Abnormal visual scan paths: a psychophysiological marker of delusions in schizophrenia

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Abstract
The role of the visual scan path as a psychophysiological marker of visual attention has been highlighted previously (Phillips and David, 1994). We investigated information processing in schizophrenic patients with severe delusions and again when the delusions were subsiding using visual scan path measurements. We aimed to demonstrate a specific deficit in processing human faces in deluded subjects by relating this to abnormal viewing strategies. Scan paths were measured in six deluded and five non-deluded schizophrenics (matched for medication and negative symptoms), and nine age-matched normal controls. Deluded subjects had abnormal scan paths in a recognition task, fixating non-feature areas significantly more than controls, but were equally accurate. Re-testing after improvement in delusional conviction revealed fewer group differences. The results suggest state-dependent abnormal information processing in schizophrenics when deluded, with reliance on less-salient visual information for decision-making. © 1998 Elsevier Science B.V.

Keywords: Visual scan paths; Persecutory; Delusions; Schizophrenia

1. Introduction

Delusions are a core feature of psychosis and are particularly evident in paranoid psychoses such as schizophrenia. One popular explanation of delusion formation is that they result from the rational interpretations of abnormal experiences (Maher, 1974). Evidence consistent with this theory has come from studies of deluded subjects with perceptual deficits (Kay et al., 1976) and with facial processing deficits (Ellis and Young, 1990). Other studies have emphasized abnormalities in attention or information processing in subjects with persecutory delusions, who selectively attend to threatening events (Kaney et al., 1992; Ullman and Krasner, 1969). An alternative theory has emphasized the role of abnormal reasoning (Hemsley and Garety, 1986; Garety et al., 1991; Garety and Hemsley, 1994), with studies demonstrating that deluded subjects require less information before reaching a decision compared with non-deluded subjects, i.e. they have a tendency to 'jump to conclusions'.

These purely cognitive approaches to uncovering the basis of delusions suffer since they cannot easily provide a means of measuring information processing in deluded subjects in real time. The
measurement of visual scan paths is one method that, potentially, enables this to occur.

1.1. Visual scan paths: parameters

The visual scan path is a map that traces the direction and extent of gaze when an individual comprehends a complex scene (Noton and Stark, 1971), i.e. a psycho-physiological ‘marker’ of sensory input and directional attention on viewing a stimulus. The measurements include fixations, defined as consecutive gaze positions within 1° of visual field for a duration of 200 ms or more, and voluntary saccades, i.e. voluntary eye movements in between fixations. Fixations represent ‘points of attention’ by a subject on viewing the stimulus. Studies have demonstrated, for example, that on viewing facial stimuli, normal subjects have a tendency to fixate features of the face (i.e. eyes, nose, mouth, ears; Walker-Smith et al., 1977; Mertens et al., 1993), with both the external features of the visual stimulus and the presence of internal schemata acting as influences on the visual scan path pattern (Rizzo et al., 1987).

1.2. Clinical studies

A small number of studies have investigated visual scan paths in schizophrenic patients [reviewed in Phillips and David (1994)]. Gaebel et al. (1987) demonstrated a relationship between symptomatology and viewing pattern, with schizophrenics with positive symptoms demonstrating increased scanning (i.e. reduced fixations), and schizophrenics with negative symptoms demonstrating increased staring (i.e. increased duration of fixation). A second study (Gordon et al., 1992) demonstrated that schizophrenics, on viewing a facial stimulus, attend less, initially, to facial features compared with normal controls. A later study indicated that schizophrenics have a less efficient viewing strategy compared with normal controls on viewing picture completion figures (Kurachi et al., 1994). Visual scan path patterns therefore appear to be related to symptomatology, and schizophrenic patients as a group may use less efficient viewing strategies than normal controls.

The current study investigated the cognitive processes underlying delusions in schizophrenia (David, 1993) using visual scan path measurements as a means of tracking information processing in deluded patients (Phillips and David, 1997). The content of delusions often revolves around a person’s relationship to others and role in society rather than neutral or impersonal themes (Brennan and Hemsley, 1984; Bentall et al., 1991). It is therefore important to utilize socially-relevant stimuli when investigating delusion formation. Human faces are ideal stimuli in that they convey a wealth of socially-relevant information, such as age, gender, identity and expression (Ellis and Young, 1988). Stimuli from the Recognition Memory Test (Warrington, 1984) are useful in that they can be employed in free-viewing (single faces) and task-dependent (face pairs in the forced-choice recognition task) conditions. In addition, if only a small number of stimuli are used (e.g. eight out of the maximum number of fifty stimuli), then the recognition task is relatively straightforward. We would therefore expect all subjects to perform well on the recognition task, thereby minimizing any effect of task difficulty on visual scan path variables. We used these stimuli in order to test the hypotheses below.

