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A Novel Set-Shifting Modification of the Iowa Gambling Task: Flexible Emotion-Based Learning in Schizophrenia

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Although it might seem that people with schizophrenia would perform poorly on measures of emotion-based learning, several studies have shown normal levels of performance on the Iowa Gambling Task (IGT; C. E. Y. Evans, C. H. Bowman, & O. H. Turnbull, 2005; L. M. Ritter, J. H. Meador-Woodruff, & G. W. Dalack, 2004; B. Shurman, W. P. Horan, & K. H. Nuechterlein, 2005; K. E. Wilder, D. R. Weinberger, & T. E. Goldberg, 1998). The present article describes a newly developed modification of the IGT involving initial familiarization with the basic contingency pattern then 3 periods of contingency shift. Control participants showed substantial gains during the later trials of each shift period. Analyzed in terms of positive symptoms, those with schizophrenia were little different from control participants. Those high in negative symptoms could perform the basic task but showed remarkably poor performances (no better than chance) in the shift phases, retaining a preference for decks that had previously been "good," even when they experienced substantial losses.

Keywords: emotion-based learning, Iowa Gambling Task, negative symptoms, schizophrenia, set shifting

Modern neuroscience has shown a growing interest in the role of emotion in a range of psychological abilities, especially in the domain of complex problem solving. Of especial interest has been the surprising finding that emotion appears to make a substantial, and previously unheralded, contribution to decision making (Bechara, Damasio, Damasio, & Anderson, 1994; Damasio, 1996; Manes et al., 2002; Rogers et al., 1999; Rolls, Hornack, Wade, & Mcgrath, 1994), perhaps representing a novel class of memory sometimes referred to as emotion-based learning (Damasio, 1996; LeDoux, 1996, 2000; Turnbull, Berry, & Bowman, 2003). The system appears to provide knowledge about the possible outcome of decisions on the basis of previous experience of the emotional consequences of interactions with particular people and/or objects (Bechara et al., 1994; Claparede, 1911/1951; Damasio, 1996; Johnson, Kim, & Riss, 1985; LeDoux, 2000; Rogers et al., 1999; Tranel & Damasio, 1993). The most commonly used research tool for the investigation of this phenomenon has been the Iowa Gambling Task (IGT; Bechara et al., 1994; Happaney, Zelazo, & Stuss, 2004; though see also Bickel, DeGrandpre, & Higgins, 1995; Bowman & Turnbull, 2004; Rogers et al., 1999), which was initially developed to investigate patients with frontal lesions (e.g., Bechara et al., 1994; Bechara, Damasio, & Damasio, 2000; Manes et al., 2002). It is now generally accepted that patients with frontal lesions have substantial difficulties in using emotion-related information for the purposes of learning and complex decision making (Bechara et al., 1994; Damasio, 1994; Happaney et al., 2004; Manes et al., 2002; though see Tomb, Hauser, Deldin, & Caramazza, 2002).

There have long been reports that people with schizophrenia show modifications in a range of psychological domains related to emotion (e.g., Aghevli, 2003; Berenbaum & Oltmanns, 1992; Crespo-Facorro et al., 2001; Krause, Steimer, Sänger-Alt, & Wagner, 1989; Schneider et al., 1990; Taylor, Liberzon, Decker, & Koeppe, 2002; though see also Kring & Earnst, 1999; Kring, Feldman Barrett, & Gard, 2003; Kring, Kerr, Smith, & Neale, 1993; Kring & Neale, 1996). On this basis one might anticipate that people with schizophrenia should perform poorly on measures of emotion-based learning, such as the IGT. In particular, the negative symptoms of schizophrenia, involving affective or motivational abnormalities, have long been associated with impaired frontal lobe function (e.g., Andreasen et al., 1986; Carter et al., 1996; Sanfilipo et al., 2000; Wolkin et al., 1992) and might be expected to impair affective decision making. However, whereas there have long been reports of poor episodic memory function in people with schizophrenia (e.g., Baddeley, 1982; Clare, McKenna, Mortimer, & Baddeley, 1993; Tamlyn et al., 1992), several studies have shown normal levels of performance on the IGT in this group (C. E. Y. Evans, Bowman, & Turnbull, 2005; Ritter, Meador-Woodruff, & Dalack, 2004; Shurman, Horan, & Nuechterlein, 2005; Wilder, Weinberger, & Goldberg, 1998).

