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Relationship of behavioural and symptomatic syndromes in schizophrenia to spatial working memory and attentional set-shifting ability

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ABSTRACT

Background. Behavioural syndromes (thought disturbance, social withdrawal, depressed behaviour and antisocial behaviour) offer a different perspective from that of symptomatic syndromes on the disability that may be associated with schizophrenia. Few studies have assessed their relationship with neuropsychological deficits. We hypothesized that these syndromes may represent behavioural manifestations of frontal-subcortical impairments, previously described in schizophrenia.

Method. Long-stay inpatients ($n = 54$) and community patients ($n = 43$) with enduring schizophrenia were assessed, using measures of symptoms and behaviour and tests of executive functioning. The relationship between syndromes and neuropsychological function was assessed using multiple regression and logistic regression analyses.

Results. Significant associations were found between performance on the spatial working memory task and the psychomotor poverty symptomatic syndrome, and between attentional set-shifting ability and both disorganization symptoms and the thought disturbance behavioural syndrome. These results were not explained by the effect of premorbid IQ, geographical location, length of illness or antipsychotic medication. Length of illness was an independent predictor of attentional set-shifting ability but not of working memory performance.

Conclusion. The specific relationship between negative symptoms and spatial working memory is consistent with involvement of the dorsolateral prefrontal cortex. The associations between difficulty with set-shifting ability and both disorganization symptoms and behaviours may reflect inability to generalize a rule that had been learned and impaired ability to respond flexibly. The specific relationship of illness duration to set-shifting ability may suggest progressive impairment on some executive tasks. The nature of these relationships and their neurobiological and rehabilitation implications are considered.

INTRODUCTION

Symptomatic syndromes have been proposed in an attempt to define and understand the heterogeneous nature of schizophrenia (Crow, 1980; Andreasen & Olsen, 1982; Bilder *et al.* 1985; Liddle, 1987*b*). This approach has proved informative in that these symptom-based syndromes have been associated with specific neuropsychological deficits (Bilder *et al.* 1985; Liddle, 1987*a*; Pantelis & Brewer, 1995;

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Norman *et al.* 1997; Liddle, 2001). The most consistent finding has been an association between a negative symptom-based syndrome (e.g. Peralta *et al.* 1992) and neuropsychological deficits, particularly those hypothesized to depend upon normal function in the dorsolateral prefrontal cortex (DLPFC; Liddle, 1987*a*; Liddle *et al.* 1992; Pantelis *et al.* 2001). Relationships have also been found between symptoms of disorganization and neuropsychological function, particularly on tasks of attention and inhibitory control (Liddle, 2001).

The distinctions between symptomatology and various domains of functioning (such as social behaviour) are often blurred (Scott & Lehman, 1998; Fossey & Harvey, 2001), with overlap between these domains apparent in rating scales of symptomatology and behaviour (Harvey *et al.* 1996; Fossey & Harvey, 2001). Nevertheless, these distinctions are important and a focus on behaviour may illuminate how symptomatic impairments relate to day-to-day functioning (Scott & Lehman, 1998). We have previously identified four behavioural syndromes in two separate, epidemiologically defined samples of patients with schizophrenia (Harvey *et al.* 1996; Curson *et al.* 1999) and proposed that such measures of behavioural disturbance could complement symptomatic measures of psychopathology. While these behavioural syndromes ('social withdrawal', 'depressed behaviour', 'thought disturbance', 'anti-social behaviour') overlapped with symptom-based syndromes they were not synonymous. Therefore, they provide further descriptors of the phenomena of schizophrenia.

Models that link neurological lesions of specific prefrontal-subcortical circuits to unique patterns of behavioural, cognitive and symptomatic abnormalities have been proposed (Mega & Cummings, 1994; Pantelis & Brewer, 1995, 1996). Hence, we hypothesized that different cognitive, behavioural and symptomatic presentations of schizophrenia may arise from disruption to these different prefrontal-subcortical neuronal networks, especially those that converge on the DLPFC and orbitofrontal cortex (OFC) (Pantelis & Brewer, 1996). While it is difficult to test this hypothesis directly using neuroimaging or neuropathological methodologies, an indirect test can be carried out by determining whether specific patterns of impaired performance on neuropsychological tests are associated with the different symptomatic and behavioural syndromes of schizophrenia. In the current study we examined the relationships between Liddle's symptom-based syndromes (Liddle, 1987*b*; Liddle & Barnes, 1990) and the four behavioural syndromes (Harvey *et al.* 1996; Curson *et al.* 1999) of schizophrenia and performance on a set of neuropsychological tests previously shown to assess the integrity of the different frontal-subcortical networks in neurological patients.

Specifically, we hypothesized that the 'psychomotor poverty' syndrome and the 'social withdrawal' behavioural syndrome would be associated with deficits on measures of DLPFC function, such as working memory. Further, we hypothesized that the disorganization symptomatic syndrome (characterized by disordered thinking and inappropriate affect) and the behavioural syndromes of 'thought disturbance' and 'antisocial behaviour', would be associated with deficits of inhibitory control or other tasks specifically related to integrity of the OFC (Harvey *et al.* 1996; Pantelis & Brewer, 1996).

METHOD

Sample

Ninety-seven patients with DSM schizophrenia were derived from two independent samples of patients with enduring illness. All patients met DSM-IV criteria for 'continuous longitudinal course'. All patients had adequate visual and auditory functioning as assessed by standardized charts, adequate knowledge of English to perform neuropsychological tests, and no known antecedent neurological or significant medical history, and no evidence of recent drug abuse. Written informed consent to participate was obtained from each patient, as approved by the respective local ethics committees.

UK sample

54 of 60 possible patients from a long-stay hospital, fulfilling DSM-III-R criteria for schizophrenia (APA, 1987), completed neuropsychological and clinical assessments.

