Short communication

Association of an oculomotor delayed response task and the Wisconsin Card Sort Test in schizophrenic patients

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Abstract

The relationship between a widely-used neuropsychological test of frontal lobe function, the Wisconsin Card Sort Test, and spatial working memory, as assessed by the oculomotor delayed response task, was examined in schizophrenic patients. Schizophrenic patients were impaired compared with bipolar and normal control subjects on both tasks and their working memory performance was significantly correlated with their WCST measures. The spatial working memory and the WCST deficits in schizophrenia may reflect disrupted circuitry mediated by the dorsolateral prefrontal system. © 1997 Elsevier Science B.V.

Keywords: Schizophrenia; Working memory; Frontal lobe; Wisconsin Card Sort Test; Delayed response

1. Introduction

Neuropsychological testing of schizophrenic patients typically yields symptom profiles that are similar to frontal and temporal lobe dysfunctions but dissimilar to parietal lobe disorders (e.g. Kolb and Wishaw, 1983). Patients with frontal lobe lesions also tend to display anergia, inappropriate affect, attention deficits and recall problems (Stuss and Benson, 1984, 1987), similar to that observed in a large proportion of chronic schizophrenic patients.

Functional imaging studies also indicate frontal lobe dysfunction in schizophrenia. Medicated schizophrenic patients do not show 'hyperfrontal'
regional cerebral blood flow (rCBF), typically manifested by normals at resting state (Ingvar and Franzen, 1974; Ingvar, 1980). In addition, hypofrontality is related to the negative symptomatology, as well as specific cognitive deficits (Andreasen et al., 1992; Wolkin et al., 1992). During the Wisconsin Card Sort Test (WCST), the regional cerebral blood flow to the dorsolateral prefrontal cortex was significantly increased in normal controls but not in schizophrenic patients (Weinberger et al., 1986, 1988; Sagawa et al., 1990). However, during a number matching task, which is not mediated by the prefrontal cortex but still requires cognitive effort, there was no difference between the normal controls and patients in the rCBF pattern (Weinberger et al., 1986, 1988; Berman et al., 1988).

A variety of cognitive experiments, especially those involving the control of eye movements, also implicate the role of frontal lobe deficit in schizophrenia. Lesions in the dorsolateral prefrontal region in the rhesus monkey lead to profound deficits in spatial working memory, as assessed by delayed response tasks (e.g. Jacobsen, 1936; Goldman-Rakic, 1987; Funahashi et al., 1989). Humans with prefrontal lesions also show analogous deficits in delayed response tasks (Freedman and Oscar-Berman, 1986) or in memory-guided eye movement tasks (Pierrot-Deseilligny et al., 1991). Similarly, schizophrenic patients show deficits in oculomotor and haptic delayed response tasks, whereas bipolar patients do not show any impairments on the same tasks (Park and Holzman, 1992, 1993). Thus, working memory deficit, as assessed by the delayed-response tasks, provide additional evidence for the presence of prefrontal pathology in schizophrenic patients, who seem unable to regulate behavior by means of working memory, mediated by the prefrontal cortex (see Goldman-Rakic, 1991).

The WCST is a complex neuropsychological task with multiple neurocognitive components, some of which require active working memory. Spatial working memory, as assessed by the delayed response task is mediated by the dorsolateral prefrontal system in the monkey and although the evidence is mixed, the ability to perform well on the WCST also seems to be mediated by the dorsolateral prefrontal system rather than the orbitofrontal system. Therefore, delayed response and WCST performances should be associated, if they both share the same underlying neural and psychological mechanisms. Indeed, data from psychometrically ascertained schizotypic subjects indicate that their WCST performance is associated with deficits in spatial working memory (Park et al., 1995). It was hypothesized that the spatial working memory deficit would be associated with the WCST performance in schizophrenic patients.

2. Subjects and methods

2.1. Subjects

Fourteen schizophrenic out-patients (four women) and 13 bipolar out-patients (three women) who met the DSM-III-R diagnosis (Spitzer and Williams, 1985) participated in the study. They had no evidence of organic brain damage and were not mentally retarded. All patients were medicated. Scores of working memory function from 12 of these patients have been reported in Park and Holzman (1992). Fif-

| Table 1 |
|---|---|---|---|
| Mean age, years of education, IQ and the duration of illness | | | |
| | Age (S.D.) | Years of education (S.D.) | WAIS verbal (S.D.) | Duration of illness (S.D.) |
| Schizophrenic (n = 14) | 31.8 (5.0) | 12.4 (1.5) | 102.1 (14.1) | 11.6 (3.6) |
| Bipolar (n = 13) | 33.5 (9.5) | 13.2 (1.8) | 102.9 (11.9) | 12.6 (7.8) |
| Normal (n = 15) | 34.6 (8.8) | 13.8 (1.0) | 108.2 (8.8) | Not applicable |
teen normal control subjects (five women) who did not have a history of mental illness in the family, were recruited. Demographic variables are summarized in Table 1. There were no statistical differences in age, years of education and IQ scores among the three subject groups. The two patient groups did not differ in the duration of illness.