Cognitive theories of delusion formation emphasize the tendency of paranoid patients to rely less on salient information prior to decision-making. We therefore predicted that patients with persecutory delusions (common in patients with paranoid schizophrenia) would view facial stimuli with reduced attention to discriminating feature areas compared with non-deluded schizophrenic and normal control subjects. Specifically, we predicted that deluded schizophrenics would look more at irrelevant features of the face compared with non-deluded subjects and normal controls both in free vision and during a specified task such as recognition. It was further hypothesized that this abnormality would become less marked on resolution of delusions at a later testing session after controlling for the effects of practice.

2. Method

2.1. Subjects

Patients with a diagnosis of schizophrenia (DSM-III-R criteria, American Psychiatric
Association, 1987) were recruited from the inpatient and outpatient populations of the Maudsley and Bethlem Royal Hospitals, London. Six deluded schizophrenics [scoring 3 or more on the delusion section of the Scale for the Assessment of Positive Symptoms (SAPS; Andreasen, 1983)], including four inpatients and two outpatients, and five minimally-deluded schizophrenics (<3 on SAPS), including three inpatients and two outpatients, were tested and rated by the same experimenter in order to avoid problems with inter-rater reliability. The latter group acted as patient controls. In addition, nine age-matched normal controls were recruited from local job centres. The delusions were mainly persecutory in nature, and included the following themes: being monitored by electronic devices under the control of the government; being terrorized and controlled by evil spirits; being the victim of a plot to take away your children; believing other people are constantly talking about you; being the victim of a mafia and government plot involving satellites; and having references made about you frequently on television.

All subjects had Snellen visual acuity within the normal range. In order to exclude those with marked cognitive deficits and poor visuospatial ability, subjects performed the Mini-mental state examination (MMSE; Folstein et al., 1975), National Adult Reading Test (NART; Nelson and O'Connell, 1978), which provides an estimate of premorbid IQ, and Visual Object and Space Perception battery (VOSP; Warrington and James, 1991). Schizophrenic subjects were assessed with the Scale for the Assessment of Negative Symptoms (SANS; Andreasen, 1982). Scores for auditory hallucinations and formal thought disorder for the patients were obtained from the SAPS. In addition, current medication, number of admissions and duration of illness were noted.

There was no significant difference among the three subject groups on score for both space and object perception (VOSP). There were small, non-significant changes in the SANS score for both patient groups (0.5 and -0.2, respectively). There were no significant changes over the two testing sessions in dose of neuroleptic medication for both patient groups (patient details are shown in Table 1).

2.2. Apparatus

The apparatus employed a pupil-centred technique (AMTECH, Germany). This enabled accurate measurement of eye position in time and space (resolution less than 1°). Subjects sat 1.5 m away from the screen on to which the stimuli were projected as slides by means of a S-AV 2050 Kodak slide projector. At head shifts of more than 1 mm in horizontal and vertical directions, recordings are often lost (see Phillips and David, 1997). Subjects therefore sat with the chin on a chin rest and the forehead against a bar designed to allow minimal movement of the head in the horizontal and vertical planes. The head was further secured by means of a strap fastened from behind. Each slide subtended 38° horizontally and 26° vertically.
Table 1
Subject details

