Stroop interference and facilitation in the cerebral hemispheres in schizophrenia.

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Abstract

A divided visual field presentation of the Stroop colour-word test was used to study interhemispheric (transcallosal) function in schizophrenic and normal subjects. The modified test used a colour strip paired with either an incongruent, neutral or congruent colour word. Interference and facilitation were defined as the difference between the mean reaction times for incongruent stimuli and neutral stimuli and that between neutral stimuli and congruent stimuli, respectively. The stimuli were presented tachistoscopically with the two components either separated across the midline centrally, up or down from the midpoint (bilateral presentation), or presented to a single visual half-field (unilateral presentation). The inclusion of the 'up' and 'down' bilateral conditions controlled for the reaction time advantage for central compared with unilateral stimulus presentations noted in an earlier study (David, 1993a). The difference in reaction time to an incongruent compared with a congruent colour-word pairing, the Combined Stroop Effect (CSE), was not affected significantly by stimulus presentation position (bilateral vs. unilateral) in either the control or schizophrenic group, unlike in the earlier study of David. For controls, interference was significantly greater than facilitation for both bilaterally- and unilaterally-presented stimuli. Schizophrenics had a significantly smaller interference effect for bilaterally-presented stimuli, indicating reduced interhemispheric interference in this group. For the control group, there was no significant difference between right and left CSEs, interference being significantly greater than facilitation on both visual half-field presentations. For schizophrenics, the CSE for left-presented stimuli was significantly greater than that for right-presented stimuli. In addition, left-field facilitation was significantly greater than right-field. Reduced Stroop facilitation with right-field presentations in schizophrenic subjects may reflect increased vulnerability of colour-naming by word-reading in the left hemisphere - evidence for the non-unitary nature of attentional processes and disintegration of these in schizophrenia.

Keywords: Schizophrenia; Stroop; Interhemispheric; Interference; Facilitation

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Introduction

The corpus callosum has been the subject of much interest and investigation in relation to schizophrenia, with various studies providing evidence of structural abnormalities (Rosenthal and Bigelow, 1972; Nasrallah et al., 1986; Raine et al., 1990; Woodruff et al., 1993, 1995; David, 1994). The notion of abnormal interhemispheric callosal function in schizophrenia has led to a large number of neuropsychological investigations in recent years (Merriam and Gardner, 1987; David, 1987; for a review, see Coger and Serafetinides, 1990), with some results suggestive of an impairment in trans-callosal transmission in schizophrenia. This has been linked to dysfunction in forebrain and brainstem interhemispheric processes (Doty, 1989). Studies employing electrophysiological techniques including sensory evoked potentials and interhemispheric EEG coherence have, on the other hand, demonstrated the presence of increased interhemispheric transfer in schizophrenic subjects (Gulman et al., 1982; Merrin et al., 1989), particularly in subjects with early onset of the illness and negative symptomatology (Coger and Serafetinides, 1990).

The colour-word test of John Ridley Stroop (Stroop Test) has been used extensively in neuropsychological investigation of a variety of subject groups (MacCleod, 1991). In the classical Stroop Test, the subject is presented with a colour-word written in either the same-colour ink as the colour-word (congruent condition) or in a different colour (incongruent condition). The subject is asked to name either the colour word or the colour ink in which the word is written, with the response to the incongruent condition being slower or more error-prone than that to the congruent condition. The difference in reaction time (RT) in the incongruent condition compared with the congruent condition is referred to as the Combined Stroop Effect (CSE). The task is thus a useful test of selective attention.

A version of the colour-word test has been used in order to study interhemispheric (trans-callosal) function in various subject groups (David, 1992, 1993a). The modified test uses a colour strip paired with either an incongruent or congruent colour word and presented tachistoscopically with the two components either separated across the midline (central presentation) or presented to a single visual half-field (lateral presentation) (David, 1993a). The CSE has been calculated in previous studies employing this modified test, with the results demonstrating the presence in schizophrenics of a larger CSE centrally compared with normal controls or with subjects with affective disorder (David, 1993a). This was interpreted by David as evidence either for increased interhemispheric interference for incongruent stimuli or increased interhemispheric facilitation for congruent stimuli for schizophrenics compared with controls.

