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# Perception of threat in schizophrenics with persecutory delusions: an investigation using visual scan paths

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## ABSTRACT

**Background.** Cognitive theories of persecutory delusions in schizophrenia include increased attention to threat and reduced re-appraisal of information during decision-making.

**Methods.** We employed visual scan path measurements, an 'on-line' marker of attention, in schizophrenic patients with persecutory delusions ($N = 19$), negative symptom- and medication-matched patients with non-persecutory delusions ($N = 8$), and normal controls ($N = 18$). Stimuli comprised black-and-white photographs of social scenes rated as depicting either neutral, ambiguous or overtly threatening activity. Foreground areas containing salient information with regard to the overall scene were rated independently as either threatening or non-threatening in both the overtly threatening and ambiguous scenes; all foreground areas were rated as non-threatening in the neutral scene.

**Results.** For the ambiguous scene only, schizophrenics with persecutory delusions directed gaze to less threatening areas, and, for all three scenes, demonstrated reduced re-appraisal of information compared with both control groups. All subjects showed similar viewing strategies for the overtly threatening and neutral scenes.

**Conclusions.** These findings suggest abnormal information gathering and evaluation in schizophrenics, specifically related to the presence of persecutory delusions. In particular, the results point to biased processing of contextual information in an ambiguous setting in these patients, and perhaps perception of threat in inappropriate places.

## INTRODUCTION

Paranoia, or feelings of persecution, would appear to entail increased attention to threat, i.e. a sense of being under threat, with the subject ever-vigilant for the source of such threat. In evolutionary terms, such vigilance may be advantageous. Schizophrenic patients with persecutory delusions appear to experience this state in inappropriate or ambiguous contexts, believing there to be threat without supporting evidence. It has been hypothesized in cognitive terms that patients with persecutory delusions demonstrate heightened attention to threatening stimuli (Ullman & Krasner, 1969). Experimental evidence for this includes the significantly longer time paranoid patients require to name the print colours of threatening compared with depressive and neutral words in an emotional Stroop test (Bentall & Kaney, 1989), and their demonstrating preferential recall of threat-related propositions in a story recall task (Kaney *et al.* 1992).

Frith (1992) has linked persecutory delusions and delusions of reference (paranoid delusions) with the inability to monitor the beliefs and intentions of others, a disorder of meta-representation. Corcoran *et al.* (1995, 1997) have

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demonstrated that patients with paranoid delusions perform poorly only with visual jokes requiring understanding of the mental states of others, and not with those that could be understood on the basis of physical and semantic analysis. Thus, an important factor underlying persecutory delusion formation is the processing of socially-salient, often ambiguous, information.

A further consideration has been the presence of abnormal or biased reasoning in schizophrenic patients with persecutory delusions. It has been demonstrated, for example, that paranoid patients show differences in hypothesis-testing, requiring less information before reaching a conclusion than non-deluded controls (Huq *et al*. 1988; Garety *et al*. 1991; Dudley *et al*. 1997), and being more inclined to stick to hypotheses in the presence of negative feedback (Young & Bentall, 1995). Other investigators have proposed that schizophrenic patients with persecutory delusions have abnormal attributional processes, making external attributions for negative events and internal attributions for positive events (Kaney & Bentall, 1989).

The research to date has, therefore, demonstrated the presence of two types of cognitive dysfunction in schizophrenic patients with persecutory delusions: (1) increased attention to threatening stimuli in general, and an inability to monitor the intentions of others; and (2) abnormal reasoning, such that decisions are made on the basis of less information with a tendency to make external attributions for negative events. It is as yet unclear as to the relative importance of these as cognitive dysfunctions underlying persecutory delusion formation and maintenance. One approach is to employ an 'on-line' marker of directed attention in patients with persecutory delusions. This approach would reveal abnormal strategies, such as increased attention to threat in various contexts. The measurement of visual scan paths is one such method.

The visual scan path is a map that traces the direction and extent of gaze when an individual comprehends a complex scene (Noton & Stark, 1971), and comprises: (1) fixations – consecutive gaze positions within a predetermined window, such as 1° of visual field, for a duration of 200 ms or more (Gaebal *et al*. 1987; Gordon *et al*. 1992); and (2) voluntary saccades – voluntary eye movements in between fixations. Fixations therefore represent 'points of attention' on viewing the stimulus.

Several studies employing tachistoscopic presentation of stimuli (e.g. Magaro & Chamrad, 1983*a*, *b*; David, 1993) have demonstrated that perception of visual stimuli can occur with presentation of visual stimuli for durations $< 200$ ms, the minimum duration of a fixation. Thus, rather than measuring the initial stages of input of sensory information, the visual scan path is a useful marker of later stages of visual information processing, as the observer appraises and re-appraises components of the visual stimulus.