One reason for the surprising finding of apparently preserved emotion-based learning in schizophrenia may be that existing

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measures of this psychological process do not tap the ability of people to use such learning flexibly—for example, in modifying or regulating these emotion-related resources. Researchers have long known that people with schizophrenia have great difficulty with flexible behavior (e.g., Koren et al., 1998; Pantelis et al., 1999; Van der Does & Van den Bosch, 1992), though no studies have yet been published that use versions of the IGT that require substantial flexibility—for example, by requiring shifting or reversal learning. The present study describes a newly developed modification of the IGT designed to evaluate foundational emotion-based learning skills as well as the ability of people with schizophrenia to use emotion-based resources in a flexible way.

Method

Participants

People with schizophrenia. Twenty-one patients were recruited from Bangor, United Kingdom, and Nashville, Tennessee, United States. All had chronic schizophrenia (greater than 5 years since first episode), all were taking a variety of new generation antipsychotic medication, and all met *Diagnostic and Statistical Manual of Mental Disorders* (4th ed., text rev.) criteria for the diagnosis of schizophrenia (American Psychiatric Association, 2000). On the basis of the widely accepted distinction between *positive* and *negative* in assessing symptomatic status (e.g., Andreasen & Olsen, 1982; Fanous, Gardner, Walsh, & Kendler, 2001; Frith, 1987; Johnstone, Owens, Frith, & Crow, 1986; Potkin et al., 2002), we assessed participants with the Scale for the Assessment of Negative Symptoms (SANS; Andreasen, 1994a) and the Scale for the Assessment of Positive Symptoms (SAPS; Andreasen, 1994b). The performance on SANS and SAPS, as well as other demographic information, is given in Table 1.

Each person with schizophrenia was assessed on a measure of general intellectual ability (Wechsler Abbreviated Scale of Intelligence; Wechsler, 1999). In addition, they completed a range of tests of executive function: the Controlled Oral Word Association Test (Benton & Hamsher, 1989) and three tasks that are specifically designed to measure *set-shifting* ability: the Modified Wisconsin Card Sorting Test (WCST; Nelson, 1976), the Rule Shift subtest of the Behavioral Assessment of the Dysexecutive Syndrome (BADS; Wilson, Alderman, Burgess, Emslie, & Evans, 1996), and the Hayling Test and the Brixton Test (Burgess & Shallice, 1997). The performance of the patient group is shown in Table 2. There were no significant differences in performance between the high and low SANS group or the high and low SAPS group in terms of demographic or executive function.

Table 1
Demographic and Clinical Information for Control Group and People With Schizophrenia

Variable	Schizophrenia	Control
Age in years, *M* (*SD*)	38.3 (10.4)	36.14 (8.9)
Education in years, *M* (*SD*)	12.6 (1.0)	12.6 (1.0)
Gender		
Men	13 (61.9%)	13 (61.9%)
Women	8 (38.1%)	8 (38.1%)
Symptom ratings		
SAPS (high)	12	
SAPS (low)	4.6	
SANS (high)	13.1	
SANS (low)	6.1	

Note. SAPS = Scale for the Assessment of Positive Symptoms; SANS = Scale for the Assessment of Negative Symptoms.

Table 2
Performance on Tasks of Executive Function and Intelligence for People With Schizophrenia

Participant	WCST[a]	COWAT[b]	Hayling[c]	Brixton[d]	BADS[e]	WASI
1	38	36	5	4	3	66
2	42	21	4	1	0	70
3	36	20	4	1	1	81
4	25	32	2	3	0	100
5	18	19	6	7	0	100
6	42	19	1	3	3	65
7	18	24	6	4	4	95
8	40	47	6	6	4	107
9	31	27	4	2	4	75
10	6	32	6	5	4	92
11	3	40	5	6	4	101
12	6	49	7	5	4	93
13	6	43	6	6	4	129
14	41	26	6	2	4	96
15	7	39	4	5	0	101
16	11	54	5	7	4	112
17	4	50	6	8	4	115
18	42	11	1	2	1	53
19	24	7	4	7	3	87
20	36	35	4	5	8	114
21	22	19	5	4	0	81

Note. WCST = Modified Wisconsin Card Sorting Test; COWAT = Controlled Oral Word Association Test; BADS = Behavioral Assessment of the Dysexecutive Syndrome; WASI = Wechsler Abbreviated Scale of Intelligence.
[a] Number of errors possible = 48. [b] Score: *Nil* (0) to *Superior* (53+). [c] Score: *Superior* (10) to *impaired* (1). [d] Score: *Superior* (10) to *impaired* (1). [e] Score: *Superior* (4) to *impaired* (0).