This current investigation attempted to investigate whether it is interference or facilitation or both which are increased trans-callosally in schizophrenia. The difficulties associated with accurate measurement of interference and facilitation have been highlighted by Lindsay and Jacoby (1994), who demonstrated the independence of the two processes. The current study, by incorporating a neutral condition in addition to the interfering (incongruent) and facilitating (congruent) conditions provided a baseline against which approximations of the two processes can be measured. Both parameters may then be compared across different subject groups.

The previous study of David (1993a) had demonstrated a bilateral RT advantage for the Stroop stimuli (see also Ludwig et al., 1993). Such a finding may have confounded the CSE results in David’s study. The current study therefore controlled for this by incorporating two further central stimulus presentation positions with the stimulus presented in the vertical axis above and below the midpoint – referred hereafter as the ‘up’ and ‘down’ positions.

The effect of illness subtype on performance in the Stroop task has recently been investigated by Carter et al. (1993). Using a non-divided field presentation technique, they demonstrated that patients with the paranoid subtype showed normal amounts of facilitation and increased interference whereas the undifferentiated subtype showed increased facilitation.
The aims of the current study were therefore the following:

to attempt to replicate the findings of David (1993a), in which schizophrenic subjects demonstrated a greater CSE in the central compared with the unilateral presentation positions.

to examine the CSE when the bilateral condition included stimuli presented above and below the midpoint (the 'up' and 'down' positions).

to measure separately interference and facilitation in the unilateral and bilateral conditions, in both schizophrenic and normal subjects.

to demonstrate an effect of illness subtype on performance in the divided visual field version of the Stroop test.

2. Method

2.1. Subjects

All subjects in the study were recruited as part of a larger neuroimaging study restricted to males. Twenty-seven patients with a diagnosis of schizophrenia (DSM-III-R criteria based on symptoms at interview and in the case notes; APA, 1987) at various stages of illness: acute-on-chronic (n = 1), chronic (n = 15), in remission (n = 11); and with different subtypes: paranoid (n = 9), undifferentiated (n = 2), residual (n = 5), remission (n = 11) were recruited from the in- and outpatient departments of the Maudsley and Bethlem Royal Hospitals, London. All were right-handed (Annett criteria: Annett, 1970). Overall psychopathology was rated on the modified Brief Psychiatric Rating Scale (range: 0–216; Bech et al., 1986; Bech, 1993). The presence and number of first rank symptoms (FRS) was also noted (0–3 with the value label ‘4’ designated for three or more FRS), defined according to Wing et al. (1974). The presence and type of auditory hallucinations was also noted. In addition, 31 male, right-handed normal control subjects were recruited from local job centres and from staff at the Institute of Psychiatry. These were matched for age with the schizophrenic subjects.

All subjects completed the National Adult Reading Test (NART) – an estimate of premorbid IQ (Nelson et al., 1978).

Subject details are summarised in Table 1. The mean BPRS score for the schizophrenic subjects was 15.11 (±SD 11.05). The groups were well-matched for age (p = 0.43). The mean IQ of the schizophrenics was somewhat lower at 107 (±SD 10.02) compared with 113 (±SD 9.25) of the controls (p = 0.02). Schizophrenic subjects were taking a variety of medications: neuroleptics (22), lithium (4), antidepressants (3), anticholinergics (11) and benzodiazepines (2). No normal controls were taking medication, except one normal control subject who was prescribed a benzodiazepine.

2.2. Apparatus and stimuli

This consisted of a Kodak S-AV 2050 projector with shutter attachment, controlled by a tachistoscope timer panel. Slides (stimuli) were projected on to a perspex screen with a central fixation point. Subjects sat with their chin resting on a support 50 cm from the screen and wore a set of headphones and microphone attached to a voice key. The verbal response of each subject to each stimulus activated the voice key, enabling the reaction time to be recorded and entered directly into a personal computer for analysis. The maximum time allowed for a response was 2500 ms, thereafter an error being recorded for the stimulus. A Polaroid filter was used to reduce the glare from the projector beam.

