	2.54 (2.1)	3.12 (1.86)	9.08 (7.31)

Note: PDITot = Total PDI score, PDIdis = PDI distress subscale score, PDIPre = PDI preoccupation subscale score, PDICon = PDI conviction subscale score, and LSHS = total LSHS score.

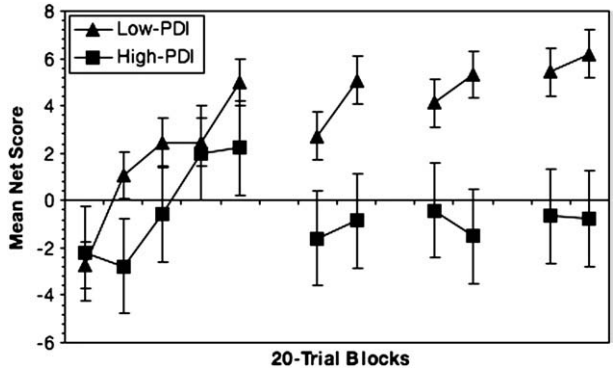

Fig. 2. The mean net score performance for the high- and low-PDI groups for the five 20-trial blocks in Phase 1 and the six 20-trial blocks in Phase 2.

that our findings are at odds with those of Turnbull et al. for patients high in positive symptoms as we observed unimpaired performance in Phase 1 and below-chance performance in Phase 2 for participants with high hallucination- and delusion-proneness. Generally, however, our findings demonstrate that impairments associated with hallucination- and delusion-proneness are specific to the shift phase of the contingency-shifting variant IGT.

Similar to a number of previous studies conducted with patients with schizophrenia, our findings suggest that features of psychosis might not alter performance on the original version of the IGT during Phase 1 (Evans et al., 2005; Rodriguez-Sanchez et al., 2005). An alternative explanation for the similar performance during the original IGT trials might be the fact that psychosis-proneness, as measured by the instruments employed, is an indicator of psychopathological propensity, rather than actual psychopathological symptomatology. It follows that the intensity of the traits expressed by the participants in this study can be considered of lower intensity than those of patients with schizophrenia. Therefore, symptom severity and symptomatological composition should be taken into consideration by future studies investigating emotional decision-making within a psychosis framework.

The effect of confounding factors such as medication, institutionalization, substance abuse, and illness length cannot be ruled out in explaining the results of the studies showing schizophrenic deficits on the original IGT (Sevy et al., 2007). Such potential confounds make comparisons between the present findings and those from research conducted with patients with schizophrenia difficult. For instance, of the 20 participants in Ritter et al.'s (2004) study, three participants were prescribed typical anti-psychotic medication, while the majority ($n = 17$) were prescribed atypical medication, and the average duration of illness was 25.8 years. It is known that patients on typical anti-psychotics are more impaired on the IGT than on the WCST compared with patients on atypical anti-psychotics (Beninger et al., 2003; but see Martino et al., 2007). Clearly, medication-type or duration of illness, or both, may have contributed to the results obtained in previous studies. Further research is therefore necessary to disentangle the effects of different medication-types and illness duration on emotion-based learning abilities in the various psychiatric disorders studied to date. Further sub-clinical analyses with non-medicated populations conducted according to the dimensionality of psychopathology framework are also warranted.

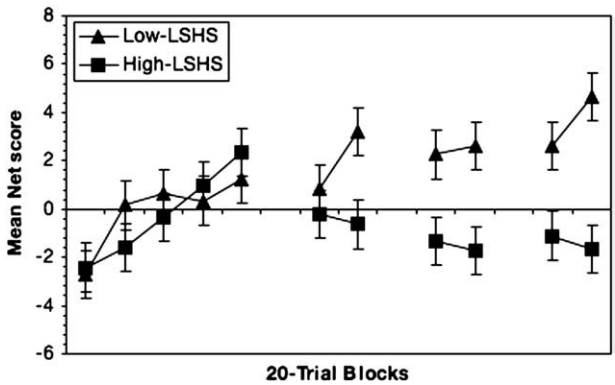

Fig. 3. The mean net score performance for the high- and low-LSHS groups for the five 20-trial blocks in Phase 1 and the six 20-trial blocks in Phase 2.