Measurements of visual scan paths is possible in psychiatric patients using a pupil-centred infrared technique (Phillips & David, 1997*a*). Studies investigating visual scan paths in schizophrenic patients have demonstrated that negative symptoms, such as reduced motivation and social withdrawal, are associated with increased staring, while positive symptoms, including delusions and hallucinations, tend to be associated with increased scanning (e.g. Gaebel *et al*. 1987; Gordon *et al*. 1992; Kurachi *et al*. 1994; Streit *et al*. 1997). We have shown previously that deluded schizophrenic patients have abnormal viewing strategies for human facial stimuli, fixating facial features less and non-salient background areas more than control groups (Phillips & David, 1977*a*, *b*). Their facial recognition accuracy was unimpaired despite the abnormal viewing strategies, suggesting that such patients make decisions on the basis of less salient visual information (Garety *et al*. 1991).

No study to our knowledge, however, has investigated the specific effect of persecutory delusions on viewing strategies by comparing visual scan paths of schizophrenic patients with these delusions and those of patients with other, non-persecutory delusions. The inclusion of the latter patient group would control for the effects of schizophrenia and presence of delusions and other positive symptoms *per se* and the influence of neuroleptic medication on visual scan paths. The two patient groups would therefore be distinguished on the basis of the theme of the delusion only.

The aim of this study was to examine viewing strategies of schizophrenic patients with persecutory delusions (compared with normal sub-

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jects and schizophrenic patients with other, non-persecutory delusions) specifically during the viewing of a complex social scene depicting ambiguous or potentially threatening social activity. We hypothesized the following.

1 Schizophrenic patients with persecutory delusions would demonstrate increased attention to potentially threatening aspects of this scene compared with control groups. There would be no difference in viewing strategies for both an overtly threatening scene, with all subjects attending preferentially to threatening areas, and for a non-threatening (neutral) scene, with all subjects demonstrating similar viewing strategies, attending equally to foreground areas.

2 For all pictures, schizophrenics with persecutory delusions would demonstrate reduced evaluation of information, and would therefore return to view each foreground area of each picture less often, and would view fewer foreground areas overall compared with control groups.

3 If subjects were asked to view scenes on a second occasion and look specifically at threatening aspects of each scene, then normal subjects and schizophrenics with non-persecutory delusions would appear to adopt a 'paranoid' viewing strategy: they would view threatening foreground areas of threatening and, particularly, ambiguous scenes more than for the first, 'free-viewing' viewing sessions. Since schizophrenics with persecutory delusions would have viewed such areas excessively during the first viewing session, it was hypothesized that there would be no additional change in their viewing strategies on this second occasion.

## METHOD

### Subjects

Patients with a diagnosis of schizophrenia (DSM-IV criteria: APA, 1994) made after a detailed clinical interview by an experienced psychiatrist (Department of Psychiatry, Institute of Psychiatry, London, 1997) were recruited from the in-patient and out-patient populations of the Maudsley and Bethlem Royal Hospitals. Nineteen schizophrenic patients with persecutory delusions (scoring $\geqslant 3$ on the delusion section of the Scale for the Assessment of Positive Symptoms, Andreasen, 1984, i.e. moderate to severe extent of belief conviction) and a smaller comparison group of eight schizophrenic patients with other, non-persecutory delusions, and no history of persecutory delusions or persecutory hallucinations, were tested. A second rater, blind to the diagnosis of each schizophrenic patient, gave an independent judgement regarding the nature of the delusions (persecutory or non-persecutory) in each patient after examination of a detailed description of the clinical history and current mental state. These ratings were in agreement with those of the original clinical interview in all cases. Eighteen age-matched normal controls were recruited from local job centres. All subjects gave informed consent and received a small payment for participation in the study. Schizophrenic patients with persecutory delusions held beliefs that others, either a political group or individuals, were talking maliciously about them, controlling their thoughts, feelings and actions, or keeping watch on them. The beliefs of the non-persecutory-deluded patients were either bizarre in content (e.g. that various spirits lived inside their head, but were not malicious), nihilistic (e.g. that they were dead and could no longer feel emotions), or grandiose (e.g. that the Holy Trinity had a unique relationship with them).

All subjects had normal Snellen visual acuity. In order to exclude those with marked cognitive deficits and poor visuospatial ability, subjects performed the Mini-Mental State Examination (Folstein *et al.* 1975: cut-off score 23/30), National Adult Reading Test (Nelson & O'Connell, 1978: cut-off pre-morbid IQ score 80), and Visual Object and Space Perception battery (Warrington & James, 1991: cut-off score: 2/4 in each set of four tests of visual object and visuospatial perception). In addition, schizophrenic subjects were tested with the Scale for the Assessment of Negative Symptoms (Andreasen, 1983). Scores for auditory hallucinations and formal thought disorder were obtained from the appropriate sections of the SAPS. Current medication, number of admissions and duration of illness were noted. (Subject details are shown in Table 1.)