All stimuli consisted of a vertical colour strip, approx. 1° in width and 3° in height, coupled with a word written vertically in upper case letters (black Helvetica medium type) and with the same dimensions. The word and colour strip were always presented alongside each other and separated by 1.4°.

The word and colour strip were presented either centrally – colour strip and word equidistant from the fixation spot; laterally (right or left visual half-field) – the medial edge of each part of the stimulus 3° lateral (right or left) to the fixation spot; or centrally – vertically above or below the fixation spot (inferior edge of the stimulus 3° above or superior edge 3° below the fixation spot) (see Fig. 1).
Table 1
Comparision of schizophrenic and normal control subjects

<table>
<thead>
<tr>
<th></th>
<th>Schizophrenics</th>
<th>Normal controls</th>
<th>t</th>
<th>P</th>
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</thead>
<tbody>
<tr>
<td>Total No.</td>
<td>27</td>
<td>31</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age (years)</td>
<td>32.89 (1.28)</td>
<td>31.35 (1.43)</td>
<td>0.79</td>
<td>0.43</td>
</tr>
<tr>
<td>IQ (NART)</td>
<td>107.00 (1.93)</td>
<td>113.06 (1.67)</td>
<td>2.40</td>
<td>0.02</td>
</tr>
<tr>
<td>Errors (%)</td>
<td>6.70 (1.17)</td>
<td>2.78 (0.48)</td>
<td>3.10</td>
<td>0.004</td>
</tr>
<tr>
<td>Overall mean reaction time (ms)</td>
<td>890.15 (40.61)</td>
<td>725.95 (20.34)</td>
<td>3.62</td>
<td>0.001</td>
</tr>
</tbody>
</table>

The numbers in parentheses refer to the standard error of the mean.

Prior to testing, all subjects demonstrated their ability to read all the words and name all the colours in the slides. 20 practice slide were shown before the testing procedure. The slides were presented in pseudo-random order with respect to stimulus position and congruity at approx. 1 every 2.5 s.

2.3. Procedure

Subjects were instructed to look at the central fixation spot at all times. A warning tone sounded over the headphones 500 ms before the presentation of each slide. Each slide remained for 120 ms. Subjects were asked to name the colour (as opposed to the word) as quickly and as accurately as possible.

3. Results

The data were analysed with the use of multivariate analyses of variance with diagnosis as the between subject factor, position (5 levels) and congruity (3 levels) as within subject factors. Univariate analyses of variance, two-tailed unpaired t-tests and matched pairs t-tests were used for post-hoc exploratory analyses as appropriate.

3.1. Effects of diagnosis, stimulus position and congruity on reaction time

Reaction times (RT) for the different stimulus conditions are shown in Table 2. Diagnosis exerted a significant effect, with total mean RT for the
schizophrenics 890.2 ms (±SD 211.0), which was significantly greater than that of the controls 726.0 ms (±SD 113.3) (p=0.001). The schizophrenic subjects also made significantly more errors than the normal control subjects in the testing procedure: 6.7% compared with 2.8% (p=0.004) (see Table 1).

Pearson product moment correlation coefficients were calculated for total mean RT and subject age, IQ, BPRS, number of first rank symptoms, education in years, number of hospital admissions and number of errors. None approached significance except for the relationship between total mean RT and number of errors made in the schizophrenic group (r=0.57; p<0.01), with a near significant relationship for total mean reaction time and number of errors made in the control group (r=0.33).

Neuroleptic medication appeared to have a significant effect on RT: mean RT for schizophrenic subjects on neuroleptics 921.9 ms (±SD 221.1); not on neuroleptics 750.1 ms (±SD 50.7) (r=3.29; p=0.003), although this may reflect the fact that subjects on neuroleptic medication were more severely ill. In view of the small number of schizophrenic subjects not taking neuroleptics (5) and wide variance in response, this result should be viewed with caution. None of the other medications had any significant effect on RT.

Prior to discussing the analyses directly related to the four aims of the study described above, the effects of stimulus presentation position and stimulus congruity on RT were analysed.