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Table 1. *Symptom and behaviour-based syndromes in schizophrenia*

(*a*) Symptom-based syndromes (Liddle, 1987*a*; Liddle & Barnes, 1990)

Psychomotor poverty	Disorganization	Reality distortion
Poverty of speech	Disorder of the form of thought	Delusions
Flatness of affect	Inappropriate affect	Hallucinations
Decreased spontaneous movement		

(*b*) Behavioural syndromes (Harvey *et al.* 1996; Curson *et al.* 1999)

Social withdrawal	Depressed behaviour	Thought disturbance	Anti-social behaviour
Little spontaneous communication	Depression	Incoherence of speech	Hostility
Poor self care	Suicidal ideas/behaviour	Odd or inappropriate conversation	Socially unacceptable habits
Slowness	Panic attacks or phobias	Poor attention span	Destructive behaviour
Underactivity	Demanding attention	Overactivity	Poor self-care
		Laughing or talking to self	
		Acting out bizarre ideas	

Australian sample

Patients with DSM-IV schizophrenia (APA, 1994) were recruited from community rehabilitation programmes.

Demographic information and clinical history

Demographic and clinical details included age, gender, age of illness onset, illness duration, medical history including alcohol and drug use, admission and medication history (including anticholinergic use). Antipsychotic dosage was converted to milligram equivalents of chlorpromazine and antipsychotic type (typical *v.* atypical) was noted.

Clinical assessment

DSM Axis 1 diagnoses of schizophrenia were confirmed using the Structured Clinical Interview for DSM-IV (SCID) (First *et al.* 1997) for the Australian sample and by a check-list of DSM-III-R criteria specially developed for community surveys in the UK (Duke *et al.* 1994; Harvey, 1996).

The Modified Manchester Scale (MS; Krawiecka *et al.* 1977), a semi-structured rating scale of psychopathology in chronic psychosis, was used to assess symptoms, including psychotic symptoms, depression and anxiety. Presence and severity of each symptom over the preceding week was rated on a five-point scale (0 = absent to 4 = severe). Symptomatic syndrome scores were determined by summing symptom scores comprising each syndrome shown in Table 1 (Liddle, 1987*b*).

Presence and severity of extra-pyramidal symptoms were assessed using the Extra-pyramidal Side Effects Rating Scale (Simpson & Angus, 1970). Trained raters (T.R.E.B., C.H.) assessed all patients blind to the neuropsychological assessments. The global measure of parkinsonism was used in the analyses.

Behavioural assessments

The MRC Social Behaviour Schedule (SBS; Wykes & Sturt, 1986) was used to assess the occurrence and severity of 21 problem social behaviours over the preceding month by interviewing a 'best informant', typically a formal or informal carer with whom the participant had regular contact. Scores for each of the four SBS behavioural syndromes were calculated by summing the component item scores comprising each syndrome (Curson *et al.* 1999), as shown in Table 1.

Neuropsychological tests

Premorbid intellectual functioning was assessed using the National Adult Reading Test (NART; Nelson, 1982) and converted to WAIS-R Full Scale IQ (FSIQ) estimates. Patients scoring less than 10 correct NART words were further tested using the Schonell Graded Word Reading Test (Schonell, 1942), which more accurately assesses premorbid IQ at below normal levels.

Cambridge Neuropsychological Test Automated Battery (*CANTAB*)

Each patient undertook the computerized working memory and set-shifting tasks from

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the CANTAB, using a high-resolution touch sensitive screen (Sahakian & Owen, 1992). Brief descriptions of these tests are provided below (see also Owen *et al*. 1990; Pantelis *et al*. 1997).

The spatial short-term memory task (visuospatial span) required patients to remember a sequence of squares presented on the screen. The visuospatial span score was the largest sequence of squares successfully remembered, and assessed the ability of patients to hold information on-line.

The spatial working memory task (SWM) required patients to search an increasing number of boxes (2, 3, 4, 6 and 8) on the screen to locate hidden tokens. The key instruction was that once a token had been located behind a particular box, that box would not hide another token in the sequence. A 'between search error' (SWM errors) was made when a patient returned to search a box in which a token had already been found. A 'strategy' score, ranging from 1 (best) to 37 (worst), was calculated for the more difficult six and eight box levels (Owen *et al*. 1990), reflecting extent to which a systematic search was adopted.

The attentional set shift task (Intra-dimensional/extra-dimensional – ID/ED; Pantelis *et al*. 1999) assessed a patient's ability to maintain attention to different examples within a reinforced stimulus dimension (intra-dimensional shift) and then to shift attention to a previously irrelevant stimulus dimension (extra-dimensional shift). The task involved nine stages, with patients proceeding to the next stage only after attaining a criterion of six consecutive correct responses. Performance measures were: percentage of subjects successfully completing each stage, and numbers of trials and errors required to attain criterion for each stage.

Data processing and analysis

The Statistical Package for the Social Sciences version 10 (SPSS Inc., 1999) was used for data analysis. Examination of the univariate distribution of working memory performance identified four values more than 3 standard deviations from the mean. In order to reduce the effect of these observations, all outlying values were replaced by the value of the next most extreme value (Dixon & Tukey, 1968).

Relationships of working memory and of attentional set-shifting ability to symptomatic and behavioural syndromes were examined using standard multiple regression analysis or logistic regression, as appropriate. Bivariate plots and regression diagnostics were used to ensure the robustness of the regression models. As the Australian sample was younger, with more females than the UK sample, age and gender were used as covariates. As the data were derived from independent samples, the effect of source (whether patients were derived from the UK or Australian samples) was also examined. Product terms (Jaccard *et al*. 1990) indicated that the interactions between geographical location and syndrome variables were not significant, indicating that the observed relationships generalized across the two samples. Therefore, the two samples were combined to examine the relationships between each syndrome and neuropsychological function.

The associations of interest were between SWM and both 'psychomotor poverty' and 'social withdrawal' syndromes, and between set-shifting ability and the syndromes of 'disorganization', 'thought disturbance' and 'antisocial behaviour'. To take account of multiple comparisons significance was adjusted using a false discovery rate controlling procedure, which takes into account the number and significance of the results (Benjamini & Yekutieli, 2001). The false discovery rate is defined as the proportion of positive test results that are 'false positives' under the assumption that some tests result from true differences, with others being statistical errors where the null hypothesis is true. The procedure is robust to non-independence between the tests for most commonly encountered statistical distributions.