<table>
<thead>
<tr>
<th></th>
<th>Normal subjects</th>
<th>Non-deluded patients</th>
<th>Deluded patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>9</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>Gender (male:female)</td>
<td>6:3</td>
<td>5:0</td>
<td>4:2</td>
</tr>
<tr>
<td>Age (years)</td>
<td>27.4 (1.3)</td>
<td>36.4 (4.4)</td>
<td>32.8 (4.8)</td>
</tr>
<tr>
<td>NART IQ</td>
<td>116.0 (2.2)</td>
<td>114.3 (5.2)</td>
<td>104.0 (5.1)</td>
</tr>
<tr>
<td>Illness duration (years)</td>
<td>--</td>
<td>5.4 (2.4)</td>
<td>9.7 (2.1)</td>
</tr>
<tr>
<td>Time interval between two sessions (days)</td>
<td>44.4 (4.0)</td>
<td>36.8 (7.3)</td>
<td>44.7 (6.1)</td>
</tr>
<tr>
<td>Neuroleptic medication*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Session 1</td>
<td>--</td>
<td>525 (143)</td>
<td>670 (189)</td>
</tr>
<tr>
<td>Session 2</td>
<td>--</td>
<td>440 (204)</td>
<td>650 (165)</td>
</tr>
<tr>
<td>SANS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Session 1</td>
<td>--</td>
<td>5.4 (2.6)</td>
<td>7.3 (2.3)</td>
</tr>
<tr>
<td>Session 2</td>
<td>--</td>
<td>5.6 (3.1)</td>
<td>6.8 (2.1)</td>
</tr>
<tr>
<td>SAPSdel</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Session 1</td>
<td>--</td>
<td>1.6 (0.4)</td>
<td>3.7 (0.2)</td>
</tr>
<tr>
<td>Session 2</td>
<td>--</td>
<td>0.8 (0.5)</td>
<td>1.5 (0.5)</td>
</tr>
<tr>
<td>SAPSoth</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Session 1</td>
<td>--</td>
<td>1.2 (1.0)</td>
<td>4.2 (0.8)</td>
</tr>
<tr>
<td>Session 2</td>
<td>--</td>
<td>0.6 (0.6)</td>
<td>1.5 (0.4)</td>
</tr>
</tbody>
</table>

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

*In daily chlorpromazine equivalent dosage (mg). There was no significant effect of gender on any of the visual scan path variables in each of the three subject groups.

2.3. Procedure

In order to calibrate eye position in space with computer measurement, each subject viewed a 4 × 2 calibration grid, fixating each point on the grid in turn. This was followed by measurement of scan paths for viewing the eight single faces and eight face pairs at each testing session. Each stimulus was presented for 5 s, with the eight face pairs being presented after the eight single faces. Measurements were stored on a personal computer and analysed with software designed by the manufacturer (AMTECH, Germany).

Facial stimuli comprised eight photographs of single faces, followed by eight photographs of face pairs, one of which had been previously-viewed (Warrington, 1984). Whilst viewing the single faces and before viewing the face pairs, subjects were not informed of the forthcoming recognition task, but were asked merely to make a decision (verbally) as to whether they liked or disliked the face being viewed. Whilst viewing the face pairs, subjects were asked to make a choice verbally (‘right’ or ‘left’) as to the previously-viewed or familiar face of each pair. In order to avoid excessive head movements during recording of eye movements, subjects were requested not to talk until after the presentation of each stimulus.

2.4. Data analysis

Scan paths were analysed for each subject for the viewing of each facial stimulus at both testing sessions. Data losses due to blinking by subjects were excluded from the analysis. Data were analysed by multivariate analyses of variance (MANOVA) with diagnosis (three levels) as the between-subject variable and testing session (two levels) as the within-subject variable. Further analyses were performed using univariate analyses of variance (ANOVA) as appropriate. Dependent variables for each subject at each testing session included the following:

Temporal analysis of visual scan paths: mean duration of fixation and mean number of fixations for single faces (eight stimuli per subject) and face pairs (eight stimuli per subjects);
Spatiotemporal analysis for single faces, involv-
ing recording of actual sites fixated by each subject for each stimulus (eight single faces per subjects): mean percentage total fixation time spent viewing facial features (eyes, nose, mouth, ears); mean percentage fixation time viewing other, non-feature areas of the person (other facial areas, neck and shoulders); and mean percentage fixation time viewing background areas outside the person (outside areas).

Spatiotemporal analysis for face pairs: mean percentage fixation times viewing the familiar and unfamiliar faces of each face pair; mean percentage fixation times spent viewing features, other and outside areas of both familiar and unfamiliar faces; the mean number of movements between the two faces in the 5-s viewing period.

3. Results

There was no difference in facial recognition scores among the three subject groups for either testing session: nearly all subjects correctly identified the previously-viewed face in each of the eight face pairs on both occasions. The effect of gender did not approach significance on any of the visual scan path variables for any of the subject groups.

