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# Schizophrenic Syndromes and Frontal Lobe Performance

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A battery of neuropsychological tests sensitive to frontal lobe impairment was administered to 43 chronic schizophrenic patients to delineate the abnormality of mental processing associated with the syndromes of psychomotor poverty and disorganisation, which had been identified in a previous study of the segregation of schizophrenic symptoms. Psychomotor poverty was found to be associated with slowness of mental activity, including slowness of generating words. The disorganisation syndrome was associated with impairment in tests in which the subject is required to inhibit an established but inappropriate response.

The heterogeneity of schizophrenia suggests that several distinguishable pathological processes can contribute to the illness. Crow's (1980) proposal that there are two independent dimensions of psychopathology in schizophrenia has proved a fruitful basis for research in recent years. He proposed that positive symptoms (such as delusions, hallucinations and formal thought disorder) are generated by a pathological process which is distinct from that underlying negative symptoms (such as poverty of speech and blunted affect).

In an attempt to clarify issues relating to the positive–negative symptom dichotomy, Liddle (1987*a*) examined the relationships between symptoms in a group of schizophrenic patients with persistent symptoms, and found that their symptoms segregated into three syndromes: psychomotor poverty (poverty of speech, blunted affect, decreased spontaneous movement); disorganisation (inappropriate affect and various disorders of the form of thought); and reality distortion (various delusions and hallucinations). This segregation of symptoms has subsequently been confirmed in a different set of patients (Liddle & Barnes, 1990). Other authors have reported similar findings (Bilder *et al*, 1985; Mortimer *et al*, 1990).

In an attempt to explore the nature of the abnormality of mental activity underlying these distinguishable schizophrenic syndromes, Liddle (1987*b*) examined the relationship between syndrome scores and performance in an extensive battery of neuropsychological tests. Each syndrome was associated with a distinct pattern of neuropsychological impairment, indicating that the syndromes are associated with different patterns of brain malfunction. In particular, psychomotor poverty was associated with impairment of abstract thinking and long-term memory, while disorganisation was associated with impaired concentration and new learning. Reality distortion exhibited evidence of association with impairment of a quite circumscribed aspect of cognitive function, being associated only with impairment of figure-ground perception.

On the basis of a comparison of the clinical and neuropsychological characteristics of each of the three syndromes with the sequelae of focal brain injury, Liddle (1987*b*) proposed that psychomotor poverty and disorganisation might be associated with malfunction of different sites in the frontal lobes, while reality distortion might arise from abnormality of the temporal lobe. This study is designed to test the hypothesis that both psychomotor poverty and disorganisation are associated with impaired performance in neuropsychological tests that are sensitive to frontal lobe damage, but that each of the two syndromes is associated with a different pattern of 'frontal' neuropsychological impairments.

## Method

All 49 patients aged less than 66 and satisfying DSM-III criteria for schizophrenia (American Psychiatric Association, 1980) on three rehabilitation wards and two long-stay wards at Horton Hospital were approached to participate in the study.

### Assessment of symptoms

Current symptoms were rated, by PFL, using the Scale for the Assessment of Negative Symptoms (SANS; Andreasen, 1982) and the Manchester Scale (Krawiecka *et al*, 1977). SANS provides a comprehensive rating of negative schizophrenic symptoms, the majority of which are assessed by observation of the patient. The Manchester Scale provides a concise measure of delusions, hallucinations and formal thought disorder. It is suitable for use with severely handicapped patients who have difficulty tolerating a long, standardised interview. In the original delineation of the three syndromes Liddle (1987*a*) employed SANS for rating negative symptoms, and Andreasen's Scale for the Assessment of Positive Symptoms (SAPS) for rating positive symptoms. Subsequently, Liddle & Barnes (1990)

employed SANS and the Manchester Scale in a study which replicated the finding that schizophrenic symptoms segregate into three syndromes, virtually identical in content to the syndromes identified previously by Liddle, subject to the different degree of detail imposed by the fact that the Manchester Scale provides less detailed rating of positive symptoms than does SAPS.