RESULTS

Table 2 shows the characteristics of the two samples. Compared with the UK sample, the Australian sample was younger with a shorter duration of illness, and shorter mean total duration of inpatient stay, which is consistent with the recent expansion of community-based psychiatric services. Further, all patients in the UK sample were receiving conventional antipsychotic medication and were more likely to be on anticholinergics, while most of the Australian sample was on atypical medication with fewer receiving anticholinergic medication.

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Table 2. *Demographic and clinical characteristics of the Australian and UK patient samples*

	Australian sample ($n=43$)	British sample ($n=54$)	Test	p	Mean difference	95% CI of difference
Mean age in years (S.D.) [range]	35·4 (7·2) [23–50]	48·0 (11·0) [26–64]	$t(91{\cdot}7)=-6{\cdot}77$	<0·001	−12·5	−16·2 to −8·9
Sex (% male)	60·5	81·5	$\chi^2=5{\cdot}26$, df=1	<0·05		
Mean length of illness in years (S.D.) [range]	14·9 (6·5) [4–31]	27·1 (±10·2) [8–44]	$t(90{\cdot}7)=-7{\cdot}12$	<0·001	−12·2	−15·5 to −8·8
Mean age of onset of illness (S.D.) [range]	20·8 (4·4) [11–35]	20·9 (5·8) [12–42]	Mann–Whitney $Z=-0{\cdot}68$	N.S.		
Mean premorbid IQ (S.D.) [range]	94·9 (11·4) [67–117]	98·9 (14·3) [65–121]	$t(90)=-1{\cdot}44$	N.S.	−3·9	−9·3 to 1·5
Mean total length of all hospitalizations in months (S.D.) [range]	35·4 (47·0) [1–279]	279·5 (124·2) [54–516]	Mann–Whitney $Z=-7{\cdot}81$	<0·001		
Mean medication in chlorpromazine equivalents, mg per day (S.D.) [range]	705·8 (318·1) [225–1750]	1432·7 (1253·1) [50–5086]	Mann–Whitney $Z=-2{\cdot}52$	<0·05		
On atypicals/both conventional & atypical antipsychotics (%)	67·4/11·6	0/0	$\chi^2=65{\cdot}7$, df=2	<0·001		
On anticholinergics (%)	37·2	78	$\chi^2=15{\cdot}9$, df=1	<0·001		

Age of onset of illness and estimated premorbid IQ were similar for both groups.

Spatial working memory (SWM)

There was a highly significant relationship between the psychomotor poverty syndrome and SWM ability, independent of the effects of source, age or gender [$\beta=0{\cdot}40$, $t(4,81)=3{\cdot}96$, $p<0{\cdot}001$]. There were no partial associations between the other relevant behavioural or symptomatic syndromes and SWM.

There was a significant effect of geographical location (i.e. source) as a predictor of working memory, which was independent of the syndrome measures and either age or gender [$\beta=0{\cdot}264$, $t(4,81)=2{\cdot}19$, $p<0{\cdot}05$]. To assess this relationship further, we undertook a series of secondary analyses controlling for factors relevant to geographic location, including illness duration and use of atypical medications. The significant effect of source was eliminated when both length of illness and use of atypical antipsychotics were included in the regression model ['psychomotor poverty', $\beta=0{\cdot}381$, $t(4,80)=3{\cdot}64$, $p<0{\cdot}001$; source, $\beta=0{\cdot}139$, $t(4,80)=0{\cdot}828$, $p=0{\cdot}41$; atypical antipsychotics, $\beta=-0{\cdot}141$, $t(4,80)=-0{\cdot}887$, $p=0{\cdot}378$; length of illness, $\beta=0{\cdot}066$, $t(4,80)=0{\cdot}596$, $p=0{\cdot}55$].

Examination of the impact of these two explanatory variables (illness duration and the use of atypical medications), without source in the model, revealed that atypical medication [$\beta=-0{\cdot}234$, $t(3,80)=-2{\cdot}085$, $p<0{\cdot}05$], rather than length of illness [$\beta=0{\cdot}091$, $t(3,80)=0{\cdot}859$, $p=0{\cdot}39$], was predictive of SWM performance. However, psychomotor poverty remained as the most important predictor of SWM ability [$\beta=0{\cdot}397$, $t(3,80)=3{\cdot}858$, $p<0{\cdot}001$].

There was no significant contribution of anticholinergic medication use to working memory ability [$\beta=0{\cdot}146$, $t(3,78)=1{\cdot}46$, $p=0{\cdot}18$], while the effect of atypical medication was not significant in this model [$\beta=-0{\cdot}201$, $t(3,78)=-1{\cdot}74$, $p<0{\cdot}10$]. Again, these potential confounders did not explain the relationship between psychomotor poverty and working memory [$\beta=0{\cdot}407$, $t(3,78)=3{\cdot}96$, $p<0{\cdot}001$].

The contribution of negative symptom confounders to the observed relationship between working memory and psychomotor poverty syndrome was examined. Positive symptoms [$\beta=0{\cdot}142$, $t(5,79)=1{\cdot}37$, $p=0{\cdot}17$], depression [$\beta=-0{\cdot}149$, $t(5,79)=-1{\cdot}52$, $p=0{\cdot}13$] and parkinsonism [$\beta=0{\cdot}034$, $t(5,79)=0{\cdot}36$, $p=0{\cdot}72$] were not predictive of working memory ability, and did not explain the relationship with psychomotor poverty [$\beta=0{\cdot}445$, $t(5,79)=3{\cdot}89$, $p<0{\cdot}001$], while source remained significant [$\beta=0{\cdot}265$, $t(5,79)=2{\cdot}55$, $p<0{\cdot}05$].