### Stimuli

Black-and-white photographs collected from magazines and depicting complex social scenes displaying either threatening, ambiguous or

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Table 1. *Subject details*

| | Normal controls | Schizophrenics with persecutory delusions | Schizophrenics with non-persecutory delusions |
|---|---|---|---|
| *N* | 18 | 19 | 8 |
| Age | 36 (±2·3) | 35 (±2·6) | 35·5 (±2·4) |
| Sex ratio M:F | 12:6 | 16:3 | 7:1 |
| NART IQ | 116 (±1·9) | 107·5 (±2·4) | 108 (±3·8) |
| Admissions, *N* | — | 4·5 (±1·0) | 5·3 (±1·1) |
| Neuroleptic medication* | — | 750 (±137) | 450 (±110) |
| SANS | — | 7·3 (±1·1) | 8·0 (±2·0) |
| SAPSdel† | — | 4·1 (±0·2) | 3·8 (±0·3) |
| SAPSoth‡ | — | 2·3 (±0·5) | 1·9 (±0·7) |

* In chlorpromazine (mg) equivalents.
† Score for delusion subsection of SAPS.
‡ SAPS score minus delusion subsection score.
(See text for key to abbreviations.)
Figures are means. The numbers in parentheses refer to the standard error of the mean.

neutral activity were employed in the study. Permission to do this was obtained from the appropriate magazines. The three scenes chosen for the study were rated on a six-point scale by ten normal volunteers with respect to overall theme of activity, and represented the best exemplars of the three categories (very threatening, potentially threatening/ambiguous, and neutral). The scenes were also rated and matched for level of visual complexity on a similar six-point scale. (These scenes are available from the authors on request.)

The foreground areas (i.e. those areas containing the prominent activity and detail) of each scene were then sub-divided into eight to eleven rectangular areas; each area subtended a visual angle of at least 2°. Each individual foreground area was then rated by normal volunteers on a four-point scale for the extent of threat (none (0), uncertain (1), possible (2), probable (3)) in the context of the overall scene. For both the overtly threatening and ambiguous scenes, the three foreground areas rated as most threatening were defined as threatening areas, the one–two foreground areas rated as least threatening were defined as the non-threatening areas. For the neutral scene, all foreground areas were rated as non-threatening.

In order to obtain sufficiently detailed information regarding the nature of the visual scan paths employed by subjects when viewing these complex stimuli, measurements of 'clusters' of individual gaze positions were made. A cluster was defined as a total duration of 200 ms or more of consecutive individual gaze positions (each of 10 ms or more in duration) within a foreground area of each scene.

## Apparatus

The apparatus employed a pupil-centred technique (AMTECH, Germany), which enabled accurate measurement of eye position in time and space (resolution $< 1°$; sampling rate 200 Hz). Subjects sat with the chin on a chin rest and the forehead against a firm, rounded bar designed to allow minimal horizontal movement. In addition, the head was secured in position by means of a strap fastened behind the head. The apparatus is comfortable, while allowing accurate measurements of visual scan paths (Phillips & David, 1997*a*).

Subjects sat at a distance of approximately 50 cm from a computer screen on which the stimuli were presented. Each scene was presented over the entire screen, and subtended a visual angle of approximately 23° horizontally and 18° vertically.

## Procedure

In order to calibrate eye position in space with computer measurement, each subject viewed a 3 by 3 calibration grid, fixating each point on the grid in turn. This was followed by measurement of scan paths for viewing three scenes depicting either threatening, neutral or ambiguous activity. Each scene was presented for ten seconds. Subjects were requested merely to look at the scene during this first viewing session. All three

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scenes were then presented for a second time. Before this second viewing, all subjects were asked to look at those areas of each scene which showed threatening activity, either with respect to the viewer or to other people in the scene. Subjects were requested to try hard to find some aspect of the scene which displayed threatening activity. Measurements of visual scan paths were stored on a personal computer and analysed with software designed by the manufacturer. After viewing the scenes, subjects were debriefed; nearly all subjects agreed on the above categorization of each scene as either threatening, ambiguous or neutral.

### Analysis

Multivariate analyses of variance was performed, with diagnosis as the between-subject variable, and stimulus category (threatening, ambiguous or neutral), and viewing session as the within-subject variables. The following dependent variables were included.