There was no significant interaction of diagnosis, stimulus presentation position and congruity overall (F=1.19; (4, 53); p=0.33). Further analysis revealed a significant effect of stimulus congruity on RT; however, in both schizophrenic and control groups (F=33.45; (2, 25); p<0.001 and F=58.81; (2, 29) p<0.001, respectively), with RTs to incongruent stimuli significantly greater than neutral and neutral greater than congruent.

There was no significant main effect of presentation position (bilateral vs. unilateral) on RT in the schizophrenic group (t=0.70; p=0.49). There was a bilateral field advantage (i.e., shorter RT)
for control subjects when reaction times for central only versus unilateral stimulus presentation positions were compared \((t = 3.56; \ p = 0.01)\), thereby confirming the finding of David (1993a). With the inclusion of the ‘up’ and ‘down’ stimulus presentation positions, this advantage was lost \((t = 1.30; \ p = 0.20)\). The inclusion of the two conditions ‘up’ and ‘down’ therefore controlled for the bilateral field advantage in the control subject group.

Further analysis of the effect of stimulus presentation position (up, down, central, right, left) on RT in the control group revealed a significant main effect \((F = 4.32; \ (4, 27); \ p = 0.008)\). Univariate analysis revealed that this was the result of the RT being significantly greater for right compared with central presentations \((F = 13.17; \ (1, 30); \ p = 0.001)\) and up compared with central presentations \((F = 8.14; \ (1, 30); \ p = 0.008)\). The greater RT for right compared with central presentation positions is possibly a reflection of the left hemisphere’s role in processing language and the confounding effect of this on colour-naming. The greater RT for up compared with central presentation positions is possibly related to the effect of distance from the midpoint of the stimulus on RT, with greater distance from the midpoint leading to a greater RT. The lack of significant difference between RTs for central compared with down-presentation positions is difficult to explain.

Analysis of the effect of visual half-field presentation (right vs. left) on RT led to some interesting results. Although there was no overall significant effect of diagnosis on the interaction of visual half-field presentation and stimulus congruity \((F = 2.20; \ (3, 54); \ p = 0.10)\), post-hoc analysis revealed an effect of visual half-field presentation on RT in the schizophrenic group, with there being a significant interaction between visual half-field presentation (right vs. left) and stimulus congruity \((F = 3.27; \ (3, 24); \ p = 0.04)\). For the control subjects, there was no such interaction \((F = 0.47; \ (3, 28); \ p = 0.70)\). Further analysis of the results of the schizophrenic group revealed that the interaction was due largely to the difference in RT to congruent stimuli on right vs. left field presentation (right greater than left) \((t = 3.01; \ p = 0.01)\). This suggested a difference in right vs. left hemisphere function in the schizophrenic group with respect to facilitation. In view of this finding, further analysis was performed of CSE, interference and facilitation differences between right and left visual half-field presentations in the schizophrenic group. These results will be discussed further below.

### 3.2. Combined Stroop Effects (CSE)

AN aim of the study was to replicate the finding of the study of David (1993a), in which the central (bilateral) CSE was smaller than the unilateral CSE for control subjects but greater than the unilateral CSE for schizophrenic subjects.

The results of the current study did not demonstrate any main effects for diagnosis or position on CSE. There was no significant interaction of diagnosis and presentation position (bilateral vs. unilateral) on CSE \((F = 0.63; \ (2, 55); \ p = 0.53)\). Unlike the findings of David (1993a), there was no significant difference in CSE for all bilateral compared with all unilateral presentations in the schizophrenic group \((t = 1.02; \ p = 0.32)\) or control group \((t = 0.33; \ p = 0.75)\) (see Fig. 2). Comparison of the central CSE only with the unilateral CSE (i.e., omission of the up and down stimulus presentation positions as in the study of David, 1993a) revealed a significantly greater CSE for the central presentation compared with the unilateral presentation in both schizophrenic and control groups \((t = 2.63; \ p = 0.01\) and \(t = 2.40; \ p = 0.02\), respectively). This result replicates the finding of David (1993a) for the schizophrenics but differs from his results on normal controls.

### 3.3. Interference and Facilitation

The interference effect was calculated as the difference between the mean RT for incongruent and neutral stimuli, with the facilitation effect being calculated as the difference between the mean RT for neutral and congruent stimuli. Mean interference and facilitation effects were calculated and compared for bilateral and unilateral presentations in both subject groups.