Syndrome scores for each of the three syndromes of schizophrenic symptoms were derived by summing scores for the component symptoms in the manner described previously (Liddle, 1987*b*), modified to employ scores for delusions, hallucinations and formal thought disorder rated according to the Manchester Scale instead of SAPS. The score for the psychomotor poverty syndrome was the sum of SANS item scores for poverty of speech, decreased spontaneous movement, and four aspects of blunted affect (decreased facial expression, decreased use of expressive gesture, lack of emotional response, and lack of vocal inflections, each weighted by a factor of 0.25). The maximum possible score is 15. The score for the disorganisation syndrome was the sum of SANS scores for inappropriate affect and poverty of content of speech, and the Manchester Scale score for irrelevant and incoherent speech. The maximum possible score is 14. The score for the reality distortion syndrome was the sum of Manchester Scale scores for delusions and hallucinations. The maximum possible score is 8.

A score for overall severity of illness was obtained by adding the scores for the nine items of the Manchester Scale. These nine items provide a quite comprehensive coverage of schizophrenic signs and symptoms. They include neurotic symptoms such as depressed mood and anxiety; two items characteristic of psychomotor poverty (flat affect, poverty of speech), two items characteristic of disorganisation (incoherence and irrelevance of speech, inappropriate affect) and two items characteristic of reality distortion (delusions, hallucinations). The ninth item, psychomotor retardation, can reflect either psychomotor poverty or depression.

### Neuropsychological tests

A brief neuropsychological battery, comprising an abbreviated version of the Stroop test (Stroop, 1935), the FAS word fluency test (Borkowski *et al*, 1967), the Modified Card Sorting Test (MCST; Nelson, 1976) and Reitan's Trail Making Test (Reitan, 1958), was administered in that order to each subject by DLM, who was blind to the symptom scores. These neuropsychological tests were chosen to include a variety of functions attributed to the frontal lobes, including ability to generate strategies and ability to respond flexibly to changing circumstances. In addition, DLM administered the graded naming task (McKenna & Warrington, 1983), which provides an estimate of general intelligence, in a concurrent study of tardive dyskinesia.

In the abbreviated Stroop test, the subject was first asked to read, as rapidly as possible, ten rows of five colour names printed in black ink on white card. Following the nomenclature of Stroop, this trial was designated 'reading colour names in black' ($RCN_b$). Subsequently, the subject was presented with ten rows of five colour names, each word printed in a colour different from the colour it names. The subject was asked to name the colour of the ink for each word, as rapidly as possible. This trial was designated 'naming colour of word', where the colour of the print and the name of the word are different ($NCW_d$). Successful execution of this trial depends on suppression of the tendency to respond to the meaning of the written word. The score for each trial is the time taken to complete the 50 items.

In the FAS word fluency test, the subject is asked to name words beginning with a specified letter of the alphabet. The letters F, A and S are presented in that order. The number of words produced in one minute for each letter is recorded, and the score is the total number of words generated in the three minutes.

Nelson's Modified Card Sorting Test is a modification of the Wisconsin Card Sorting Test. The subject has to sort cards into four heaps which match four key cards, matching according to the number, shape or colour of items printed on the card. The subject is not told which attribute should be matched, but has to deduce the correct rule for sorting on the basis of being informed after each card is placed whether or not it was correctly sorted. After six consecutive correct placements, the rule for sorting is changed. The subject is warned when the rule is about to change. Sorting errors in which a card is incorrectly sorted according to the same attribute as the previous card are designated perseverative errors. The percentage of errors which are perseverative is a measure that is sensitive to frontal lobe damage (Nelson, 1976), and was the principal score of interest in this study.

Reitan's Trail Making Test comprises two trials. In the first (Trail Making A), the subject is presented with a sheet of paper on which are scattered 25 printed circles, each enclosing one of the numbers from 1 to 25. The subject is required to join the circles in numerical order, as quickly as possible. In the second (Trail Making B), the subject is presented with a similar sheet of paper on which are scattered 25 circles enclosing the numbers 1 to 13 and the letters A to L, and is required to join them in the order 1,A,2,B, . . . etc., as quickly as possible. To achieve the required alternation between numbers and letters, the subject must inhibit the tendency to move from a number to the next number or from a letter to the next letter in the alphabet. For each trail, the score is the time taken to complete the task.

### Data analysis

Because many patients exhibit evidence of more than one of the three syndromes of schizophrenic symptoms, analysis of correlations between syndrome scores and neuropsychological test scores is more appropriate than comparisons of group mean scores for separate groups of patients. Therefore, correlation coefficients between syndrome scores and test scores were calculated.