Attentional set-shifting ability

The results of logistic regression, assessing the relationship between the behavioural or symptomatic syndromes and intra-dimensional (ID)

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and extra-dimensional (ED) shift stages of the set-shifting task indicated that the disorganization syndrome was significantly associated only with ID shift ($B = -0{\cdot}311$, S.E. $= 0{\cdot}144$, Wald $= 4{\cdot}682$, df $= 1$, $p < 0{\cdot}05$) and ID reversal ($B = -0{\cdot}344$, S.E. $= 0{\cdot}155$, Wald $= 4{\cdot}947$, df $= 1$, $p < 0{\cdot}05$). The thought disturbance behavioural factor was associated with ID reversal ($B = -0{\cdot}139$, S.E. $= 0{\cdot}069$, Wald $= 4{\cdot}069$, df $= 1$, $p < 0{\cdot}05$) and ED shift ($B = -0{\cdot}174$, S.E. $= 0{\cdot}084$, Wald $= 4{\cdot}278$, df $= 1$, $p < 0{\cdot}05$), with a trend for ED reversal ($B = -0{\cdot}165$, S.E. $= 0{\cdot}086$, Wald $= 3{\cdot}687$, df $= 1$, $p > 0{\cdot}05$). Geographic location, age, gender and medication type or treatment with anticholinergics were not significant predictors in these analyses. However, length of illness significantly predicted performance on this task (IDR: $B = -0{\cdot}049$, S.E. $= 0{\cdot}021$, Wald $= 5{\cdot}571$, df $= 1$, $p < 0{\cdot}05$; EDS: $B = -0{\cdot}091$, S.E. $= 0{\cdot}027$, Wald $= 11{\cdot}336$, df $= 1$, $p = 0{\cdot}001$; EDR: $B = -0{\cdot}097$, S.E. $= 0{\cdot}028$, Wald $= 11{\cdot}955$, df $= 1$, $p = 0{\cdot}001$), though disorganization and thought disturbance syndromes were independent predictors of performance. Further, because working memory contributed significantly to performance on the set-shifting task, secondary analysis was undertaken to assess the contribution of working memory. Disorganization syndrome remained as an independent predictor at the ID reversal learning stage (disorganization: $B = -0{\cdot}364$, S.E. $= 0{\cdot}172$, Wald $= 4{\cdot}481$, df $= 1$, $p < 0{\cdot}05$; SWM errors: $B = -0{\cdot}031$, S.E. $= 0{\cdot}011$, Wald $= 7{\cdot}184$, df $= 1$, $p < 0{\cdot}01$). There was no relationship found to the antisocial behaviour behavioural syndrome.

Of the eight tests examining the relationship between disorganization/thought disturbance factors and the IDS/IDR and EDS/EDR stages, four had an unadjusted significance at $p < 0{\cdot}03$. If the null hypothesis is rejected for all four tests, the associated false discovery rate is 0·06, which is marginally greater than the accepted rate of 0·05, but suggests that the overall null hypothesis is false.

DISCUSSION

In this study we examined the relationships between neuropsychological functions and the symptomatic and behavioural syndromes characterizing schizophrenia, using a cross-national sample of patients. Significant and specific relationships were identified between SWM ability and negative symptoms, and between attentional set-shifting ability and both the thought disturbance behavioural factor and the disorganization symptom-based syndrome. While length of illness and type of medication (greater use of atypical antipsychotics in the Australian sample) explained some of the differences between the two populations, these variables did not explain the specific relationships identified between syndromes of schizophrenia and neuropsychological test performance. These findings are also broadly consistent with the relationships identified between symptoms and neuropsychological performance in the UK sample (Pantelis *et al.* 1999, 2001), although behavioural syndromes were not previously examined. It is also of interest that length of illness was an independent predictor of performance on the attentional set-shifting task, while no such relationship was observed for performance on SWM.

Spatial working memory ability and psychomotor poverty syndrome

A greater severity of negative symptoms was associated with poorer SWM, which was not explained by key demographic and clinical features of the populations studied, including illness duration or medication. Further, this relationship was not associated with secondary negative symptoms. Our results suggested that patients with prominent negative symptoms, characterized by apathy, amotivation, and impoverished affect and speech have impaired ability to represent information internally. Thus, impaired working memory may indicate a limited capacity to handle increasing amounts of information and to use this information to generate and guide behaviour. This is consistent with other findings that patients with schizophrenia are able to perform within the normal range on externally cued motor sequencing tasks, but have more difficulty when cues have to be internally generated (Williams *et al.* 2000). Similarly, prominent negative symptoms have been associated with impaired ability to generate action (Frith, 1992), thereby requiring external cueing or guidance. This is in line with clinical observations that such patients have difficulty engaging in rehabilitation interventions. It also supports the suggested use of external prompting

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(e.g. by carers), task simplification and provision of graduated information to enable patients to participate in activities more effectively (Malla *et al*. 1997; Velligan *et al*. 2000).

A number of studies consistently find a relationship between more severe negative symptoms and impaired performance on tests involving working memory, such as the Wisconsin Card Sorting Test (WCST; Liddle, 1987*a*; Addington *et al*. 1991; Liddle & Morris, 1991; Brown & White, 1992; Berman *et al*. 1997; Norman *et al*. 1997; Pantelis *et al*. 2001). Based on functional imaging evidence that the SWM task in this study is mediated through DLPFC and associated subcortical circuits (Owen *et al*. 1996*a*, *b*), our findings suggest these same neural circuits are implicated in the negative symptoms of schizophrenia. This is supported by imaging studies, which have identified DLPFC hypofrontality to be associated with negative symptom severity (e.g. Liddle *et al*. 1992; Schroder *et al*. 1996; Rodriguez *et al*. 1997; Lahti *et al*. 2001; Potkin *et al*. 2002). Further, additional areas relevant to working memory ability have been implicated in association with negative symptoms in schizophrenia, including basal ganglia, thalamus, cerebellum and parietal lobes (Menon *et al*. 2001; Potkin *et al*. 2002). Magnetic resonance structural and spectroscopic studies also suggest that grey and white matter abnormalities in prefrontal and subcortical areas are associated with negative symptoms (Callicott *et al*. 2000; Sanfilipo *et al*. 2000, 2002). Taken together, these studies suggest that the neural systems relevant to working memory ability, and involving frontal, parietal and subcortical regions, are pathophysiologically relevant to negative symptoms.

Our failure to demonstrate a relationship between SWM and illness duration is consistent with evidence for working memory deficits from the earliest phases of psychosis (Hutton *et al*. 1998; Wood *et al*. 2002), including premorbidly (Wood *et al*. 2003), as well as with evidence of DLPFC dysfunction in neuroleptic-naïve first-episode patients (Barch *et al*. 2001).