1 Percentage total viewing time for each scene viewing all foreground areas (i.e. detail). The small differences in areas of all foreground and all non-foreground areas among the three scenes were controlled for with the use of appropriate scale factors.

2 Percentage total viewing time spent viewing off-screen.

3 The proportion of foreground area viewing time (corrected for differences in area of foreground areas in each scene) for threatening (proportion-threat) and non-threatening (proportion-non-threat) areas – in the ambiguous and threatening scenes.

4 A threat index, designed to reflect the relative proportions of viewing time for threatening and non-threatening foreground areas, calculated as: (proportion-threat minus proportion-non-threat)/(proportion-threat plus proportion-non-threat), again for both ambiguous and threatening scenes.

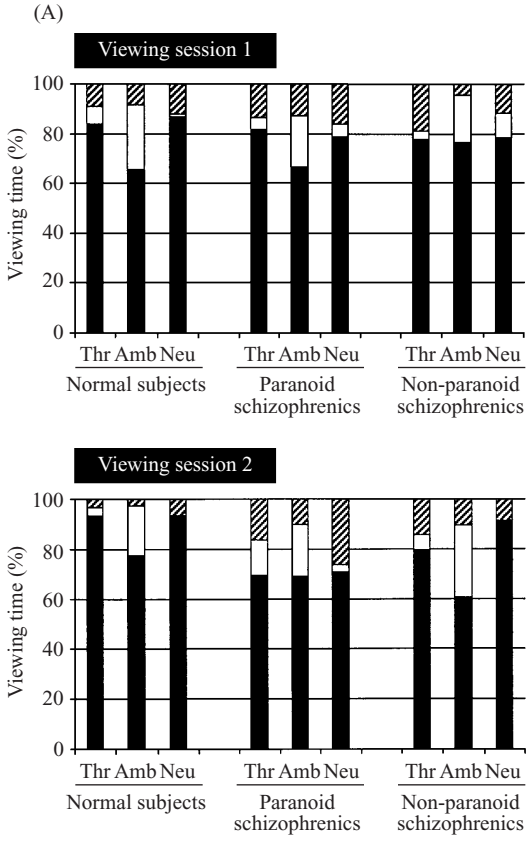
5 The total number of foreground areas viewed for each scene (as a proportion of the total number of such areas in each scene).

6 The 'repeatability' index for each foreground area viewed for each scene, i.e. the sum of the number of separate viewing occasions (separate clusters of points of gaze) for all areas divided by the total number of areas in the scene.

## RESULTS

There was no significant difference among the three subject groups on score for both space and object perception (VOSP). Normal controls had

(A)




(B) MANOVA results of the main effects

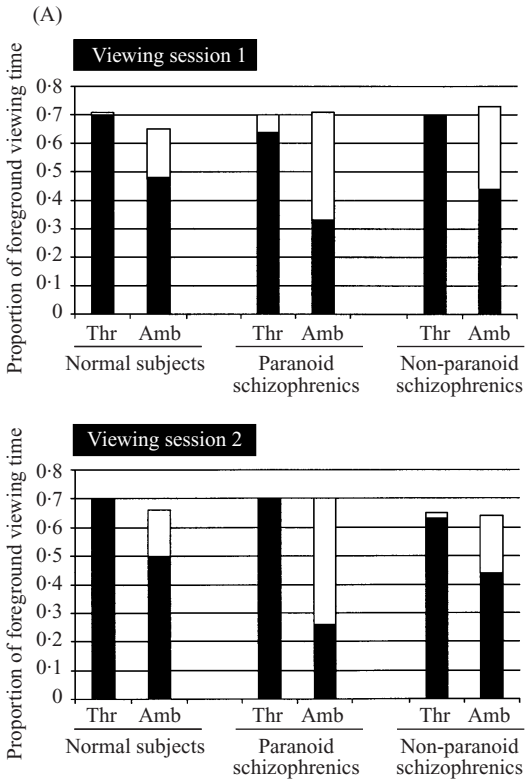
*Foreground areas*

| | *F* | *P* |
|---|---|---|
| Diagnosis | <1·0 | >0·1 |
| Scene | 11·22 | <0·001 |
| Session | <1·0 | >0·1 |
| Diagnosis × scene | <1·0 | >0·1 |
| Diagnosis × session | 2·65 | 0·09 |
| Session × scene | <1·0 | >0·1 |
| Diagnosis × scene × session | 3·54 | 0·01 |

*Non-foreground areas* – no significant effects.
*Off-screen areas* – no significant effects.

FIG. 1. (A) Percentage viewing time for foreground (■), non-foreground (□) and off-screen (▨) areas of the three scenes: overtly threatening (Thr); ambiguous (Amb) and neutral (Neu) during both viewing sessions. (B) MANOVA results for the main effects of diagnosis, scene, viewing session and interactions of these on the above.