2.2. Procedure

2.2.1. Oculomotor delayed response task (ODR)

Only a brief description of the ODR is given here. Details of the ODR paradigm and a description of the ISCAN eye monitoring equipment are found in Park and Holzman (1992) (1993). The target, a black circle (2°) was flashed for 200 ms in the periphery while the subject fixated on a dot (0.5°) in the center of the stimulus display monitor. The distance between the fixation point and the target was 12°. Target locations were presented in a random order. Immediately following the target presentation, there was a delay period of 15 s, during which subjects performed an intervening verbal task, introduced to prevent them from using idiosyncratic mnemonic strategies and also to make sure that they maintained fixation in the center during the delay. The intervening task does not interfere with the spatial working memory performance (Park, 1991). After the delay, subjects were required to move their eyes to the remembered position of the target. Eye positions were recorded every 20 ms. There were 64 trials (see Fig. 1).

2.2.2. Wisconsin Card Sort Test

The Nelson Revised version of the WCST was used. It makes less cognitive demands because the rules are made explicit to the subject so that errors are less likely to be due to the failure to grasp the rules of sorting (Lezak, 1983).

3. Results

Schizophrenic patients performed worse than the two control groups on the working memory task and on the WCST. The results are summarized in Table 2.

3.1. Working memory task

An analysis of variance showed a significant effect of diagnostic group on accuracy of working
Table 2
Results of the working memory task and the WCST

<table>
<thead>
<tr>
<th></th>
<th>Working memory % correct (S.D.)</th>
<th>Wisconsin Card Sort Test No. of errors (S.D.)</th>
<th>No. of perseverative errors (S.D.)</th>
<th>No. of sets achieved (S.D.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Schizophrenic (n = 14)</td>
<td>68.8 (7.5)</td>
<td>16.9 (11.5)</td>
<td>8.6 (5.8)</td>
<td>4.8 (1.2)</td>
</tr>
<tr>
<td>Bipolar (n = 13)</td>
<td>88.0 (7.8)</td>
<td>4.5 (9.9)</td>
<td>1.1 (1.2)</td>
<td>5.8 (0.8)</td>
</tr>
<tr>
<td>Normal (n = 15)</td>
<td>86.0 (8.0)</td>
<td>2.9 (1.9)</td>
<td>1.4 (1.4)</td>
<td>6.0 (0.0)</td>
</tr>
</tbody>
</table>

memory ($F_{2,39} = 11.0, P < 0.0002$). Schizophrenics were less accurate than the normal controls ($F_{1,27} = 12.2, P < 0.002$) and bipolar patients ($F_{1,25} = 13.4, P < 0.002$).

3.2. Wisconsin Card Sort Test

There was a significant main effect of diagnostic groups in the number of errors ($F_{2,39} = 10.8, P < 0.0002$), the number of perseverative errors ($F_{2,39} = 20.1, P < 0.0001$) and the number of sets achieved ($F_{2,39} = 7.8, P < 0.0014$). Schizophrenic patients made more errors than bipolar patients ($F_{1,25} = 9.0, P < 0.007$) and the normal controls ($F_{1,27} = 21.1, P < 0.0001$). Schizophrenic patients also made more perseverative errors than the bipolar patients ($F_{1,25} = 21.0, P < 0.0001$) and the normal controls ($F_{1,27} = 21.0, P < 0.0001$). Schizophrenic patients achieved fewer sets than the bipolar patients ($F_{1,25} = 5.4, P < 0.03$) and the normal controls ($F_{1,27} = 14.4, P < 0.0008$). But there were no significant differences between the bipolar patients and the normal controls in any of the above measures.

3.3. Correlations

3.3.1. All subjects (n = 42)

There was a significant correlation between the oculomotor memory task and the number of sets achieved ($r = 0.52, P < 0.001$), the number of errors on the Wisconsin Card Sort Test ($r = -0.62, P < 0.001$) and also the number of perseverative errors ($r = -0.60, P < 0.001$).

3.3.2. Schizophrenia patients only (n = 14)

There was a significant correlation between the working memory score and the number of sets achieved ($r = -0.61, P < 0.05$), the number of errors ($r = -0.78, P < 0.001$) and the number of perseverative errors ($r = -0.58, P < 0.05$) on the WCST.

4. Discussion

Schizophrenic patients showed deficits on the oculomotor delayed response task and also on the WCST. Spatial working memory and the WCST deficits were significantly associated. This pattern of results supports the hypothesis that the ability to perform the oculomotor delayed response task and the WCST may share some common processes. It is suggested that successful performance on the WCST requires the integrity of working memory, mediated by the dorsolateral prefrontal system.

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References