By contrast, there was no relationship between SWM and the behavioural concomitant of negative symptoms, the social withdrawal factor, which may represent a more heterogeneous syndrome than psychomotor poverty. It may include both the behavioural manifestations of primary negative symptoms and behavioural concomitants of secondary negative symptoms, including, for example, side effects of medication (Barnes & Liddle, 1990) or social withdrawal associated with experiencing paranoia (Carpenter *et al*. 1988; Kirkpatrick *et al*. 2001). It may also be that symptoms of psychomotor poverty represent 'core' features of the disorder, which are mediated by the same neural substrates associated with working memory, whereas the behavioural manifestations of psychomotor poverty are less closely linked to the same neurobiological substrate.

These behavioural features of schizophrenia may be more influenced by the psychosocial milieu and may therefore be amenable to improvement by psychosocial interventions that enrich or alter a person's environment (Sommers, 1985; Anthony *et al*. 1995), even if there is underlying neurocognitive impairment related to negative symptoms. If so, the behavioural syndromes may prove useful as outcome parameters that are more sensitive to change than symptom or other impairment-based measures used in rehabilitation. In contrast, SWM ability may be more relevant as an outcome measure in studies targeting negative symptoms as the main goal of treatment, as in treatment trials with atypical antipsychotics (Speller *et al*. 1997; Green, 1999). Indeed, our results suggest that treatment with atypical antipsychotic medication may be a significant predictor of SWM ability, consistent with evidence that atypical antipsychotics improve working memory (Green *et al*. 1997; Meltzer & McGurk, 1999).

Attentional set-shifting ability and disorganization syndromes

We identified modest associations between attentional set-shifting ability and both the disorganization syndrome and the thought disturbance behavioural syndrome, which were not explained by deficits in working memory. Increased duration of illness was also a significant independent predictor of impaired performance on this task. These relationships suggest that patients with longer duration of illness and greater severity of these symptoms and behaviours are more impaired in their ability to both generalize a rule that they had learned and to shift their attention in a flexible manner when required.

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The ability to perform the various stages of a set-shifting task is mediated by prefrontal regions and associated subcortical structures. Thus, lesion studies in primates indicate that the dorsal prefrontal cortex mediates extra-dimensional shifts, while reversal learning involves orbital prefrontal cortex function (Dias *et al*. 1996*a*, *b*). However, in an imaging study of the ED/ID task, while extra-dimensional shifts were associated with DLPFC function, reversal learning was associated with caudate activation, while the association with orbitofrontal function was not confirmed (Rogers *et al*. 2000). Our findings are, however, consistent with neurological lesions of the OFC or caudate, in which patients' behaviour is strongly influenced or cued by the environment reflecting an inability to modify responses to previously learned stimulus–response associations (Lhermitte *et al*. 1986; Rudd *et al*. 1998). Our findings of a relationship between reversal learning on the set-shifting task and disorganization symptoms and behaviours, independent of working memory, are consistent with hypotheses that these phenomena are related to dysfunction of the circuitry involving orbitofrontal cortex and caudate, namely orbitofrontal-striatal-thalamic systems (Robbins, 1990; Pantelis *et al*. 1992; Pantelis & Brewer, 1995, 1996), and are consistent with some (Liddle & Morris, 1991), though not all empirical studies (Norman *et al*. 1997; Baxter & Liddle, 1998). Given the limited imaging literature to inform these findings, and the relatively modest associations found in our study, further functional imaging work is required.

Our most significant predictor of attentional set-shifting ability was duration of illness, which is consistent with findings in younger patients. Using this task, first-episode patients are reported as relatively unimpaired in set-shifting ability (Hutton *et al*. 1998), while patients with moderately severe schizophrenia fail at the EDS stage due to a tendency to perseverate (Elliott *et al*. 1995), akin to frontal lesion patients. Further, direct comparison of a more chronic group of schizophrenia patients with controls and frontal lesion patients, found more severe deficits in the schizophrenia group, with failure at both intra- and extra-dimensional shifting stages (Pantelis *et al*. 1999). Taken together, these and the present findings are consistent with progressive deterioration of attentional set-shifting ability, although there are no published longitudinal studies available (for discussion: Pantelis *et al*. 2003).

While our findings for symptomatic and behavioural syndromes of disorganization are modest, they potentially have direct implications for rehabilitation. Thus, if patients characterized by disorganization symptoms and behaviours respond perseveratively, they will have greater difficulty transferring to new living situations and will require greater support and structure to help them adapt to change. Since community life is more complex than structured treatment environments (e.g. ward), impaired ability to generalize a rule may partly explain why skills learned in the latter setting are not transferred to community settings (Pantelis *et al*. 1999). Such difficulties are well recognized and require the use of deliberate strategies in rehabilitation focused on skills training (e.g. Hayes & Halford, 1993). Assessment of attentional set-shifting and other neuropsychological abilities could usefully guide the development of strategies to enhance generalizability of rehabilitation interventions (Delahunty & Morice, 1996; Wykes *et al*. 1999; Bell *et al*. 2001; Silverstein *et al*. 2001). Further work is needed to understand how neuropsychological impairments relate to real-life tasks and to examine the impact of differing aspects of context (e.g. physical, social) on task performance and on organization of more complex sets of behaviours required in work, instrumental and social role performance, particularly as the available literature in this area is limited (Green *et al*. 2000; Bell *et al*. 2001).

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REFERENCES

Addington, J., Addington, D. & Maticka Tyndale, E. (1991). Cognitive functioning and positive and negative symptoms in schizophrenia. *Schizophrenia Research* **5**, 123–134.

Andreasen, N. C. & Olsen, S. (1982). Negative *v*. positive schizophrenia. Definition and validation. *Archives of General Psychiatry* **39**, 789–794.

Anthony, W. A., Rogers, E. S., Cohen, M. & Davies, R. R. (1995). Relationships between psychiatric symptomatology, work skills, and future vocational performance. *Psychiatric Services* **46**, 353–358.

APA (1987). *DSM-III-R: Diagnostic Manual of Mental Disorders*. American Psychiatric Association: Washington, DC.