There was no overall significant effect of diagnosis on the interaction between stimulus position (bilateral vs. unilateral) and the extent of facilitation and interference \((F = 1.19; \ (4, 53); \ p = 0.33)\).
Fig. 2. CSEs for bilateral, right and left visual half-field presentations in schizophrenic and normal control subjects. Bar chart showing combined Stroop Effects (CSE = reaction time to incongruent stimuli – that for congruent stimuli) for stimuli presented in all bilateral positions (= [reaction time to stimuli presented up + centrally + down]/3), in the right visual half-field and in the left visual half-field. For the schizophrenic subjects, the right CSE was significantly smaller than the left CSE (P=0.006). There was no significant difference between the right and left CSEs in the control subjects. In both subject groups, the bilateral and overall unilateral ([right+left]/2) CSEs did not differ significantly.

However, in view of previous work suggesting a dissociation between facilitation and interference in schizophrenia (Carter et al., 1992), further exploratory analyses were carried out. In the schizophrenic group, there was no significant effect of presentation position on the extent of facilitation and interference (F=0.18; (2, 25); p=0.84). In the control group, however, this was significant (F=6.71; (2, 29); p=0.004), although in both bilateral and unilateral presentations, there was significantly greater interference compared with facilitation (F=13.57; (1, 30); p=0.001; and F=8.99; (1, 30); p=0.005, respectively). Interference was significantly greater for bilaterally-presented stimuli in the control group compared with the schizophrenic group (t=2.03; p=0.05) (see Fig. 3).

Further analysis revealed that across all presentation positions, the interference effect was significantly greater than the facilitation effect for the control group (t=3.70; p=0.001) but not for the schizophrenic group (t=0.17; p=0.87). There was, however, a non-significant trend in the schizophrenic group of a greater interference for unilateral stimuli.

Overall, the results indicated that there was no significant effect of presentation position (bilateral vs. unilateral) on extent of facilitation and interference in the schizophrenic group, with no significant difference between interference and facilitation in either position. In the control group, however, interference was significantly greater than facilitation in all positions, although to a significantly greater extent in bilateral presentations. Further analysis revealed that interference for bilaterally- but not unilaterally-presented stimuli was significantly reduced in the schizophrenic group compared with the control group. The implication of this finding is discussed below.
3.4. Right vs. left half-field presentation

Further analysis of the effect of visual half-field presentation on CSE revealed a significant effect in the schizophrenic group, with the CSE significantly greater for left-field presentation compared with right-field presentation ($t=2.97; p=0.006$). There was no significant difference in CSE for right- and left-field presentations for the control subjects ($t=0.52; p=0.60$) (see Fig. 2). The significant reduction in CSE on right- compared with left half-field presentation in the schizophrenic group was analysed further in terms of extent of facilitation and interference differences.

Separate analysis of the effect of visual half-field for unilateral presentation on facilitation/interference revealed a significant effect in the schizophrenic group ($F=4.58; (2, 25); p=0.02$). This was due to the significant difference in facilitation on right vs. left field presentation ($F=7.37; (1, 26); p=0.01$), with left-field facilitation greater than right-field facilitation. The facilitation effect for right-field presentation was actually negative (i.e., reaction time to neutral stimuli LESS than that to congruent stimuli). In the control group, there was no significant interaction of half-field presentation and the extent of facilitation/interference ($F=0.15; (2, 29); p=0.86$) (see Fig. 4). There was thus a significant interaction between subject diagnosis and the effect of half-field presentation on facilitation/interference ($F=3.36; (2, 55); p=0.040$, with this due to the significant effect of diagnosis on right vs. left half-field facilitation ($F=4.76; (1, 56); p=0.03$).

Overall, the findings demonstrated a difference between right and left hemisphere function in the schizophrenic group that was not found in the control group: a marked reduction in CSE and facilitation on right visual half-field presentation (left hemisphere) compared with left half-field presentation (right hemisphere). Further analysis in the schizophrenic group did not reveal any significant effects of the presence of auditory hallucinations or first rank symptoms.