For the purposes of later analyses, we also divided participants into two groups on the basis of scores on the SANS and SAPS. Of the 21 patients, 11 were classified as *low* (score 0–35) and 10 as *high* (score 40–72) in negative symptoms. Of the 21 patients, 10 were classified as low (score 0–35) and 11 as high (score 40–80) in positive symptoms. Details of the classification scheme for each patient, and other demographic variables, are shown in Table 1. All participants gave informed consent prior to their inclusion in the study, which was approved by North Wales National Health Service Ethics Committee and Vanderbilt University Institutional Review Board.

Control participants. In addition, 21 control participants were recruited to the study, case-matched with the patient group for age (to within 2 years), education (exactly), and gender (see C. E. Y. Evans, Karen, & Turnbull, 2004, for rationale). Possible controls were excluded if they had any history of psychiatric or neurological disease. Participants received £10 (U.S.$18) an hour compensation for taking part and also received the money that they won on the task.

Finally, all participants completed 220 trials of the Iowa Gambling Task (IGT) in two phases: 100 trials of the standard version of the task followed by 120 trials of a modification of the IGT involving three successive shifts of the reinforcement contingencies.

Procedure

Phase 1: The standard IGT. The study used the standard administration procedure for the IGT. This runs for 100 trials, usually depicted as 5 × 20 trial periods. The present study used real (rather than facsimile) money—$1,000 on the classic Bechara et al. (1994) task was equal to £1 (U.S.$1.75; see Bowman & Turnbull, 2003). As in Bechara et al.'s (1994) study, participants selected cards, in any order, from any of four decks (A, B, C, and D). Decks A and B were disadvantageous ("bad"), and Decks C

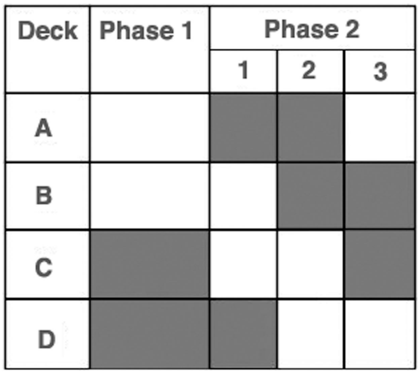

Figure 1. Pattern of good decks (shaded), and bad decks (white) during standard administration of Phase 1 and the three shift periods of Phase 2.

and D were advantageous ("good"; see Figure 1). The frequency of reward and punishment differed for each deck. Participants always won 10p (U.S.$0.17) when selecting from Decks A and B, but some cards also incurred losses of between 15p (U.S.$0.26) and £1.25 (U.S.$2.18) such that sustained selection from either of these decks resulted in overall financial loss. Participants always won 5p (U.S.$0.09) when selecting from Decks C and D, but some cards also incurred losses of between 2p (U.S.$0.03) and 25p (U.S.$0.44) such that sustained selection resulted in overall financial gain. Losses were more frequent on Deck A (bad) and Deck C (good) than on Deck B (bad) and Deck D (good). As in Bechara et al. (1994), the task was terminated after 100 card selections.

Phase 2: Contingency modification. Directly after Phase 1, when the participants had become familiar with the contingency pattern of the task (i.e., they had a substantial period of exposure to the good and bad decks), participants were invited to continue to play the game in a phase involving a modification of the original contingencies (cf. Dias, Robbins, & Roberts, 1996; Konishi et al., 1998; O'Doherty, Kringelbach, Rolls, Hornack, & Andrews, 2001; Rolls et al., 1994). This phase allowed us to evaluate the rapidity with which participants could modify their behavior to new reward–punishment patterns. Participants were explicitly informed that the nature of the game might alter such that "the rules about which decks are good and bad may have changed." Thus, after the 5 × 20 trial learning blocks (Phase 1) there were three shift periods, each consisting of 2 × 20 trial blocks (see Figure 1). Participants were informed about possible changes in contingencies before each shift began, though they received no information about the nature of these shifts.