APA (1994). *Diagnostic and Statistical Manual of Mental Disorders, DSM-IV*. American Psychiatric Association: Washington, DC.

Barch, D. M., Carter, C. S., Braver, T. S., Sabb, F. W., MacDonald 3rd, A., Noll, D. C. & Cohen, J. D. (2001). Selective deficits in prefrontal cortex function in medication-naive patients with schizophrenia. *Archives of General Psychiatry* **58**, 280–288.

Barnes, T. R. & Liddle, P. F. (1990). Evidence for the validity of negative symptoms. *Modern Problems in Pharmacopsychiatry* **24**, 43–72.

Baxter, R. D. & Liddle, P. F. (1998). Neuropsychological deficits associated with schizophrenic syndromes. *Schizophrenia Research* **30**, 239–249.

Bell, M., Bryson, G., Greig, T., Corcoran, C. & Wexler, B. E. (2001). Neurocognitive enhancement therapy with work therapy: effects on neuropsychological test performance. *Archives of General Psychiatry* **58**, 763–768.

Benjamini, Y. & Yekutieli, D. (2001). The control of the false discovery rate in multiple testing under dependency. *Annals of Statistics* **29**, 1165–1188.

Berman, I., Viegner, B., Merson, A., Allan, E., Pappas, D. & Green, A. I. (1997). Differential realtionships between positive and negative symptoms and neuropsychological deficits in schizophrenia. *Schizophrenia Research* **25**, 1–10.

Bilder, R. M., Mukherjee, S., Rieder, R. O. & Pandurangi, A. K. (1985). Symptomatic and neuropsychological components of defect states. *Schizophrenia Bulletin* **11**, 409–419.

Brown, K. W. & White, T. (1992). Sub-syndromes of tardive dyskinesia and some clinical correlates. *Psychological Medicine* **22**, 923–927.

Callicott, J. H., Bertolino, A., Egan, M. F., Mattay, V. S., Langheim, F. J. & Weinberger, D. R. (2000). Selective relationship between prefrontal *N*-acetylaspartate measures and negative symptoms in schizophrenia. *American Journal of Psychiatry* **157**, 1646–1651.

Carpenter Jr., W. T., Heinrichs, D. W. & Wagman, A. M. (1988). Deficit and nondeficit forms of schizophrenia: the concept. *American Journal of Psychiatry* **145**, 578–583.

Crow, T. J. (1980). Molecular pathology of schizophrenia: more than one disease process? *British Medical Journal* **280**, 66–68.

Curson, D. A., Duke, P. J., Harvey, C. A., Pantelis, C. & Barnes, T. R. (1999). Four behavioural syndromes of schizophrenia: a replication in a second inner-London epidemiological sample. *Schizophrenia Research* **37**, 165–176.

Delahunty, A. & Morice, R. (1996). Rehabilitation of frontal/executive impairments in schizophrenia. *Australian and New Zealand Journal of Psychiatry* **30**, 760–767.

Dias, R., Robbins, T. W. & Roberts, A. C. (1996*a*). Dissociation in prefrontal cortex of affective and attentional shifts. *Nature* **380**, 69–72.

Dias, R., Robbins, T. W. & Roberts, A. C. (1996*b*). Primate analogue of the Wisconsin Card Sorting Test – effects of excitotoxic lesions of the prefrontal cortex in the marmoset. *Behavioral Neuroscience* **110**, 872–886.

Dixon, W. J. & Tukey, J. W. (1968). Approximate behavior of the distribution of Winsorized *t*. *Technometrics* **10**, 83–98.

Duke, P. J., Pantelis, C. & Barnes, T. R. (1994). South Westminster schizophrenia survey. Alcohol use and its relationship to symptoms, tardive dyskinesia and illness onset. *British Journal of Psychiatry* **164**, 630–636.

Elliott, R., McKenna, P. J., Robbins, T. W. & Sahakian, B. J. (1995). Neuropsychological evidence for frontostriatal dysfunction in schizophrenia. *Psychological Medicine* **25**, 619–630.

First, M. B., Spitzer, R. L., Gibbon, M. & Williams, J. B. W. (1997). *User's guide for the structured clinical interview for DSM-IV Axis I disorders* (*SCID-I*). American Psychiatric Press: Washington, DC.

Fossey, E. M. & Harvey, C. A. (2001). A conceptual review of functioning: implications for the development of consumer outcome measures. *Australian and New Zealand Journal of Psychiatry* **35**, 91–98.

Frith, C. (1992). *The Cognitive Neuropsychology of Schizophrenia*. Lawrence Erlbaum Associates, Ltd: Hove, UK.

Green, M. F. (1999). Interventions for neurocognitive deficits: editor's introduction. *Schizophrenia Bulletin* **25**, 197–200.

Green, M. F., Kern, R. S., Braff, D. L. & Mintz, J. (2000). Neurocognitive deficits and functional outcome in schizophrenia: are we measuring the 'right stuff'? *Schizophrenia Bulletin* **26**, 119–136.

Green, M. F., Marshall Jr., B. D., Wirshing, W. C., Ames, D., Marder, S. R., McGurk, S., Kern, R. S. & Mintz, J. (1997). Does risperidone improve verbal working memory in treatment-resistant schizophrenia? *American Journal of Psychiatry* **154**, 799–804.

Harvey, C. A. (1996). The Camden schizophrenia surveys. I. The psychiatric, behavioural and social characteristics of the severely mentally ill in an inner London health district. *British Journal of Psychiatry* **168**, 410–417.

Harvey, C. R., Curson, D. A., Pantelis, C., Taylor, J. & Barnes, T. R. (1996). Four behavioural syndromes of schizophrenia. *British Journal of Psychiatry* **168**, 562–570.

Hayes, R. L. & Halford, W. K. (1993). Generalization of occupational therapy training in psychiatric rehabilitation: do clients use the skills they learn? *American Journal of Occupational Therapy* **47**, 161–167.

Hutton, S. B., Puri, B. K., Duncan, L. J., Robbins, T. W., Barnes, T. R. & Joyce, E. M. (1998). Executive function in first-episode schizophrenia. *Psychological Medicine* **28**, 463–473.