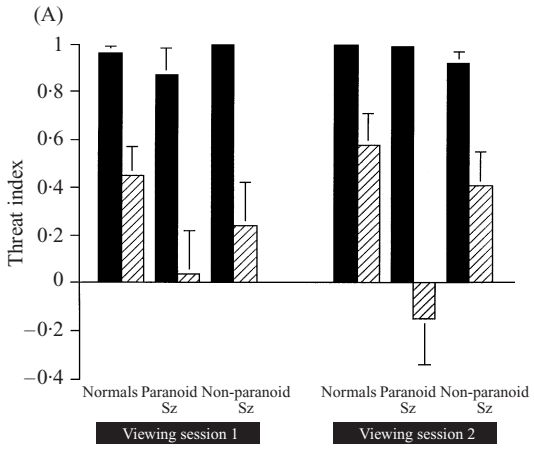
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(B) MANOVA results of the main effects

| | *F* | *P* |
|---|---|---|
| Diagnosis | 9·64 | <0·001 |
| Scene | 59·6 | <0·001 |
| Session | <1·0 | >0·1 |
| Diagnosis × scene | 4·73 | 0·02 |
| Diagnosis × session | <1·0 | >0·1 |
| Session × scene | <1·0 | >0·1 |
| Diagnosis × scene × session | <1·0 | >0·1 |

FIG. 2. (A) Proportion of the total viewing time for foreground areas of the overtly threatening (Thr) and ambiguous (Amb) scenes spent viewing threatening (threat, ■) and non-threatening (non-threat, □) areas. (B) MANOVA results for the main effects of diagnosis, scene, viewing session and interactions of these on the above.




(B) MANOVA results of the main effects

| | *F* | *P* |
|---|---|---|
| Diagnosis | 7·79 | 0·002 |
| Scene | 90·6 | <0·001 |
| Session | <1·0 | >0·1 |
| Diagnosis × scene | 7·23 | 0·002 |
| Diagnosis × session | <1·0 | >0·1 |
| Session × scene | <1·0 | >0·1 |
| Diagnosis × scene × session | <1·0 | >0·1 |

FIG. 3. (A) Threat indices for the overtly threatening (threat, ■) and ambiguous (▨) scenes for normal subjects, schizophrenics with persecutory delusions (Paranoid Sz) and schizophrenics with non-persecutory delusions (Non-paranoid Sz). The threat index was designed to reflect the relative proportions of viewing time for threatening and non-threatening foreground areas, and was calculated as: (proportion of viewing time for foreground areas for threatening areas − the proportion for non-threatening areas)/(proportion for threatening areas + proportion for non-threatening areas). (B) MANOVA results for the main effects of diagnosis, scene, viewing session and interactions of these on the above.

a near-significantly higher mean IQ compared with the two patient groups ($F(2, 21) = 3{\cdot}08$; $P = 0{\cdot}07$). There was no significant difference in IQ between the two patient groups. There were no significant differences between the two patient groups in SAPS delusion score (SAPSdel), total SAPS score minus the delusion score (SAPSoth), SANS score, duration of illness, number of admissions or daily neuroleptic dosage in chlorpromazine equivalents ($t < 2{\cdot}0$; $P > 0{\cdot}1$). All three groups had more male than female subjects.

### Hypothesis 1: The presence of abnormal viewing strategies by schizophrenics with persecutory delusions (compared with normal subjects and schizophrenics with non-persecutory delusions) specifically for viewing a complex social scene depicting ambiguous or potentially threatening activity

There was no overall effect of diagnosis on percentage of viewing time spent viewing foreground, non-foreground and off-screen areas of all three scenes: all subjects viewed foreground, non-foreground and off-screen areas to an equal extent, and most viewed foreground areas of the overtly threatening and neutral scenes to a

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Table 2. (A) *Repeatability indices for foreground areas for all three scenes*

| | Session 1 | | | Session 2 | | |
|---|---|---|---|---|---|---|
| | Thr* | Amb† | N‡ | Thr* | Amb† | N‡ |
| Normal controls | 1·01 (0·08) | 1·13 (0·10) | 1·13 (0·12) | 0·83 (0·07) | 1·16 (0·08) | 0·94 (0·1) |
| Sz with persecutory delusions | 0·95 (0·02) | 1·1 (0·13) | 0·48 (0·09) | 0·69 (0·10) | 1·08 (0·12) | 0·53 (0·09) |
| Sz with non-persecutory delusions | 0·84 (0·18) | 1·41 (0·15) | 0·98 (0·16) | 0·88 (0·2) | 1·06 (0·17) | 0·88 (0·15) |

* Overtly threatening scene.
† Ambiguous scene.
‡ Neutral scene.
Figures are means. Numbers in parentheses refer to the standard error of the mean.