Whereas Decks C and D had been good decks during Phase 1, Decks A and D, A and B, and B and C successively became good decks during the three shift periods of Phase 2 (see Figure 1). Thus, in these shift periods the participant had an emotion-based learning history of previous decisions (e.g., C and D still feel good) played off against the set of novel contingencies (A and C now are good). If they rely extensively on their emotion-based history of contingency learning, then they should favor decks that had, but no longer have, a good history. Thus, whereas people with schizophrenia should perform well on Phase 1, we might expect that they would perform poorly during Phase 2 because this patient group has previously been reported as performing poorly on reversal-learning tasks (most notably the Wisconsin Card Sorting Task; e.g., Koren et al., 1998; Pantelis et al., 1999; Van der Does & Van den Bosch, 1992).

Results

As in Bechara et al.'s (1994) study, performance for the card selections were subdivided into blocks of 20 cards each: five blocks for Phase 1 and three shift periods, each consisting of two 20-card blocks, for Phase 2. In each case, the net score of each block was calculated by subtracting the number of good from bad card selections: [(C + D) – (A + B)]. A net score above zero implied that the participants were selecting cards advantageously, and a net score below zero implied disadvantageous selection.

Performance Classified by Negative Symptoms

Phase 1. Over the first 100 trials, all three groups showed rapid learning on the task, with no apparent group differences (see Figure 2). A mixed factor analysis of variance (ANOVA) revealed

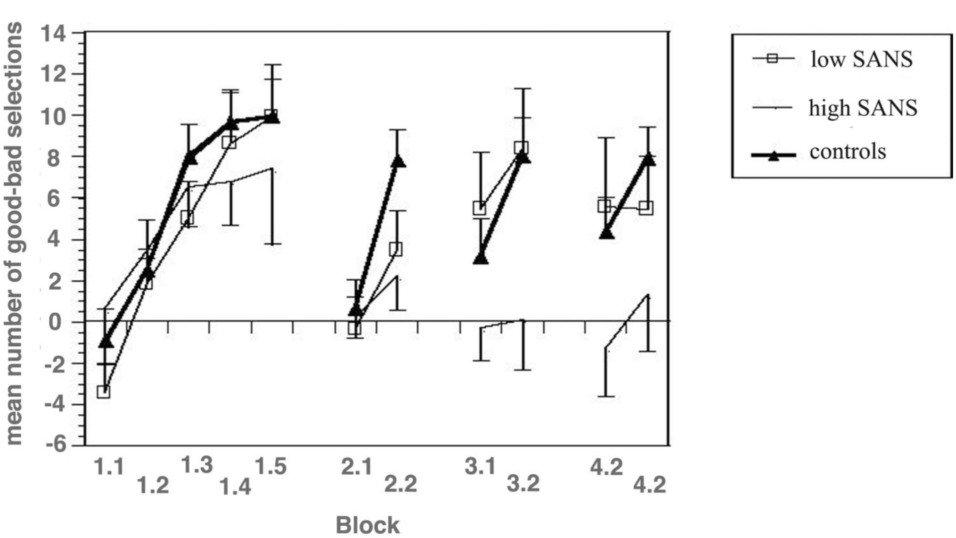

Figure 2. Pattern of performance on Phase 1 and 2 of the Iowa Gambling task, classified according to the Scale for the Assessment of Negative Symptoms (SANS). Those high in negative symptoms perform well on the standard version of the task but show chance-level performances in the shifting phase. Error bars represent one standard error.

a main effect of block, $F(2.9, 111.7) = 15.2$, $p < .001$, as participants progressively selected more cards from advantageous decks. Observed power of the main effect was 1, and the effect size was moderate ($\eta^2 = .30$). There was no main effect of group, $F(2, 39) = 0.20$, $p > .05$ ($\eta^2 = .01$, observed power = .08), and no interaction between group and block, $F(5.7, 111.7) = 0.60$, $p > .05$ ($\eta^2 = .03$, observed power = .22).

Phase 2. On the shift trials, control participants (see bold lines in Figure 2) showed a clear learning pattern. There was a sharp decline in function in the block after a shift, followed by substantial learning in the second block of the shift. Over the three shift periods, there was a general trend toward being less affected by shifting with time. Learning rates were more variable for the people with schizophrenia. However, the group that scored low in negative symptoms showed learning levels not dissimilar to control participants, especially after the first shift period (see Figure 2). In contrast, the group that was high in negative symptoms showed very poor performance levels, little better than chance, across all three shift periods.

A mixed factor ANOVA revealed a main effect of block, $F(3.5, 135.4) = 3.2$, $p < .05$ ($\eta^2 = .08$, observed power = .80), as participants progressively selected more cards from advantageous decks. There was a main effect of group, $F(2, 39) = 3.62$, $p < .05$ ($\eta^2 = .16$, observed power = .70), but no interaction between group and block, $F(6.9, 135.4) = 1.1$, $p > .05$ ($\eta^2 = .06$, observed power = .40).