Jaccard, J., Turrisi, R. & Wan, C. K. (1990). *Interaction effects in multiple regression*. Sage Publications: Newbury Park.

Kirkpatrick, B., Buchanan, R. W., Ross, D. E. & Carpenter Jr., W. T. (2001). A separate disease within the syndrome of schizophrenia. *Archives of General Psychiatry* **58**, 165–171.

Krawiecka, M., Goldberg, D. & Vaughan, M. (1977). A standardised psychiatric assessment scale for rating chronic psychotic patients. *Acta Psychiatrica Scandinavica* **55**, 299–308.

Lahti, A. C., Holcomb, H. H., Medoff, D. R., Weiler, M. A., Tamminga, C. A. & Carpenter Jr., W. T. (2001). Abnormal patterns of regional cerebral blood flow in schizophrenia with primary negative symptoms during an effortful auditory recognition task. *American Journal of Psychiatry* **158**, 1797–1808.

Lhermitte, F., Pillon, B. & Serdaru, M. (1986). Human autonomy and the frontal lobes. Part I: Imitation and utilization behavior: a neuropsychological study of 75 patients. *Annals of Neurology* **19**, 326–334.

Liddle, P. F. (1987*a*). Schizophrenic syndromes, cognitive performance and neurological dysfunction. *Psychological Medicine* **17**, 49–57.

Liddle, P. F. (1987*b*). The symptoms of chronic schizophrenia: a re-examination of the positive-negative dichotomy. *British Journal of Psychiatry* **151**, 145–151.

Liddle, P. F. (2001). *Disordered Mind and Brain: The Neural Basis of Mental Symptoms*. Gaskell (Royal College of Psychiatrists): London.

Liddle, P. F. & Barnes, T. R. (1990). Syndromes of chronic schizophrenia. *British Journal of Psychiatry* **157**, 558–561.

Liddle, P. F., Friston, K. J., Frith, C. D. & Frackowiak, R. S. (1992). Cerebral blood flow and mental processes in schizophrenia. *Journal of the Royal Society of Medicine* **85**, 224–227.

Liddle, P. F. & Morris, D. L. (1991). Schizophrenic syndromes and frontal lobe performance. *British Journal of Psychiatry* **158**, 340–345.

Malla, A. K., Lazosky, A., McLean, T., Rickwood, A., Cheng, S. & Norman, R. M. G. (1997). Neuropsychological assessment as an aid to psychosocial rehabilitation in severe mental disorders. *Psychiatric Rehabilitation Journal* **21**, 169–173.

Mega, M. S. & Cummings, J. L. (1994). Frontal-subcortical circuits and neuropsychiatric disorders. *Journal of Neuropsychiatry & Clinical Neurosciences* **6**, 358–370.

Meltzer, H. Y. & McGurk, S. R. (1999). The effects of clozapine, risperidone, and olanzapine on cognitive function in schizophrenia. *Schizophrenia Bulletin* **25**, 233–255.

Menon, V., Anagnoson, R. T., Mathalon, D. H., Glover, G. H. & Pfefferbaum, A. (2001). Functional neuroanatomy of auditory working memory in schizophrenia: relation to positive and negative symptoms. *Neuroimage* **13**, 433–446.

Nelson, H. E. (1982). *National Adult Reading Test* (*NART*): *Test Manual*. NFER, Nelson: Windsor, UK.

Norman, R. M. G., Malla, A. K., Morrison-Stewart, S. L., Helmes, E., Williamson, P. C., Thomas, J. & Cortese, L. (1997). Neuropsychological correlates of syndromes in schizophrenia. *British Journal of Psychiatry* **170**, 134–139.

Owen, A. M., Downes, J. D., Sahakian, B. J., Polkey, C. E. & Robbins, T. W. (1990). Planning and spatial working memory following frontal lobe lesions in man. *Neuropsychologia* **28**, 1021–1034.

Owen, A. M., Doyon, J., Petrides, M. & Evans, A. C. (1996*a*). Planning and spatial working memory: a positron emission tomography study in humans. *European Journal of Neuroscience* **8**, 353–364.

Owen, A. M., Evans, A. C. & Petrides, M. (1996*b*). Evidence for a two-stage model of spatial working memory processing within the lateral frontal cortex: a positron emission tomography study. *Cerebral Cortex* **6**, 31–38.

Pantelis, C., Barber, F. Z., Barnes, T. R., Nelson, H. E., Owen, A. M. & Robbins, T. W. (1999). Comparison of set-shifting ability in patients with chronic schizophrenia and frontal lobe damage. *Schizophrenia Research* **37**, 251–270.

Pantelis, C., Barnes, T. R. & Nelson, H. E. (1992). Is the concept of frontal-subcortical dementia relevant to schizophrenia? *British Journal of Psychiatry* **160**, 442–460.

Pantelis, C., Barnes, T. R. E., Nelson, H. E., Tanner, S., Weatherley, L., Owen, A. M. & Robbins, T. W. (1997). Frontal-striatal cognitive deficits in patients with chronic schizophrenia. *Brain* **120**, 1823–1843.

Pantelis, C. & Brewer, W. (1995). Neuropsychological and olfactory dysfunction in schizophrenia – relationship of frontal syndromes to syndromes of schizophrenia. *Schizophrenia Research* **17**, 35–45.

Pantelis, C. & Brewer, W. J. (1996). Neurocognitive & neurobehavioural patterns & the syndromes of schizophrenia: role of frontal-subcortical networks. In *Schizophrenia: A Neuropsychological Perspective* (ed. T. R. E. Barnes), pp. 317–343. John Wiley: London.

Pantelis, C., Stuart, G. W., Nelson, H. E., Robbins, T. W. & Barnes, T. R. (2001). Spatial working memory deficits in schizophrenia: relationship with tardive dyskinesia and negative symptoms. *American Journal of Psychiatry* **158**, 1276–1285.

Pantelis, C., Yucel, M., Wood, S. J., McGorry, P. D. & Velakoulis, D. (2003). Early and late neurodevelopmental disturbances in schizophrenia and their functional consequences. *Australian and New Zealand Journal of Psychiatry* **37**, 399–406.