Table 2. (B) *MANOVA results of the main effects of diagnosis, scene, viewing session and interactions of these on the above*

| | *F* | *P* |
|---|---|---|
| Diagnosis | 3·05 | 0·06 |
| Scene | 17·16 | < 0·001 |
| Session | 4·20 | 0·05 |
| Diagnosis × Scene | 2·69 | 0·04 |
| Diagnosis × Session | 4·67 | 0·002 |
| Session × Scene | < 1·0 | > 0·1 |
| Diagnosis × Scene × Session | 2·31 | 0·07 |

greater extent than the ambiguous scene ($F(2, 35) = 11{\cdot}22$; $P < 0{\cdot}001$) (Fig. 1). As predicted, there was a significantly different viewing strategy of the schizophrenics with persecutory delusions compared with the other two subject groups for the ambiguous scene, but not for the overtly threatening or neutral scenes. Overall, there was a significant effect of diagnosis on the relative percentages of viewing time for threatening *versus* non-threatening foreground areas for the overtly threatening and ambiguous scenes ($F(2, 34) = 9{\cdot}64$; $P < 0{\cdot}001$): schizophrenics with persecutory delusions viewed threatening foreground areas less, and non-threatening foreground areas more, than the other two subject groups. This was particularly evident for the ambiguous scene ($F(2, 33) = 4{\cdot}73$; $P = 0{\cdot}02$), but not for the overtly threatening scene (Fig. 2). All significant effects of diagnosis on viewing strategies remained significant after covarying for differences in NART IQ among subject groups.

There was a significant effect of diagnosis on the threat indices of both the overtly threatening and ambiguous scenes ($F(2, 34) = 7{\cdot}79$; $P = 0{\cdot}002$), and a further effect of scene on this ($F(2, 34) = 7{\cdot}23$; $P = 0{\cdot}002$), with schizophrenics with persecutory delusions having a lower index (i.e. greater viewing time for non-threatening than threatening foreground areas) compared with control groups for the ambiguous scene, but a similar index for the threatening scene (Fig. 3).

Thus, the specific abnormality in viewing strategy of the schizophrenics with persecutory delusions for the ambiguous scene appeared to be increased viewing time for non-threatening, although a similar viewing time for threatening foreground areas compared with control groups. This was despite a similar description of each scene as threatening or non-threatening by schizophrenic patients and normal controls. In order to investigate further whether schizophrenics with persecutory delusions and normal subjects had, in fact, a different understanding of threat or potential threat in foreground areas of all three scenes, an independent group of seven schizophrenics (DSM-IV criteria) with

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Table 3. (A) *Proportion of total number of foreground areas viewed for each scene*

| | Session 1 | | | Session 2 | | |
|---|---|---|---|---|---|---|
| | Thr* | Amb† | N‡ | Thr* | Amb† | N‡ |
| Normal controls | 0·51 (0·04) | 0·57 (0·05) | 0·53 (0·04) | 0·49 (0·04) | 0·54 (0·04) | 0·56 (0·06) |
| Sz with persecutory delusions | 0·43 (0·04) | 0·50 (0·04) | 0·32 (0·05) | 0·38 (0·05) | 0·45 (0·03) | 0·31 (0·06) |
| Sz with non-persecutory delusions | 0·44 (0·09) | 0·59 (0·07) | 0·47 (0·01) | 0·44 (0·09) | 0·50 (0·06) | 0·59 (0·09) |

* Overtly threatening scene.
† Ambiguous scene.
‡ Neutral scene.
Figures are means. Numbers in parentheses refer to the standard error of the mean.

Table 3. (B) *MANOVA results of the main effects of diagnosis, scene, viewing session and interactions of these on the above*

| | *F* | *P* |
|---|---|---|
| Diagnosis | 6·12 | 0·005 |
| Scene | 4·53 | 0·01 |
| Session | < 1·0 | > 0·1 |
| Diagnosis × Scene | 2·69 | 0·04 |
| Diagnosis × Session | < 1·0 | > 0·1 |
| Session × Scene | < 1·0 | > 0·1 |
| Diagnosis × Scene × Session | < 1·0 | > 0·1 |

persecutory delusions (> 3 on the SAPS delusion subscale and persecutory theme) was asked to rate the individual foreground areas for the presence or absence of threat in the context of the overall scene. The ratings of both the schizophrenic patients with persecutory delusions and the initial normal subject group were similar, suggestive of a similarity in ability to detect threat in both groups.