Performance Classified by Positive Symptoms

Phase 1. Over the first 100 trials, there was a similar level of performance by the control participants and by the group with high positive symptoms. The group low in positive symptoms showed poorer levels of learning, though these remained well above chance.

A mixed factor ANOVA revealed a main effect of block, $F(2.8, 108.5) = 15.81$, $p < .001$ ($\eta^2 = .30$, observed power = 1), as participants progressively selected more cards from advantageous decks. There was no main effect of group, $F(2, 39) = 1.05$, $p > .05$ ($\eta^2 = .05$, observed power = .22), and no interaction between group and block, $F(5.6, 108.5) = 1.52$, $p > .05$ ($\eta^2 = .08$, observed power = .55).

Phase 2. On the shift trials, the performances of both the low and the high positive symptom groups were marginally poorer than those of control participants, though both groups showed some learning in the shift phases (see Figure 3). The high positive symptom group showed marginally better learning, at levels almost comparable with control participants, in all shift periods.

A mixed factor ANOVA revealed a main effect of block, $F(3.5, 138.4) = 3.5$, $p < .05$ ($\eta^2 = .08$, observed power = .81), as participants progressively selected more cards from advantageous decks. There was no main effect of group, $F(2, 39) = 1.8$, $p > .05$ ($\eta^2 = .83$, observed power = .35), and no interaction between group and block, $F(7.1, 138.4) = 0.51$, $p > .05$ ($\eta^2 = .03$, observed power = .22).

Investigating the Causes of Failure to Shift

To further investigate the difficulties in shifting for those high in negative symptoms, we analyzed their pattern of choice in the shifting period (Phase 2) in the context of preferences in the standard phase (Phase 1). During the standard phase, participants showed normal levels of learning, such that Decks C and D were perceived as good decks. During the shifting periods the contingencies systematically alter. This offers an opportunity to investigate the extent to which the various groups had retained a strong preference for the decks that were originally good (C and D) as opposed to those that acquire good characteristics during various periods of the shifting phase.

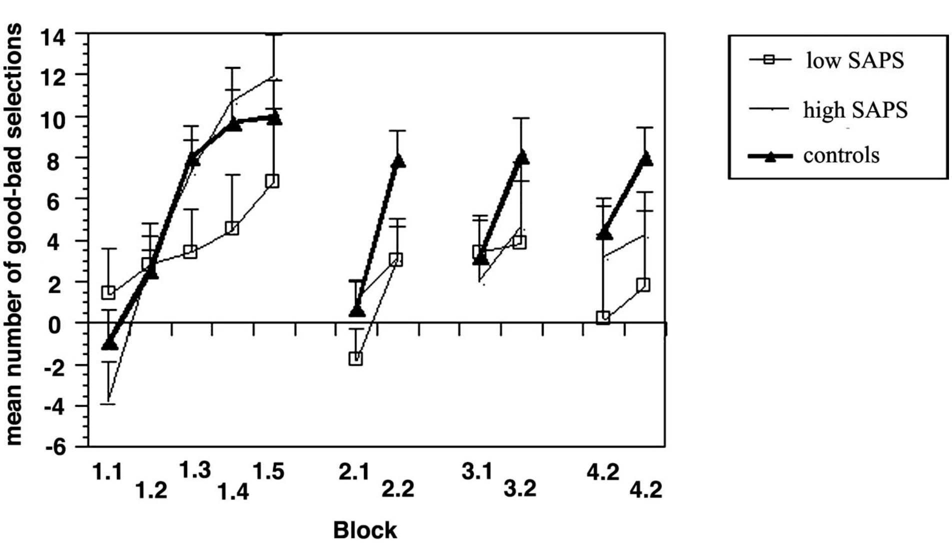

Figure 3. Pattern of performance on Phase 1 and 2 of the Iowa Gambling task, classified according to the Scale for the Assessment of Positive Symptoms (SAPS). Both the low- and the high-positive-symptom groups were marginally poorer than control participants, but both groups showed learning even in the shifting phase. Error bars represent one standard error.