Performance on each test involves a number of distinguishable psychological processes, and some of these distinguishable processes were common to several tests. Partial-correlation analysis was used to obtain an indication

of the extent to which the correlation between syndrome scores and a particular neuropsychological test could be accounted for by the shared association with other neuropsychological tests which involve overlapping psychological processes.

In particular, verbal fluency, Stroop $RCN_b$, and Stroop $NCW_d$ all involve timed production of words. The verbal fluency task requires the internal generation of words and the articulation of these words. Stroop $RCN_b$ involves the recognition of words and the articulation of these words. Stroop $NCW_d$ involves recognition and naming of a colour, suppression of the interfering effect of the lexical meaning of the stimulus, and articulation of the name of the colour. Of these three tasks, Stroop $RCN_b$ is the simplest, and is the one for which rate of articulation of words would be expected to make the greatest relative contribution to performance. Therefore, an indication of the extent to which rate of articulation of words contributed to observed first-order correlations of syndrome scores with verbal fluency was obtained by calculating the partial correlation of syndrome scores with verbal fluency, partialling out the contribution from any shared association with performance on Stroop $RCN_b$. Similarly, the partial correlation between syndrome scores and Stroop $NCW_d$, partialling out the shared association with Stroop $RCN_d$, were calculated.

Similarly, an indication of the extent to which the characteristics of the task that are common to Trail Making A and B (i.e. joining 25 circles) contributed to the first-order correlations between syndrome scores and Trail Making B performance was obtained by calculating partial correlations between syndrome scores and Trail Making B score, partialling out the shared association with Trail Making A score.

## Results

Forty-three (28 men, 15 women) of the 49 patients approached consented to participate in the study. These 43 patients had a mean age of 51.9 years (range 31–65) and a mean duration of illness of 28.9 years (range 9–47). Forty-one were receiving antipsychotic medication. Their mean daily dose in chlorpromazine equivalents was 1289 mg (range 72–7457 mg). Thirty-four were receiving anticholinergic medication.

The mean scores for the entire patient group on each of the tests and thresholds for impairment derived from published data are shown in Table 1. The patient group as a whole were impaired in performance on all of the tests.

The first-order Pearson correlation coefficients between syndrome scores and test performance are shown in Table 2. As predicted, the psychomotor poverty syndrome and the disorganisation syndrome were each associated with neuropsychological impairment, while the correlations between the reality distortion syndrome and performance in these tests were all near zero. Psychomotor poverty and disorganisation differed substantially in their patterns of correlation with neuropsychological impairment.

The partial correlations of syndrome scores with neuropsychological scores, partialling out the contribution from characteristics of the task that are common to several tests, are shown in Table 3. Partialling out the effect of shared association with Stroop $RCN_b$ reduced the magnitude of the correlation of psychomotor poverty with both verbal fluency and with Stroop $NCW_d$. In contrast, partialling out the shared association with Stroop $RCN_b$ did not decrease the magnitude of the correlation between disorganisation and either verbal fluency or Stroop $NCW_d$. Partialling out the shared association with Trail Making A reduced the small correlation between psychomotor poverty and Trail Making B to a value less than zero, while making only a slight reduction in the magnitude of the correlation between disorganisation and Trail Making B.

It is necessary to consider the possibility that the principal determinant of neuropsychological impairment in schizophrenic patients is overall severity of illness, and that the findings of this study might reflect a tendency for disorganisation and/or psychomotor poverty to be associated with greater overall severity of illness. This possibility can be investigated by examining the relationship between syndrome scores and overall severity of illness. The score for each of the three syndromes was correlated significantly with overall severity. The correlation coefficient for reality distortion was 0.62 ($P<0.001$); that for disorganisation was 0.53 ($P<0.001$); while that for psychomotor poverty was 0.44 ($P<0.01$). Thus reality distortion is associated at least as strongly with overall severity of illness as are the other two syndromes, and it is unlikely that overall severity could account for the

Table 1
Group mean scores for the neuropsychological tests and percentage of cases satisfying criteria for impairment

| | No. of cases | Mean score | Criterion for impairment | % of cases impaired | Reference for criterion |
|---|---|---|---|---|---|
| Verbal fluency | 40 | 25.5 | <23.1 | 52 | Borkowski *et al* (1967) |
| Stroop $RCN_b$ | 40 | 30.1 | >24.3 | 40 | Stroop (1935) |
| Stroop $NCW_d$ | 36 | 108.6 | >63.8 | 92 | Stroop (1935) |
| Trail Making A | 39 | 113.5 | >55.0 | 72 | Reitan (1958) |
| Trail Making B | 26 | 254.3 | >125.0 | 92 | Reitan (1958) |
| % perseverative errors in MCST | 41 | 53.3% | >51.0% | 41 | Nelson (1976) |

The criterion for each test is two standard deviations greater than the mean for normal subjects, except in the case of verbal fluency, for which the criterion is less than the mean score for a group of brain-damaged subjects.