3.5. The effect of schizophrenic illness stage and subtype

Further analysis was performed in order to determine the effect on performance in the schizophrenic subjects of illness stage and subtype. This did not reveal any significant effect of illness stage (acute-on-chronic and chronic vs. remission). In particular, the illness stage and subtype did not have a significant effect on the extent of facilitation on right half-field presentation.

4. Discussion

The results demonstrated that schizophrenics had greater overall RTs compared with controls on a Stroop test. The total mean RT also correlated positively with total number of errors, in both schizophrenic and control subjects, indicating that reaction speed was not at the expense of accuracy. The Stroop effect was not different between the groups, however (see David, 1993a; Everett et al., 1989).

Surprisingly, there was no significant effect of
stimulus presentation position (bilateral vs. unilateral) on CSE in either the schizophrenic or control group with the inclusion of the two bilateral presentation control positions (up and down). With these two conditions excluded, the bilateral (central) CSE was significantly greater than the unilateral CSE in both subject groups. This pattern of results concurs with that of David (1993a) in schizophrenic patients but is the reverse of that found in normal controls in the earlier study. It was suggested that the original finding was evidence of abnormal interhemispheric function in the schizophrenics.

The discrepancy in the findings of the two studies may be a reflection of the choice of control subjects, with the current study testing control subjects largely from outside the hospital, whereas the earlier study of David recruited controls from staff of the hospital. A further explanation may lie within the choice of male-only subjects in the current study, with the earlier study testing both male and female subjects. This may have confounded the results relating to performance in the test for right versus left stimulus presentation, and also for performance for unilateral versus bilateral stimulus presentation.

Is there a psychological explanation for the different pattern of performance in the two studies? The main difference between the study of David (1993a) and the current study is the inclusion of ‘up’ and ‘down’ bilateral positions. Hence three out of five stimuli were central compared with one out of three in the earlier study. Perhaps this offsets a difficulty in schizophrenia in applying a selective attentional filter at the same time as returning the ‘attentional spotlight’ to the midline. However, this normalisation seems to have a cost in terms of modulating the attentional filter to facilitative and interfering information in the right lateral visual field.

4.1. Interference vs. facilitation effects

For schizophrenics, there was found to be no significant difference in interference compared with facilitation for bilaterally- or unilaterally presented stimuli. For controls, interference was significantly greater than facilitation for both bilaterally and unilaterally presented stimuli (see Fig. 3). There was also a non-significant trend for any difference between interference and facilitation to increase (interference greater than facilitation) on moving from bilateral to unilateral presentation in the schizophrenic group. Further analysis demonstrated that, compared with the control group, the schizophrenics had a significantly smaller interference effect for bilaterally presented stimuli.

It could therefore be postulated that in the schizophrenic group it is the interference effect which decreases as stimuli move from unilateral to bilateral presentation, resulting in a relative increase in the facilitation effect. This is not found in the control group, in which interference is significantly greater than facilitation regardless of position. The results of David (1993a) suggestive of abnormal callosal function in schizophrenia may well be explained by the reduced interference and relative increase in Stroop facilitation in the bilateral position. Evidence for selective Stroop facilitation in schizophrenia has been provided by Carter et al. (1992). Their study used a standard version of the Stroop Test, however, and did not attempt to test specifically for interhemispheric function with the use of the current split-field presentation technique. The current study did not demonstrate any effect of illness subtype on the extent of facilitation and interference in the bilateral or unilateral condition in the schizophrenic subjects. This study therefore fails to replicate the findings of Carter et al. (1993), perhaps due to stimulus and presentation differences.

4.2. Right vs. left visual half-field presentation

For schizophrenics, although there was found to be no significant difference in overall mean RT for stimuli presented to the right- as opposed to the left-field, the CSE for left-presented stimuli was found to be significantly greater than that for right-presented stimuli (see Fig. 2). In addition, left-field facilitation was found to be significantly greater than that of the right field, with the facilitation effect on right-field presentation negative i.e., evidence of impaired facilitation on right half-field (left hemisphere) presentation (see Fig. 4). The findings for normals were different, with there
being no significant difference between right and left CSEs and the interference effect significantly greater than the facilitation effect on both right and left visual half-field presentations.