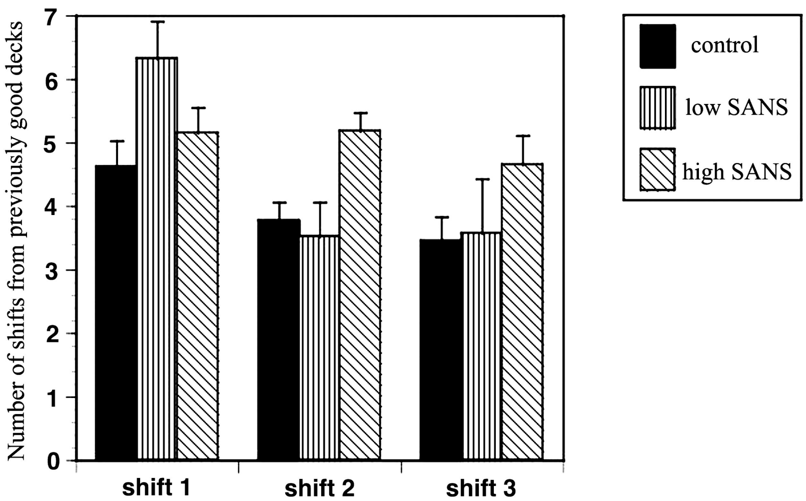

Figure 4. The pattern of shifting, for those high in negative symptoms, during the shifting period. Especially in the 2nd and 3rd shifting period, those high in negative symptoms were more likely to select from decks that had previously been good. SANS = Scale for the Assessment of Negative Symptoms. Error bars represent one standard error.

For this analysis we calculated choices, in the shifting phase, of decks that were previously good (C and D) so that the once-good-now-bad decks were C (in Shift 1), C and D (in Shift 2), and D (in Shift 3). In the second and third shifting periods, those participants high in negative symptoms were more likely to select from decks that had previously been good than were both the control participants and those low in negative symptoms (see Figure 4). A mixed factor ANOVA for these data revealed a main effect of shift, $F(2, 78) = 9.98$, $p < .001$, no main effect of group, $F(2, 39) = 2.50$, $p > .05$, and no interaction between group and shift, $F(4, 78) = 2.74$, $p > .05$.

Of especial interest is the second shifting period, in which the decks that were originally good (C and D) were now bad—that is, the only period of the shifting phase that represents a complete reversal of contingencies from the initial learning phase. In this important shift period the performance of the control participants and of those low in negative symptoms were not significantly different, $t(30) = 0.44$, $p > .01$. In contrast, those high in negative symptoms chose bad decks significantly more often than both control participants, $t(29) = 2.92$, $p < .01$, and those low in negative symptoms, $t(15.28) = -2.71$, $p < .01$. These data suggest that the difficulties in shifting are caused by a pattern of overreliance on decks that had previously been learned to be favorable—a pattern of cognitive perseveration.

This opens the question of whether this failure to shift represents a general impairment in intellectual flexibility. Our set of tests of executive function included three that are explicitly described as measures of set shifting (WCST, the Rule Shift subtest of the BADS, and the Brixton Test). A correlation was calculated between the scores on each of these tests against a composite score for the shifting period of the modified IGT ([(C + D) – (A + B)] for the entire 120-trial data set for Phase 2). There were no significant correlations between modified IGT performance and any of the three measures of set shifting (correlations ranging between −0.32 and 0.24). Neither did any of the measures of set shifting correlate significantly with each other (correlations ranging between −0.15 and 0.35).

Comment: A Further, Converging Form of Data Analysis

To eliminate the chance of making a Type II (false positive) error as a result of dichotomizing the SANS and SAPS groups, we performed a multiple linear regression analysis with Phase 1 (standard) IGT performance as the dependent variable, and SANS, SAPS, Wechsler Abbreviated Scale of Intelligence, WCST, Controlled Oral Word Association Test, Hayling, Brixton, and BADS scores as the independent variables. This multiple linear regression analysis revealed that none of the independent variables was a significant predictor of standard IGT performance, with the exception of SAPS, which approached significance ($\beta = .62$, $p < .05$).

Further regression analyses were run with the same eight independent variables, each shifting period acting in turn as the dependent variable. During the first shifting period, the only significant predictor of performance was SANS ($\beta = -.60$, $p = .018$), and in the second shifting period the only significant predictor of performance was SAPS ($\beta = -.65$, $p = .038$). In the third shifting period, SANS again approached significance as a predictor ($\beta = .50$, $p = .05$), and by using a composite score for the entire shifting period, we found that it was the only measure that approached significance ($\beta = -.45$, $p = .077$).

