

BRIEF COMMUNICATION

Frontal lobe impairment in schizophrenia: relationship to intellectual functioning

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SYNOPSIS Schizophrenic subjects ($N = 48$) and individually matched healthy controls were administered the Verbal Scale of the Wechsler Adult Intelligence Scale (VIQ) and a test of verbal fluency. The verbal fluency and VIQ scores of the schizophrenic subjects were significantly lower than the scores of the control subjects. An additional sample of healthy subjects ($N = 144$) was used to generate a regression equation for the prediction of verbal fluency scores from Verbal IQ and age. The verbal fluency scores obtained by the schizophrenic subjects were significantly lower than the scores predicted from the regression equation, whereas a significant difference was not obtained in the matched controls. These results provide further evidence of frontal lobe dysfunction in schizophrenia.

INTRODUCTION

The reported reductions in resting cerebral glucose metabolism and resting cerebral blood flow in the frontal lobes of schizophrenics (as reviewed by Holcomb *et al.* 1989) have provided evidence for local dysfunction of the frontal lobe in schizophrenia. However, these reductions in regional blood flow and metabolism have not always been replicated and they have been difficult to interpret. As a consequence their significance has remained controversial (Waddington, 1990). Evidence from a complementary approach, that of neuropsychological studies of schizophrenic patients, may be useful in examining this issue.

With a few exceptions (e.g. Saykin *et al.* 1991), the results from most neuropsychological studies provide evidence that schizophrenic patients perform poorly on neuropsychological tests sensitive to frontal lobe injury (e.g. Malmö, 1974; Goldberg *et al.* 1987). Of these tests, the card sorting and initial letter verbal fluency

tasks are the best validated cognitive measures of frontal dysfunction (see Parker & Crawford, 1992 for review). We are aware of only two controlled studies of the verbal fluency performance of schizophrenics, both of which reported impairment (Kolb & Wishaw, 1983; Gruzelier *et al.* 1988). However, schizophrenics perform poorly on many other neuropsychological tests and on tests of general intellectual ability (Nelson *et al.* 1990; Crawford *et al.* 1992a). Consequently, the verbal fluency deficits of schizophrenics cannot necessarily be attributed to local frontal lobe dysfunction, particularly as verbal fluency performance is highly correlated with performance on tests of general verbal ability such as the Wechsler Adult Intelligence Scale (WAIS) (Wechsler, 1955), the Mill Hill Vocabulary Test (Raven, 1943), and the National Adult Reading Test (Nelson, 1982) in both clinical groups (Borkowski *et al.* 1967; Hanley *et al.* 1990) and healthy subjects (Miller, 1984; Crawford *et al.* 1992b). Furthermore, while performance on verbal fluency tests is maximally affected by damage to the frontal lobes, and the left frontal lobe in particular (Benton, 1968), it is also associated with damage to non-frontal areas of the brain (Borkowski *et*

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al. 1967). The extent to which the impaired performance of schizophrenics on tests of frontal lobe function is differentially greater than their current general intellectual ability remains to be established.

Using data from healthy subjects, Miller (1984) derived a regression equation to predict verbal fluency scores from VIQ. Unlike the performance of healthy subjects, the performance of individuals with focal frontal lobe lesions on the Verbal Fluency Test was significantly lower than the performance predicted by their WAIS results. This result indicates that the impaired performance of individuals with focal frontal lobe lesions on this test is not due to general intellectual deterioration. In contrast, predicted and obtained fluency scores did not differ significantly in a group of patients with Alzheimer's disease, suggesting that their impaired performance on the verbal fluency challenge was simply a reflection of general deterioration in verbal intellectual abilities, and not circumscribed frontal lobe dysfunction (Miller, 1984).

In the present study, we compared the verbal fluency and VIQ scores of schizophrenic subjects with those of matched healthy subjects in an attempt to confirm the presence of deficits on these tasks. In addition, we hypothesized that the schizophrenics' impairment on the verbal fluency task would be differentially greater than that predicted from their verbal intelligence.

METHOD

Generating the regression equation to predict verbal fluency scores from Verbal IQ

A sample of 144 subjects free from neurological, psychiatric or sensory disorder was administered the Verbal scale of the WAIS (VIQ) (Wechsler, 1955) and the Verbal Fluency test (VF). The VF test was administered by asking subjects to produce, in one minute, as many words as possible beginning with each of three letters (F, A and S) in turn. Subjects were informed that any kind of words were acceptable, except proper nouns, and the same words ending with different suffixes. To ensure comprehension, a practice trial with the letter C was administered with the examiner providing examples and asking the subjects to provide their own. Examples of

incorrect words were also provided (e.g. Colin, Colchester).

The mean age of the sample was 41.1 years (S.D. = 16.5) and the mean years of education was 12.5 years (S.D. = 3.0). The mean VIQ was 111.6 (S.D. = 14.1) and the mean VF score was 41.3 (S.D. = 12.1). VF scores were significantly correlated with VIQ ($r = 0.64$, $P < 0.001$). Because VF scores are not adjusted for age, whereas VIQ scores are, it was also considered necessary to examine age effects. The correlation between age and VF did not achieve significance ($r = 0.05$, NS). A forced entry multiple regression analysis was conducted to determine whether age would nevertheless exert a mediating effect on the relationship between VIQ and VF scores. The addition of age to the regression model led to a modest but significant increase in the predicted variance (R^2 change = 0.02, $P < 0.05$). A regression equation was derived to predict VF scores from VIQ and age. The total variance accounted for by these two variables was 44 % (multiple $r = 0.66$, $P < 0.001$). The regression equation was as follows: predicted VF = $(0.572 \times \text{VIQ}) - (0.095 \times \text{age}) - 18.85$.