Peralta, V., de Leon, J. & Cuesta, M. J. (1992). Are there more than two syndromes in schizophrenia? A critique of the positive-negative dichotomy [see comments]. *British Journal of Psychiatry* **161**, 335–343.

Potkin, S. G., Alva, G., Fleming, K., Anand, R., Keator, D., Carreon, D., Doo, M., Jin, Y., Wu, J. C. & Fallon, J. H. (2002). A PET study of the pathophysiology of negative symptoms in schizophrenia. Positron emission tomography. *American Journal of Psychiatry* **159**, 227–237.

Robbins, T. W. (1990). The case for frontostriatal dysfunction in schizophrenia. *Schizophrenia Bulletin* **16**, 391–402.

Rodriguez, V. M., Andree, R. M., Castejon, M. J. P., Labrador, R. G., Navarrete, F. F., Delgado, J. L. C. & Vila, F. J. R. (1997). Cerebral perfusion correlates of negative symptomatology and parkinsonism in a sample of treatment-refractory schizophrenics: an exploratory 99mTc-HMPAO SPET study. *Schizophrenia Research* **25**, 11–20.

Rogers, R. D., Andrews, T. C., Grasby, P. M., Brooks, D. J. & Robbins, T. W. (2000). Contrasting cortical and subcortical activations produced by attentional-set shifting and reversal learning in humans. *Journal of Cognitive Neuropsychiatry* **12**, 142–162.

Rudd, R., Maruff, P., MacCuspie-Moore, C., Velakoulis, D., Brewer, W. & Pantelis, C. (1998). Stimulus relevance in eliciting utilisation behaviour. Case study in a patient with a caudate lesion. *Cognitive Neuropsychiatry* **3**, 287–298.

Sahakian, B. J. & Owen, A. M. (1992). Computerized assessment in neuropsychiatry using CANTAB: discussion paper. *Journal of the Royal Society of Medicine* **85**, 399–402.

Sanfilipo, M., Lafargue, T., Rusinek, H., Arena, L., Loneragan, C., Lautin, A., Feiner, D., Rotrosen, J. & Wolkin, A. (2000). Volumetric measure of the frontal and temporal lobe regions in schizophrenia: relationship to negative symptoms. *Archives of General Psychiatry* **57**, 471–480.

Sanfilipo, M., Lafargue, T., Rusinek, H., Arena, L., Loneragan, C., Lautin, A., Rotrosen, J. & Wolkin, A. (2002). Cognitive performance in schizophrenia: relationship to regional brain volumes and psychiatric symptoms. *Psychiatry Research* **116**, 1–23.

Schonell, F. (1942). *Backwardness in the Basic Subjects*. Oliver and Boyd: London.

Schroder, J., Buchsbaum, M. S., Siegel, B. V., Geider, F. J., Lohr, J., Tang, C., Wu, J. & Potkin, S. G. (1996). Cerebral metabolic activity correlates of subsyndromes in chronic schizophrenia. *Schizophrenia Research* **19**, 41–53.

Scott, J. E. & Lehman, A. F. (1998). Social functioning in the community. In *Handbook of Social Functioning in Schizophrenia* (ed. K. T. Mueser and N. Tarrier), pp. 1–19. Allyn & Bacon: Boston, MA.

Silverstein, S. M., Menditto, A. A. & Stuve, P. (2001). Shaping attention span: an operant conditioning procedure to improve neurocognition and functioning in schizophrenia. *Schizophrenia Bulletin* **27**, 247–257.

Simpson, G. M. & Angus, J. W. (1970). A rating scale for extrapyramidal side effects in drug-induced extrapyramidal disorders. *Acta Psychiatrica Scandinavica* (Suppl. 44) **212**, 11–19.

Sommers, A. A. (1985). 'Negative symptoms': conceptual and methodological problems. *Schizophrenia Bulletin* **11**, 364–379.

Speller, J. C., Barnes, T. R. E., Curson, D. A., Pantelis, C. & Alberts, J. L. (1997). One-year, low-dose neuroleptic study of in-patients with chronic schizophrenia characterised by persistent negative symptoms – amisulpride *v.* haloperidol. *British Journal of Psychiatry* **171**, 564–568.

SPSS Inc. (1999). *Statistical Package for the Social Sciences*, Release 10. Chicago, IL (www.spss.com).

Velligan, D. I., Bow-Thomas, C. C., Huntzinger, C., Ritch, J., Ledbetter, N., Prihoda, T. J. & Miller, A. L. (2000). Randomized controlled trial of the use of compensatory strategies to enhance adaptive functioning in outpatients with schizophrenia. *American Journal of Psychiatry* **157**, 1317–1323.

Williams, S. B., Phillips, J. G., Bellgrove, M. L., Bradshaw, J. L., Bradshaw, J. A. & Pantelis, C. (2000). Use of advance information in patients with schizophrenia. *Journal of Clinical Experimentation and Neuropsychology* **22**, 472–482.

Wood, S. J., Pantelis, C., Proffitt, T., Phillips, L. J., Stuart, G. W., Buchanan, J.-A., Mahony, K., Brewer, W. J., Smith, D. J. & McGorry, P. D. (2003). Spatial working memory ability is a

marker of risk-for-psychosis. *Psychological Medicine* **33**, 1239–1247.

Wood, S. J., Proffitt, T., Mahony, K., Smith, D. J., Buchanan, J. A., Brewer, W., Stuart, G. W., Velakoulis, D., McGorry, P. D. & Pantelis, C. (2002). Visuospatial memory and learning in first-episode schizophreniform psychosis and established schizophrenia: a functional correlate of hippocampal pathology? *Psychological Medicine* **32**, 429–438.

Wykes, T., Reeder, C., Corner, J., Williams, C. & Everitt, B. (1999). The effects of neurocognitive remediation on executive processing in patients with schizophrenia. *Schizophrenia Bulletin* **25**, 291–307.

Wykes, T. & Sturt, E. (1986). The measurement of social behaviour in psychiatric patients: an assessment of the reliability and validity of the SBS schedule. *British Journal of Psychiatry* **148**, 1–11.