Comment: Effects of Education

A potentially confounding variable might have been that some of the sample had intellectual ability levels toward the lower end of the normal range, with 5 participants having Wechsler Abbreviated Scale of Intelligence-predicted IQ scores of 75 or below. It is of some interest that these (“low-IQ”) participants all performed well above chance, and well within the normal range, on both the standard IGT (mean score 21.6) and the shifting version of the IGT (mean score 18.8). Indeed, the scores for these low-IQ participants do not differ greatly from those of the 5 participants with the highest predicted IQs (above 105), who also did well on the standard IGT (mean score 20.6) and the shifting version of the IGT (mean score 26.2). These findings, which suggest that intellectual ability does not appear to be related to IGT performance, are consistent with previous findings suggesting that education is, if anything, inversely related to performance on the IGT (C. E. Y. Evans et al., 2004).

There is a second issue relating to the effects of education in these findings. It might be argued that matching for education in the control group described above might not be appropriate if these control participants have low education for reasons quite different to those that produce lower levels of education in the group with schizophrenia.[1] To investigate this issue, we tested a further control group of 25 randomly selected undergraduates (16 women, 9 men; mean age = 21.6 years) on the modified IGT. Between-groups performance was analyzed with a mixed factor ANOVA. The findings were almost identical to those reported with the earlier age- and education-matched control group. In Phase 1, there was a main effect of block, $F(3.2, 139.9) = 24.07$, $p < .001$, and a main effect of group, $F(1, 44) = 14.5$, $p < .001$, but no Block × Group interaction, $F(3.2, 139.9) = 1.4$, $p > .05$. Post hoc t tests revealed no significant differences in Blocks 1, 2, and 5, but significant differences for Block 3, $t(44) = 2.8$, $p < .01$, and Block 4, $t(44) = 2.6$, $p < .05$. In Phase 2 (shifting), there was a main effect of block, $F(5, 220) = 10.7$, $p < .001$, but no main effect of group, $F(1, 44) = 2.1$, $p > .05$, or interaction, $F(5, 220) = 0.53$, $p = .76$.

Discussion

In Phase 1, the standard 100 trials of the Iowa Gambling Task (IGT), participants from all groups showed normal rates of learning. This is a clear replication of the findings of previous studies (Ritter et al., 2004; Shurman et al., 2005; Wilder et al., 1998), which showed preserved learning on the IGT in people with schizophrenia. Previous studies have not always examined the role of symptomatology in performance. However, the present study replicates that of Ritter et al. (2004) in showing that those high in negative symptoms (see Figure 2) perform relatively well on the standard version of the IGT (i.e., the first 100 trials). The present study extends these findings to demonstrate that those who are low in positive symptoms (see Figure 3) show poorer performance levels on the first 100 trials. However, it is of note that this relatively poor performance remains well within the range achieved by neurologically and psychiatrically normal control participants in previous studies (e.g., Bechara & Damasio, 2002; Bechara et al., 2001; Bowman & Turnbull, 2003; Clark, Manes, Autoun, Shakian, & Robbins, 2003; C. E. Y. Evans et al., 2004).

There is a well-established literature showing that people with schizophrenia have difficulties on tasks that require flexibility of executive resources, such as the reversal of contingencies (Koren et al., 1998; Pantelis et al., 1999; Van der Does & Van den Bosch, 1992). The present study represents a novel attempt at evaluating this process in the context of emotion-based learning. During the contingency modifications in Phase 2, control participants showed a clear and reliable pattern of performance (see Figures 2 and 3). Following each reversal period, performance was greatly reduced, but control participants showed substantial gains during the second 20 trials of each shift period. The decrement sustained after each shift period lessened with time.

Whereas people with schizophrenia performed well on the standard task of Phase 1, performance was far more variable during the shift periods of Phase 2 and was strongly related to symptom severity. Those with both high and low positive symptoms (see Figure 3) performed relatively well, though their average performance was marginally (and nonsignificantly) lower in the shift periods. Essentially, the division into groups on the basis of positive symptoms does not appear to be an important predictor of poorer performance on the shifting phase.