Recruitment and testing of schizophrenic subjects

Patients meeting DSM-III criteria (American Psychiatric Association, 1980) for a diagnosis of schizophrenia were recruited from the Grampian Region Psychiatry Service. Potential subjects were excluded if there was evidence of a pre-existing mental handicap, or if they had been subject to a cerebral insult following illness onset (i.e. insulin coma therapy or frontal leucotomy). A sample of 48 subjects (26 males, 22 females) was obtained. The sample was split almost equally between those resident in long-term wards and those resident elsewhere (i.e. acute admissions, day hospital attenders, hostel residents). The mean age was 44.3 (S.D. = 16.2) and the mean number of years since illness onset was 10.5 (S.D. = 10.6). The mean number of years of education was 10.5 (S.D. = 1.8). The majority of patients (89.6%) were receiving neuroleptic medication. The mean number of daily chlorpromazine units (or mg equivalent) at the time of testing was 411.2 (S.D. = 443.7).

Schizophrenic subjects were individually matched for age (± 3 years), sex, and years of education ($+ 2$ years) with a healthy subject

drawn from the sample described above. The mean age in the control group was 46.5 (S.D. = 17.0) years and the mean number of years of education was 10.4 (S.D. 1.7). The schizophrenic subjects were administered the Verbal Scale of the WAIS and the verbal fluency test following the procedures noted above for the healthy subjects. VIQ scores in both groups were entered into the regression equation to obtain *predicted* VF scores.

RESULTS

The scores (mean and S.D.) for VIQ, VF and predicted VF for the schizophrenic and matched controls are presented in Table 1. Paired samples *t* tests (one-tailed) revealed that mean VF score for the schizophrenic subjects was significantly lower than the mean score for the control subjects ($t = 6.16, P < 0.001$). The VIQ of the schizophrenic subjects was also significantly lower than that of controls ($t = 5.51, P < 0.001$). The *predicted* VF scores of the control subjects were compared with their *obtained* VF scores by a repeated measures *t* test (two-tailed). As expected, no significant difference emerged ($t = 0.33, NS$). Repeating the same procedure with the scores of the schizophrenic subjects revealed that the *predicted* VF score was significantly higher than the *obtained* VF score ($t = 4.64, P < 0.001$).

Table 1. Mean scores for Verbal IQ, Verbal Fluency and predicted Verbal Fluency in schizophrenic patients and matched controls

	VIQ	Verbal Fluency	Predicted Verbal Fluency
Schizophrenics	90.7 (17.0)	23.9 (10.4)	28.8 (10.1)
Controls	107.6 (13.5)	39.0 (12.3)	38.5 (7.7)

Note: standard deviations in parentheses.

DISCUSSION

The highly significant difference in the performances on the verbal fluency tests between the schizophrenic and control subjects confirms the results from previous studies (Kolb & Wishaw, 1983; Gruzelić *et al.* 1988) that schizophrenics

are impaired on this task. The mean score of the schizophrenic subjects was more than one standard deviation below that of the control subjects.

The crucial result of the present study is that the poor performance of schizophrenic patients on the Verbal Fluency tests is differentially greater than would be predicted from their verbal intelligence as measured by the WAIS. These results demonstrate that the impaired verbal fluency performance of schizophrenics is not entirely explained by their current general intellectual ability and is consistent with the presence of specific frontal lobe dysfunction.

The pattern of performance in the present schizophrenic sample falls between that observed by Miller (1984) in patients with focal frontal lesions and in patients with Alzheimer's disease. The schizophrenic subjects differ from patients with focal frontal lesions in that their current verbal intelligence is impaired. However, they resemble frontal patients, but not Alzheimer patients, in that their level of intellectual functioning does not fully account for the severity of their verbal fluency deficit.

Physiological studies of schizophrenic patients maintained on medication - as were most of the patients in the present study - and studies of patients temporarily withdrawn from medication for a few weeks, demonstrate that cerebral glucose metabolism or resting cerebral blood flow in the frontal lobes of these patients is reduced in comparison to healthy controls, in both the resting state and during a cognitive challenge (as reviewed by Holcomb *et al.* 1989). However, frontal hypometabolism has not been a consistent finding in unmedicated schizophrenics. The present study helps to clarify this issue by demonstrating that the poor performance on a neuropsychological task of frontal lobe function is greater than would be predicted from general intellectual ability, and so may be due to frontal lobe dysfunction.

The possibility has also been raised that frontal dysfunction in schizophrenia may be secondary to antipsychotic medication, as studies of never-medicated patients have not found any indication of hypometabolism in the frontal lobe (see Szechtman *et al.* 1988). The data from this study provide no support for an iatrogenic explanation of frontal lobe dysfunction in schizophrenia. The mean verbal fluency

score of the 5 unmedicated subjects (20-6) was lower than the mean score of the 43 medicated subjects (24-3). In addition, the mean discrepancy between the predicted and obtained fluency score of the unmedicated subjects (7-8) was larger than that of the medicated subjects (4-6), a result which runs counter to an iatrogenic explanation. Further neuropsychological studies of the type described above, in never-medicated schizophrenics, would be useful in clarifying this issue.

The possibility cannot be discounted that the impaired performance of schizophrenics on this task is not due to frontal lobe dysfunction, but to dysfunction elsewhere in the brain, or even to retardation. These alternative explanations deserve further investigation, but in the light of the considerable neuropsychological and physiological evidence for frontal lobe dysfunction in schizophrenia, and of the close association between impaired verbal fluency and frontal lobe damage, we suggest that the specific impairment of the schizophrenic subjects on the verbal fluency task, differentially greater than predicted from their global intellectual ability, confirms the results of studies in cerebral metabolism by providing neuropsychological evidence for frontal-lobe dysfunction in schizophrenia.

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