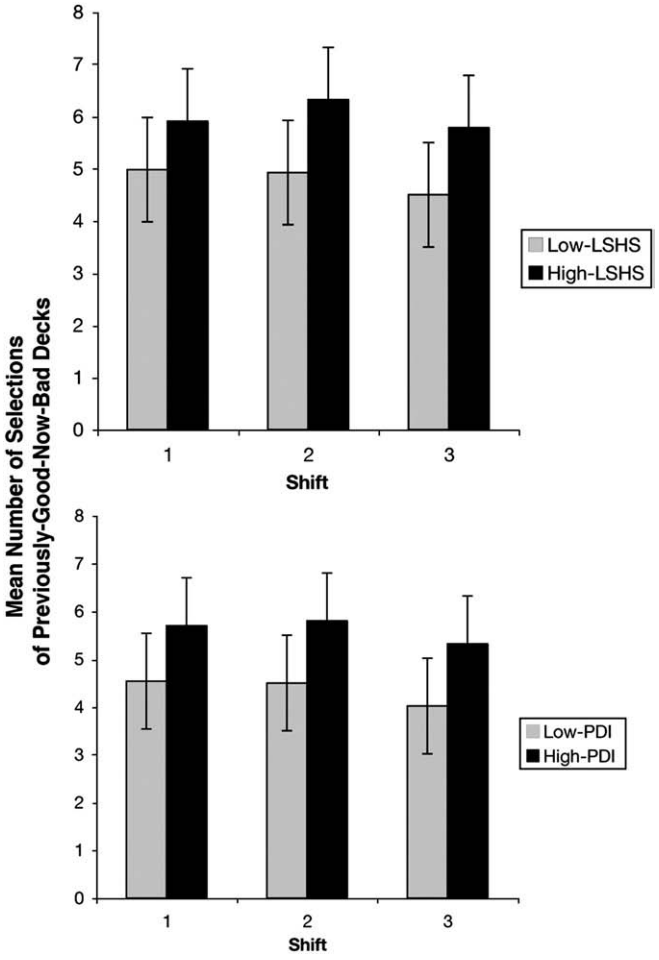

Fig. 4. The mean number of previously-good-now-bad selections by the high- and low-HSHS (upper panel) and high- and low-PDI (lower panel) groups during each of the 3 shift periods of Phase 2. Error bars represent 2 standard errors.

A number of studies have advanced the importance of different prodromal factors in the development of psychosis (e.g., Verdoux and van Os, 2002). The present findings suggest that emotion-based learning impairments generally, and the contingency-shift variant IGT specifically, may have potential implications as experimental indicators of psychosis risk. In particular, the extended version comprising the contingency-shift phase seems to be particularly be sensitive to features of schizophrenia-proneness (Fusar-Poli et al., 2007). Advantages of using an emotion-based learning paradigm in sub-clinical and clinical research include the neuropsychological background upon which the task was developed, the finding that impaired performance in tasks such as the IGT has been shown to be related to frontal lobe damage (Bechara et al., 1994, 2000), that research has identified brain abnormalities in the frontal lobes in people at risk of psychosis (Fusar-Poli et al., 2007), and that poor performance on the task has been shown to correlate highly with social and functional impairment in people with frontal lobe damage (Shamay-Tsoory et al., 2007). Further research on the utility of the contingency-shift variant IGT with those at risk of psychosis appears warranted.

The present findings may have relevance to the literature on response perseveration in schizophrenia (Brazo et al., 2005). We showed that during the contingency-shift phases, hallucination- and delusion-prone participants were more likely to continue to select the previously-good-now-bad decks, indicating a persistence of previously learned reinforcement contingencies (from Phase 1) and an impaired ability to adapt to the changing outcomes (i.e., perseverative errors). Response perseveration of this kind has typically been observed with tasks requiring repeated reversals of reinforcement contingencies, such as the WCST (Haut et al., 1996). Compared to the WCST, the contingency-shift variant IGT allows for a more extended analysis of the effects of progressive modifications to the underlying reward/punishment contingencies on choices from each of the four decks. In this way, the contingency-shift variant IGT may offer promise as an alternative means of investigating response perseveration.

In conclusion, the present study examined the effect of individual differences in hallucination- and delusion-proneness on performance of a contingency-shift version of the IGT. The results showed there were no significant differences between those classified as high and low on hallucination- and delusion-proneness on the original phase of the IGT. In the contingency-shifting phase of the task, however, individuals high on hallucination- and delusion-proneness performed significantly worse than those low on these traits. Several limitations should, however, be noted when considering the data. Firstly, no other behavioural measures of contingency-shifting, reversal learning or executive functions (e.g., WCST) were administered (cf. Lee et al., 2007; Turnbull et al., 2006). Future studies should examine performance in relation to other more widely used measures and tasks. Secondly, only university students were included in the sample, which may not be representative of the general population (Johns and van Os, 2001). Finally, hallucination- and delusion-proneness, although highly prodromic, only represent two particular facets of psychosis-proneness. This limits the potential applicability of these findings to research using clinical groups (e.g., schizophrenia patients). Despite these limitations, this study has extended previous research by demonstrating that the impairment in flexible emotion-based learning in patients with schizophrenia is also observed in sub-clinical groups with elevated scores on measures of hallucination- and delusion-proneness. It further shows the new contingency-shift version of the IGT may represent a valuable tool in examining some of the deficits that may underlie schizophrenia and psychosis-proneness.

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