**Hypothesis 2: Schizophrenics with persecutory delusions would repeatedly view each foreground area of each picture less, and would view fewer foreground areas overall, compared with control groups**

For all subjects, the greatest repeatability index was for the ambiguous picture, and the smallest for the neutral picture ($F(2, 38) = 17{\cdot}16$; $P < 0{\cdot}001$). As predicted, schizophrenics with persecutory delusions repeatedly viewed (checked) foreground areas less than the other two subject groups ($F(2, 38) = 3{\cdot}05$; $P = 0{\cdot}06$), in particular, foreground areas of the neutral picture ($F(4, 36) = 2{\cdot}69$; $P = 0{\cdot}04$) (Table 2).

Overall, subjects viewed the greatest number of different areas for the ambiguous picture and smallest number of different areas for the neutral picture ($F(2, 38) = 4{\cdot}53$; $P = 0{\cdot}01$). As predicted, schizophrenics with persecutory delusions viewed fewer areas of each scene than the other two subject groups ($F(2, 38) = 6{\cdot}12$; $P = 0{\cdot}005$), particularly the neutral scene ($F(4, 36) = 2{\cdot}69$; $P = 0{\cdot}04$) (Table 3).

**Hypothesis 3: When asked to look for threat on a second viewing occasion, normal subjects and schizophrenics with non-persecutory delusions would view threatening foreground areas of overtly threatening and, particularly, ambiguous scenes more than for the first, 'free-viewing' viewing session**

There was no significant effect of viewing session on the proportion of time viewing threatening compared with non-threatening foreground areas of the ambiguous and overtly threatening scenes by all subjects (Fig. 2). However, the interaction of the diagnosis × session × scene effects on the percentage of total viewing time

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for all foreground areas reflected the tendency of the schizophrenics with non-persecutory delusions to view the foreground areas of the ambiguous scene less, and the normal subjects to view the foreground areas of both the ambiguous and threatening scenes more, during the second viewing session ($F(4, 32) = 3{\cdot}54$; $P = 0{\cdot}01$). Thus, the normal subjects did view foreground detail of both the threatening and ambiguous scenes to a greater extent during the second viewing session.

## DISCUSSION

We investigated visual attentional strategies employed by schizophrenic patients with persecutory delusions using complex visual stimuli: social scenes depicting either overall threatening, ambiguous or neutral activity. We also incorporated the measurement of visual scan paths – a measure of directed visual attention (Noton & Stark, 1971), which monitors later stages of visual information processing.

Previous studies measuring visual scan paths in normal subjects and schizophrenic patient groups have employed more simple stimuli, such as human faces (Phillips & David, 1997*a*, *b*). If the subject is to obtain detailed information about complex visual stimuli (social scenes), s/he will adopt more elaborate viewing strategies. This allows differences in viewing strategy, reflecting differences in information processing, between schizophrenic patients and control groups to become more apparent.

The study used stimuli depicting various levels of threat in order to test the hypothesis that schizophrenic patients with persecutory delusions would attend to potentially threatening foreground areas of ambiguous social scenes to a greater extent than both non-paranoid schizophrenics and normal subjects. The results confirmed the presence in schizophrenics with persecutory delusions of a specific abnormality in later stages of processing ambiguity: this group demonstrated a significantly different viewing strategy compared with the two control groups for foreground areas of the ambiguous scene only. Contrary to our prediction, schizophrenic patients with persecutory delusions, rather than attending more to potentially threatening foreground areas in the ambiguous scene, spent less time viewing such areas compared with control groups, and more time viewing non-threatening foreground areas. Hence, the tendency to equate persecutory delusions with increased attention to threat is unsupported and clearly an oversimplification.

One possible explanation for the discrepancy between our findings and those using other methods to measure attention to threatening stimuli (e.g. Stroop stimuli) is that processing of the latter stimuli may occur earlier than that for more complex, socially-salient visual stimuli, the stimuli employed in our study. Thus, whereas the processing of ambiguity in the social context involves the re-appraisal and re-evaluation of subtle contextual cues, processing of Stroop stimuli may be more dependent upon pre-attentive, automatic processes, and the direction of attention specifically to threatening material.

The schizophrenic patients with persecutory delusions demonstrated a normal understanding of threat when asked to rate the foreground areas of the ambiguous scene, but employed abnormal viewing strategies on initial appraisal of this scene. One interpretation of these results is that in the ambiguous context, these patients also searched for threat in areas considered non-threatening by both control groups, i.e. they anticipated threat in inappropriate places. A possibility is that they demonstrated a difficulty in the appreciation of context in an ambiguous setting. There were no significant differences in viewing strategy employed by the schizophrenic patients with persecutory delusions compared with control groups for the overtly threatening scene. This fact refutes an explanation of these patients' viewing strategy as merely threat avoidance.