3.1. Temporal analysis of scan paths

The mean values of the temporal analysis dependent variables for subjects at both testing sessions are shown in Table 2. There was no significant effect of diagnosis, testing session or the interaction of the two on the mean duration of fixation for viewing single faces. For viewing face pairs, although there was no significant effect of either diagnosis or testing session on the mean duration of fixation, there was a significant interaction of the two effects \( F(2,17) = 4.92; p = 0.02 \). The deluded patients had significantly longer fixation durations for viewing face pairs compared with the other two groups in the first testing session \( F(2,17) = 4.05; p = 0.04 \). There was no significant difference in mean fixation duration for face pairs amongst the groups on improvement of delusion score at the second testing session. The mean fixation duration for viewing face pairs in the first testing session did not covary significantly with any of the following variables: age, NART score, duration of illness, SANS score, SAPSoth score or neuroleptic medication dose.

There was no significant effect of diagnosis or session on number of fixations for viewing single faces and face pairs, although there was a trend for the deluded patients to have fewer fixations compared with the other two groups overall.

3.2. Spatiotemporal analysis of scan paths

3.2.1. Single faces

There was a highly-significant difference in time spent fixating the three different face areas (feature, other areas and outside), with all subjects spending more time viewing outside areas \( F(2,17) = 12.22; p < 0.001 \). At the first testing session, there was a significant effect of diagnosis on percentage fixation time for viewing outside areas \( F(2,17) = 3.28; p = 0.06 \), with deluded patients viewing outside areas to a significantly greater extent than the other two subject groups. The factors: age, NART score, SANS score, SAPSoth score, neuroleptic medication dose and duration of illness did not covary significantly with this dependent variable.

At the second testing session, there was no significant difference amongst the three groups for percentage fixation duration time for any of the three face areas (Fig. 1).

There was a possibility that deluded subjects had normal viewing patterns in the initial stage of viewing the stimulus (i.e. first 3 s) but that this was not maintained over the total 5-s viewing period. In order to investigate this, MANOVA was performed with percentage fixation time for facial features in the first 3 s of viewing and that over the total 5-s duration as within-subject variables for testing sessions one and two. There was no significant effect of diagnosis, time period or session on percentage fixation time for features, suggesting that the viewing pattern of deluded subjects was relatively consistent throughout the 5-s viewing period at both testing sessions.
Table 2
Temporal variables

<table>
<thead>
<tr>
<th></th>
<th>Normal controls</th>
<th>Non-deluded patients</th>
<th>Deluded patients</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Single faces</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean fixation duration (ms)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Session 1</td>
<td>423 (66)</td>
<td>386 (31)</td>
<td>508 (68)</td>
</tr>
<tr>
<td>Session 2</td>
<td>541 (112)</td>
<td>446 (44)</td>
<td>722 (266)</td>
</tr>
<tr>
<td>Mean number of fixations</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Session 1</td>
<td>6.9 (0.6)</td>
<td>5.9 (0.8)</td>
<td>6.0 (0.5)</td>
</tr>
<tr>
<td>Session 2</td>
<td>7.1 (0.8)</td>
<td>6.6 (0.4)</td>
<td>5.0 (0.9)</td>
</tr>
<tr>
<td><strong>Face pairs</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean fixation duration (ms)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Session 1</td>
<td>362 (37)</td>
<td>356 (27)</td>
<td>518 (60)</td>
</tr>
<tr>
<td>Session 2</td>
<td>419 (19.7)</td>
<td>418 (27)</td>
<td>405 (32)</td>
</tr>
<tr>
<td>Mean number of fixations</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Session 1</td>
<td>5.9 (0.8)</td>
<td>5.9 (1.3)</td>
<td>4.7 (0.4)</td>
</tr>
<tr>
<td>Session 2</td>
<td>7.0 (0.3)</td>
<td>6.3 (0.8)</td>
<td>5.7 (0.7)</td>
</tr>
</tbody>
</table>

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

*MANOVA $p < 0.05$ for diagnosis $\times$ testing session.