The most abnormal finding in patients with schizophrenia was the reduced Stroop facilitation with right-field presentations. It appears that colour words interfered with colour naming even when they were congruent. Hugdahl and Franzon (1985) showed greater vocal RTs in right-handed normal subjects for naming the colour of colour words when the words were presented to the right visual half-field (left hemisphere) compared with the left half-field (right hemisphere). It is interesting that the effect was demonstrated only in the schizophrenic group, and is suggestive of impaired attentional processes in the left hemisphere in the schizophrenic group. The role of left hemisphere dysfunction in schizophrenia has been described previously (Crow, 1990). In particular, it has been noted that non-paranoid schizophrenics are impaired in the processing of letters presented tachistoscopically to the right visual half-field/left hemisphere (Magaro and Chamrad, 1983a,b), and are slower than paranoid schizophrenics in the performance of attentional tasks presented tachistoscopically to the left hemisphere (George and Neufeld, 1987). It has also been demonstrated that schizophrenic subjects are impaired compared with controls in left hemisphere-selective attentional tasks (Posner et al., 1988). Lateralization of attentional systems is problematic given the role of the right hemisphere in overall control of attention (Heilman and Van Den Abell, 1979; Weintraub and Mesulam, 1987; Bench et al., 1993). Overall, the results add to the impression that attentional processes are not unitary, and the specific disruption of facilitation within the left hemisphere points to disintegration of these processes in schizophrenia (see also David, 1993b).

5. Conclusions

1. Schizophrenics had greater overall RTs compared with controls on the divided-field Stroop test.

2. An aim of the study was to replicate the findings of David (1993a), in which schizophrenic subjects demonstrated a greater Combined Stroop Effect (CSE) (the difference in RT for incongruent and congruent stimuli) in the central (bilateral) stimulus presentation position compared with the unilateral presentation position. This had been interpreted by David (1993a) as evidence of abnormal callosal function in schizophrenia. The current study incorporated two further bilateral stimulus presentation positions (‘up’ and ‘down’), controlling for the bilateral field advantage noted in controls for central compared with unilateral stimulus presentations.

The results of the current study did not demonstrate any significant effect of stimulus presentation position (bilateral vs. unilateral) on CSE in either the schizophrenic or control group. With the two bilateral control conditions excluded, the bilateral (central) CSE was significantly greater than the unilateral CSE in both subject groups, concurring with the results of David (1993a) for the schizophrenic but not the control group. The discrepancy in the results of the two studies may have been related to the effect the inclusion of the two additional bilateral stimulus presentation positions had on attentional processes.

3. The current study was able to distinguish interference and facilitation in the unilateral and bilateral presentation positions. No significant difference in interference compared with facilitation was found in the schizophrenic subjects for bilaterally- or unilaterally-presented stimuli. In the control subjects, however, interference was found to be significantly greater than facilitation for both bilaterally-and unilaterally-presented stimuli. Compared with the control group, the schizophrenic subjects had a significantly smaller interference effect for bilaterally-presented stimuli. The results therefore indicated reduced trans-callosal interference in the schizophrenic group, and are thus consistent with other studies suggesting abnormal callosal function in schizophrenia.

4. The current study also provided evidence for abnormal left hemisphere function in schizophrenia, with the results demonstrating a smaller CSE on right half-field (left hemisphere) presentation compared with that for the left half-field (right hemisphere) in the schizophrenic group. The facili-
tation effect for the right-field/left hemisphere presentation was significantly smaller than that for left-field/right hemisphere presentation. This was interpreted as indicating impaired attentional processes in the left hemisphere in such subjects.

5. A final aim of the study was to examine the effect of illness subtype and stage on performance in the divided visual field version of the Stroop test, suggested by an earlier study of Carter et al. (1993). The results of the current study did not demonstrate any significant effect of such variables on performance in the test, suggesting that the differences in performance of schizophrenic compared with control subjects reflected trait- rather than state-dependent factors, reflecting underlying abnormalities in brain function in schizophrenia.

Further work relating these cognition deficits to cerebral structure using MRI are underway.

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References