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Table 2
Pearson correlations between syndrome scores and neuropsychological scores

| | Psychomotor poverty | Disorganisation | Reality distortion |
|---|---|---|---|
| Verbal fluency | −0.48** | −0.50** | −0.01 |
| Stroop $RCN_b$ | 0.36* | 0.09 | −0.06 |
| Stroop $NCW_d$ | 0.40* | 0.36* | −0.16 |
| Trail Making A | 0.49** | 0.27 | 0.19 |
| Trail Making B | 0.13 | 0.58** | 0.11 |
| % perseverative errors in MCST | 0.13 | 0.47** | 0.17 |

In the case of verbal fluency, greater score indicates better performance; for all other tests, greater score indicates worse performance.
*$P<0.05$; **$P<0.01$.

Table 3
Partial correlation coefficients between syndrome scores and neuropsychological scores, partialling out the effect of variation in neuropsychological scores for tests which involve overlapping mental processes

| Test score | Partialling with respect to | Psychomotor poverty | Disorganisation |
|---|---|---|---|
| Verbal fluency | Stroop $RCN_b$ | −0.37* | −0.53** |
| Stroop $NCW_d$ | Stroop $RCN_d$ | 0.27 | 0.37* |
| Trail Making B | Trail Making A | −0.27 | 0.55** |

*$P<0.05$; **$P<0.01$.

preferential association of the other two syndromes with neuropsychological impairment.

Similarly, it is possible that chronicity is a major determinant of neuropsychological impairment in schizophrenia, and a tendency for either psychomotor poverty or disorganisation to be associated with greater chronicity might account for the findings of this study. There was a significant correlation of moderate magnitude between psychomotor poverty and duration of illness ($r=0.34$, $P<0.05$), and a weak trend for disorganisation to be associated with long duration of illness ($r=0.28$, $P<0.10$). Duration of illness was also associated with neuropsychological impairment. The correlations between illness duration and test scores ranged from 0.02 (for perseverative errors in card sorting) to −0.40 (for verbal fluency performance). The partial correlations between syndrome scores and neuropsychological performance were slightly lower than the first-order correlations shown in Table 2, but all of the statistically significant correlations shown in Table 2 remained statistically significant after partialling out the effect of variation in duration of illness. Thus, longer duration of illness is associated with neuropsychological impairment, but this association accounts for only a minor component of the observed relationships between syndromes and for the pattern of neuropsychological impairment.

As is usual among a severely disabled group of patients, some patients did not attempt all of the tests, and it is important to examine the possibility that a systematic relationship between syndrome score and failure to complete tests might have contributed to the findings of the study. There was a significant negative correlation ($r=-0.41$, $P<0.01$) between number of tests completed and total Manchester Scale score. However, the correlations between each of the syndrome scores and number of tests completed were not statistically significant. Therefore it is unlikely that a relationship between syndrome score and failure to complete the tests accounts for the observed relationships between syndromes and neuropsychological impairment.

It is possible that the relationships between syndromes and impairment in frontal lobe tests might be a part of a relationship between the syndromes and generalised cognitive deficit. Performance in the graded naming test provides an approximate measure of overall intelligence. Performance on the graded naming test was correlated positively with performance on each of the frontal lobe tests. The magnitude of the correlation coefficients lay in the range 0.15 (for perseverative errors in card sorting) to 0.60 (for verbal fluency). Furthermore, there was a significant negative correlation between psychomotor poverty and graded naming performance ($r=-0.32$, $P<0.05$) and a trend towards a negative association between disorganisation and graded naming performance ($r=-0.28$, $P<0.1$). The partial correlations between performance on frontal lobe tests and both psychomotor poverty and disorganisation were slightly weaker than the corresponding first-order correlations, but all significant correlations shown in Table 2 remained statistically significant, except for the correlations with impaired performance on the Stroop test. In particular, there were significant partial correlations of disorganisation with verbal fluency performance ($r=-0.43$, $P<0.01$); perseverative errors in card sorting ($r=0.45$, $P<0.01$) and impairment in Trail Making B ($r=0.53$, $P<0.01$), after allowing for the influence of variation in performance on the graded naming test. Similarly, the partial correlations of psychomotor poverty with verbal fluency performance was −0.38 ($P<0.05$) and that with impairment in Trail Making A was 0.40 ($P<0.01$). Thus, it is unlikely that an association between syndromes and generalised cognitive deficit accounts for more than a minor part of the observed relationship between syndromes and impaired performance of frontal tests.