The clearest effects relate to the role of negative symptoms. Those who were low in negative symptoms (see Figure 2) showed performance levels indistinguishable from control participants during the shift periods. However, those high in negative symptoms showed very poor performances that failed to improve over time, remaining close to chance, over the three shift phases. These poor performances cannot be due to an inability of those high in negative symptoms to perform the basic task because their performance levels during the first 100 trials were indistinguishable from those of control participants. This effect is consistent with a long-standing literature showing a link between negative symptoms and affective or motivational abnormalities (e.g., Andreasen et al., 1986; Carter et al., 1996; Sanfilipo et al., 2000; Wolkin et al., 1992). However, it seems clear that these impairments in affective decision making do not affect the foundational ability to develop emotion-based learning but do seriously affect the flexible use of this ability.

The complex nature of this study's contingency shift pattern made it difficult to interpret the precise nature of this impairment. However, further investigation of the basis of the poorer performance showed a clear tendency for those high in negative symptoms to retain a preference for decks that had previously been good (C and D), even when they experienced substantial losses from these decks after shift changes (see Figure 4). Thus, this group appears to show a pattern of perseveration (e.g., E. Goldberg & Bilder, 1987; Luria, 1965). However, the performance of the group on other measures of set shifting suggests that this failure does not represent the same class of set-shifting impairment.

These findings suggest that the two phases of the current study appear to selectively measure different aspects of the performance of those with schizophrenia, as captured by the classification system differentiating between positive and negative symptoms (Andreasen & Olsen, 1982). Core emotion-based learning seems to be unaffected by negative symptoms, though there were marginal effects (nonsignificant) on positive symptoms on this phase of the task. In contrast, the shifting phase appears to measure a phenomenon that is quite different from that assessed during the core emotion-based learning period. It appears to capture some class of failure to shift, or modify, behavior in the face of changing affective circumstances. In this sense, it may be similar to the well-described poor performances typically seen, in those with negative symptoms, on executive tasks measuring flexible decision making (Koren et al., 1998; Pantelis et al., 1999; Ritter et al., 2004; Van der Does & Van den Bosch, 1992), though shifting performance on our measure of emotion-based learning did not correlate with performance on other measures of set shifting.

A final point relates to the pattern of performance of the people with schizophrenia on the tasks of executive function—with no significant correlations between any of the measures. In one sense this is unsurprising, given that measures of executive function have

[1] We thank an anonymous reviewer for this suggestion.

long been known to map poorly onto basic psychological constructs such as set shifting. Thus, there are poor correlations between various executive measures in the psychiatrically normal population (Burgess, Alderman, Evans, Emslie, & Wilson, 1998; Della Sala, Gray, Spinnler, & Trivelli, 1998) and in people with schizophrenia (J. J. Evans, Chua, McKenna, & Wilson, 1997; T. E. Goldberg et al., 1988). It is especially of note that, in the present study, there were very low correlations even between tasks that purport to measure set-shifting ability (WCST, BADS, Brixton) and our modified (set-shifting) version of the IGT. These findings suggest a range of possibilities, for example, perhaps that the psychological construct that we refer to as set shifting is multicomponent in nature—with, for example, more cognitive versus emotional aspects to shifting. On the Wisconsin Card Sorting Task, there are substantial intellectual demands in identifying the abstract category (form, number, etc.) that is the basis for the set, whereas the emotional outcome of the task is nothing stronger than the examiner's response of "correct" or "incorrect". On the IGT, there is far less of a cognitive demand for abstraction, but there is, arguably, the more emotionally powerful feedback of financial reward. An alternative account might be that demands of the task other than those of shifting are more salient in accounting for individual differences—so that the variance due to set shifting is lost among other causes of variability.

The present article introduces a novel modification of a well-established measure of emotion-based learning that for the first time makes it possible not merely to evaluate foundational emotion-based learning skills but to systematically evaluate the use of these resources in a flexible way. In doing so, we hope also to raise awareness of the extent to which traditional measures of executive ability might have a previously unrecognized emotional component, for example in set-shifting measures such as the Wisconsin Card Sorting Task. This issue has a range of possible implications. For example, whereas standard measures of executive ability are traditionally cognitive, the presenting complaints of neurological patients with frontal lesions typically relate to emotional experience and the emotional consequences of their actions in the interpersonal world. There are also clear implications for the role of neuropsychology in psychiatry. It has become clear that the psychopharmacology of psychiatric disorders is essentially identical to the pharmacology of core emotion systems (Panksepp, 1998). It is also clear that a range of psychiatric disorders appear to produce impairments on tests of executive functions. Thus, understanding how emotion may underpin various executive tasks may well serve as a bridge between the increasingly well-understood effects of focal brain lesions on psychological abilities and the less well-defined deficits seen in a range of psychiatric disorders such as schizophrenia.

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