There was an overall tendency by all subjects for greater re-appraisal, as measured by the repeatability of viewing index described above, of the foreground areas of the ambiguous compared with the other two scenes, suggestive of a checking strategy in the presence of uncertainty or ambiguity. The schizophrenics with persecutory delusions demonstrated reduced reappraisal of foreground areas of all three scenes compared with control groups. This was predicted in the light of studies demonstrating reasoning abnormalities in schizophrenic patients with persecutory delusions (Garety *et al*. 1991), and abnormalities in later, controlled stages of information processing

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(Braff, 1993). Schizophrenic patients with persecutory delusions would appear to rely less on salient information prior to decision-making, i.e. they adopt a 'jumping to conclusions' style of interpretation of information and reasoning.

Another measure of re-appraisal, the number of different foreground areas viewed for each scene, revealed a similar pattern of reduced re-appraisal in the schizophrenic patients with persecutory delusions. While all subjects overall viewed the greatest number of different areas for the ambiguous picture and smallest number of different areas for the neutral picture, schizophrenics with persecutory delusions viewed fewer areas across the board.

One surprising result was the absence of a significant effect of viewing session on the proportion of time viewing threatening compared with non-threatening foreground areas by normal subjects and schizophrenics with non-persecutory delusions. One explanation for this result is that normal subjects and, to a smaller extent, schizophrenics with non-persecutory delusions, were already viewing threatening areas of both the overtly threatening and ambiguous scenes at a ceiling level during the first viewing session, and thus there was no room to increase such viewing following the request to attend to threat. Normal subjects did, however, view all foreground areas of both the overtly threatening and ambiguous scenes to a greater extent during the second viewing session, suggesting that they were, in fact, viewing the foreground detail more closely when asked to look for threat. The design of the study did not enable us to examine the effect of a second viewing session independently of instructions to look for threat.

An important aspect of the study was the participation of a deluded schizophrenic patient group whose delusions were non-persecutory in nature. Although smaller in number because of the difficulty in finding patients with non-persecutory delusions, this patient group controlled for the effects of a diagnosis of schizophrenia and presence of delusions and other positive symptoms. The two schizophrenic patient groups were, therefore, distinguished on the basis of the theme of delusions only. In addition, there was no significant variation in neuroleptic mediation dosage between the two patient groups. The results indicated that there was a difference in viewing strategy, in particular for the ambiguous scene, between the two schizophrenic patient groups. The specific abnormalities in viewing strategy demonstrated by the schizophrenics with persecutory delusions are, therefore, unlikely to be the result purely of abnormal oculomotor control, reflecting abnormal neuronal circuitry. If this were the case, not only would the schizophrenic patients with non-persecutory delusions be expected to demonstrate similar patterns of abnormal viewing, but the context and theme of the scene viewed would be expected to have little impact on such viewing strategies for both patient groups.

It is difficult to distinguish between cause and effect with regard to abnormal visual scan paths and persecutory delusion formation in schizophrenic patients. Although it is possible that abnormal visual scan paths may result from the cognitive processes underlying persecutory delusion formation, it is also possible that abnormal viewing strategies serve to maintain persecutory delusions once formed. An approach to this problem is to examine visual scan paths in patients with a history of persecutory delusions both at an early stage, prior to delusion formation, and at a later stage when significantly less deluded. This would help to distinguish 'state' and 'trait'-like abnormalities in viewing strategies in these patients.

Future studies could address some of the questions raised by the results of this study. First, the size of the groups was relatively small, and so we may have lacked the statistical power to detect other differences, particularly between the schizophrenic patients with non-persecutory delusions and the normal controls. Secondly, the number of dependent variables may appear large, but, in fact, the various indices were constructed so as to control for the various confounding factors introduced by real-life photographs (such as size and number of foreground areas).

Thirdly, it would be interesting to employ stimuli that managed to control for extent of foreground area depicting threatening *versus* non-threatening activity. In the current study, the overtly threatening scene contained more threatening foreground area than the ambiguous scene (after controlling for the overall size of foreground activity in each scene). It would, however, be difficult to obtain such stimuli, since scenes are frequently rated, with respect to

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extent of threat, in terms of the amount of threatening foreground activity. Finally, the employment of novel visual stimuli during a second viewing session would help to reduce any effect of prior exposure.

Another future aim could be to employ strategies to increase the extent of re-evaluation of ambiguity and potential threat in patients with persecutory delusions, and to investigate the effect of such intervention on viewing strategies and, ultimately, reduction in the severity and extent of persecutory delusions. Some studies have, for example, investigated the effect of employment of strategies to improve affect perception on subsequent rehabilitation in patients with schizophrenia (Penn & Mueser, 1996).

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