The Pearson correlations of neuroleptic dose with the disorganisation syndrome ($r=-0.01$) and with the psychomotor poverty syndrome ($r=-0.20$) were not statistically significant. The correlations between neuroleptic dose and neuropsychological test performance were statistically insignificant. The partial correlations of psychomotor poverty and disorganisation with neuropsychological test scores, partialling out any effects associated with variation in neuroleptic dose, were not substantially different from the first-order correlations. Thus there is no evidence to support the hypothesis that neuroleptic medication was responsible for the observed correlations between syndrome scores and neuropsychological performance.

## Discussion

This group of seriously disabled schizophrenic patients performed poorly on tests that are sensitive to frontal lobe damage. In particular, the impairments were correlated with the severity of psychomotor poverty and of disorganisation, but not with severity of reality distortion. There were differences between psychomotor poverty and disorganisation in the pattern of their correlations with neuropsychological impairment.

Speed of mental activity is a shared aspect of the tests for which impaired performance was associated with psychomotor poverty score. The finding that the correlation of psychomotor poverty score with both verbal fluency and with Stroop $NCW_d$ was reduced by partialling out the shared association with Stroop $RCN_b$ suggests that a common factor related to speed of articulation of words contributes to the associations between psychomotor poverty and impairments in these tests. Nonetheless, the partial correlation between psychomotor poverty and verbal fluency after partialling out the shared association with Stroop $RCN_b$ was statistically significant. This implies that the association between psychomotor poverty and impaired verbal fluency cannot be accounted for entirely by slowness in articulating words.

The shared attribute of three of the tests for which there was a significant association between impairment and disorganisation score, is a need to inhibit an established response and employ a different strategy. In the case of Stroop $NCW_d$, the subject must inhibit the tendency to respond to the lexical significance of the stimulus. In Trail Making B, the subject must alternate between numbers and letters. In the Modified Card Sorting Test, the subject needs to change strategy when informed that the previous card was incorrectly sorted.

The disorganisation syndrome was also associated with impaired verbal fluency. It is in principle possible that a variety of different psychopathological processes might result in impairment of verbal fluency. The observation that need to inhibit inappropriate responses is a common attribute of the other three tests for which impairment is associated with the disorganisation syndrome, suggests the hypothesis that difficulty in inhibiting inappropriate mental activity during the self-regulated task of word generation is responsible for the association between disorganisation and impaired verbal fluency.

In conclusion, this study provides evidence that the psychological mechanisms underlying the psychomotor poverty syndrome involves a slowing of mental activity. This slowing affects not only the articulation of words but also the generation of words. Furthermore, the evidence suggests that the psychological mechanism underlying the disorganisation syndrome is associated with a difficulty in inhibiting inappropriate responses.

Slowing of word generation and inability to inhibit inappropriate responses are typical of the impairments seen in patients with frontal lobe damage (Stuss & Benson, 1986). This study adds to the substantial body of evidence that the function of the frontal lobes is impaired in schizophrenia (Weinberger *et al*, 1986). However, in view of the strong reciprocal connections of the pre-frontal cortex with the other areas of association cortex, with the limbic system and with the basal ganglia, these findings do not indicate that the primary abnormality in schizophrenia necessarily lies in the pre-frontal cortex. The findings merely indicate that some of the phenomena of schizophrenia are associated with neuropsychological impairments of the type seen in patients with frontal lobe damage, while other schizophrenic symptoms appear to be unrelated to such impairments. Furthermore, the findings indicate that psychomotor poverty and disorganisation are associated with distinguishable patterns of impairment of functions considered characteristic of the pre-frontal cortex.

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