Fig. 1. Percentage fixation duration viewing different stimulus areas: single faces. There was a highly-significant difference in time spent fixating the three different face areas (feature, non-feature and outside), with all subjects spending more time viewing outside areas [$F(2,17) = 12.22; p < 0.001$]. At the first testing session, there was a significant effect of diagnosis on percentage fixation time for viewing outside areas [$F(2,17) = 3.28; p = 0.06$], with deluded patients viewing outside areas to a significantly greater extent than the other two subject groups. At the second testing session, there was no significant difference amongst the three groups for percentage fixation duration time for any of the three face areas.
3.2.2. Face pairs

There was no significant difference in the percentage of total fixation time spent viewing the familiar as opposed to unfamiliar face in the three subject groups overall, and there were no additional effects of diagnosis or testing session on this pattern (Table 3). None of the possible interactions of effects was significant.

All subjects spent a significantly greater proportion of fixation time viewing outside areas of both familiar and unfamiliar faces \( F(2,17) = 50.63; p < 0.001 \). There was a significant interaction of diagnosis with this effect (feature) \( F(4,15) = 3.06; p = 0.03 \). Further analysis revealed that this result was due to the significant effect of diagnosis on percentage fixation time for viewing features and outside areas of familiar faces at the first testing session \( F(2,17) = 5.49; p = 0.01 \) and \( F(2,17) = 5.2; p = 0.02 \), respectively, and percentage fixation time viewing outside areas of unfamiliar faces at the first testing session \( F(2,17) = 4.08; p = 0.02 \), with both deluded and non-deluded patients spending a greater proportion of fixation time viewing outside areas and less time viewing feature areas for both familiar and unfamiliar faces compared with normal controls. The results for the effect of diagnosis on percentage fixation time for viewing feature and outside areas of familiar faces remained significant after covarying for the factors: age, NART score, neuroleptic medication, SANS score and SAPSoth score \( F(2,11) = 4.3; p = 0.05 \) and \( F(2,11) = 5.5; p = 0.02 \), respectively, but not that for the effect of diagnosis on percentage fixation time for viewing outside areas of unfamiliar faces. There were no significant differences in percentage fixation duration for any of these variables at the second testing session (Fig. 2a, b).

There was no significant difference in the number of switches made between the two faces over the 5-s viewing period in the three subject groups overall and at either of the two testing sessions.

4. Discussion

The study investigated the cognitive impairments underlying delusions in schizophrenia using an on-line marker of visual information processing, the visual scan path. An aim was to demonstrate the presence in deluded schizophrenics of abnormal viewing strategies for meaningful stimuli, presumed to reflect underlying information processing abnormalities. It was further hypothesized that such processing abnormalities would be less apparent as delusions resolved.

The major results of the study were as follows:

1. Deluded schizophrenics demonstrated a tendency to stare at all stimuli compared with both control groups, having longer and fewer fixations. This finding was contrary to previous work (Gaebel et al., 1987) in which positive symptoms have been associated with scanning rather than staring viewing strategies.

2. On viewing single faces, deluded schizop-
Fig. 2. Percentage fixation duration viewing different stimulus areas: face pairs. (a) Familiar face; (b) unfamiliar face. All subjects fixated outside areas of both familiar and unfamiliar faces to a significantly greater extent than other areas \( F(2,17) = 50.63; p < 0.001 \). Both patient groups spent a greater proportion of fixation time viewing outside areas and less time viewing feature areas for both familiar and unfamiliar faces compared with normal controls \( F(4,15) = 3.06; p = 0.03 \). Further analysis revealed that this result was due to the significant effect of diagnosis on percentage fixation time for viewing features and outside areas of familiar faces at the
Phrenics fixated facial features less and areas outside the face and body more than controls.

(3) In the facial recognition test, deluded schizophrenics spent a greater proportion of time viewing non-feature and non-body areas of both familiar and unfamiliar faces compared with control groups, yet were no less accurate in the recognition task itself.

(4) At a second testing session with the deluded patients significantly improved, viewing strategies were less abnormal: feature areas in all stimuli were fixated to a greater extent than for the first testing session.

One interpretation of the results is that the resolution of the abnormal viewing strategy with improvement in delusion ratings in the deluded patients provides evidence for state-dependent information processing abnormalities. The effect of diagnosis on visual scan path variables in the first testing session remained significant after covarying for the factors: age, NART score, SAPSoth score, SANS score, neuroleptic medication dose and duration of illness. In addition, there were no significant differences in medication or negative symptom ratings in the deluded patients at the second testing session. The alteration in viewing strategy at the second testing session demonstrated by deluded patients is, therefore, unlikely to have been the result of the effect of these factors at either testing session. In addition, the non-deluded patients, in whom symptomatology ratings and medication were similar at both testing sessions, did not demonstrate altered viewing patterns.

The nature of the abnormality in viewing strategy is interesting in that deluded patients attended less to facial features but made similar (correct) decisions to those of non-deluded and normal control subjects in the facial recognition task. An important question is how such an abnormal viewing pattern relates to delusion formation. One interpretation is that deluded patients have abnormal reasoning (Garety et al., 1991), or 'jump to conclusions', relying on less salient stimulus information for decision-making. Another is that the deluded patients, in view of the persecutory content of their delusions, may have merely avoided gazing at facial features. This would still suggest that they have abnormal viewing strategies, reflecting an underlying tendency to form decisions on the basis of less information than control groups.

It could be argued that since the recognition task was particularly easy, it was possible to identify the familiar face even when employing such 'abnormal' viewing strategies. Indeed, even in the normal control subjects, a large percentage of fixation time was spent viewing the outside areas of the stimuli—an indication of the low level of attention to detail required to correctly identify the familiar face in this study. In future research, we will utilize more complex stimuli, such as social scenes, in order to increase task difficulty and the probability of erroneous conclusion formation.

It is clearly difficult to determine whether visual scan paths are causal or maintaining with respect to delusions. The study has, however, demonstrated that the extent of the abnormality decreases with resolution of delusions, indicating its state-dependence, and perhaps, therefore, a delusion-maintaining role. An ideal, but practically difficult, way to clarify this would be to test patients immediately prior to delusion formation, in a state of delusional mood, in order to determine whether the abnormality in viewing strategy and information processing was a necessary prerequisite for delusion formation.

It should be noted that matching patients on all symptoms except delusions proved impossible, so that there remains a possibility that other symptoms, such as auditory hallucinations, may contribute to, or may be affected by, aberrant scan patterns. It is also noteworthy that the non-deluded patients demonstrated more of an abnormal view-

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first testing session \[F(2,17) = 5.49; p = 0.01; \text{and} \ F(2,17) = 5.2; p = 0.02, \text{respectively}\], and percentage fixation time viewing outside areas of unfamiliar faces at the first testing session \[F(2,17) = 4.08; p = 0.02\]. The results for the effect of diagnosis on percentage fixation time for viewing feature and outside areas of familiar faces remained significant after covarying for the factors: age, NART score, neuroleptic medication, SANS score and SAPSoth score \[F(2,11) = 4.3; p = 0.05; \text{and} \ F(2,11) = 5.5; p = 0.02, \text{respectively}\], but not that for the effect of diagnosis on percentage fixation time for viewing outside areas of unfamiliar faces. There were no significant differences in percentage fixation duration for any of these variables at the second testing session.
ing strategy when viewing face pairs compared with single faces, with this apparent at both testing sessions. This could be interpreted as reflecting an additional underlying information processing abnormality in schizophrenia per se, apparent in decision-making (face-recognition task), rather than in free-viewing (single faces) paradigms.

A neuropsychological interpretation of the results might implicate frontal lobe pathology, in view of the role of the frontal cortex in the control of voluntary eye movements (Crowne, 1983). Evidence for frontal dysfunction as a basis for symptomatology in schizophrenia has come from neuropsychological, neurochemical and functional imaging studies [see Robbins (1990) for a review], and similarities between exploratory eye movements in schizophrenic patients and patients with frontal lobe lesions were found in an earlier study (Matsushima et al., 1992). In the current study, however, differences in visual scan path parameters have been demonstrated between deluded and non-deluded schizophrenics and also over time in the deluded group, with the non-deluded patients’ performance not showing any consistent pattern to lean towards their delusional counterparts. It is therefore unlikely that the visual scan path abnormalities identified here can be explained on the basis of structural frontal lobe impairment alone.

In summary, the current study has highlighted the role of the visual scan path as a monitor of visual attention and information processing in normal control subjects and in schizophrenic patients with and without delusions. Further work on larger samples of patients with delusions including those with non-schizophrenic illnesses is indicated.

Acknowledgment

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