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You must be looking at me: The nature of gaze perception in schizophrenia patients

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Introduction. Accurately identifying gaze direction is an important component of successful social interaction. Preliminary research indicates that schizophrenia patients have deficits in gaze perception, but the nature of this deficit is still unclear. The current study investigates whether nonspecific perceptual abnormalities could explain gaze perception deficits and whether schizophrenia patients show a direct gaze bias in their judgement.

Methods. Fifteen chronic schizophrenia patients and nineteen normal control participants made a direct gaze judgement for eyes in a face, and a centre judgement for a geometric shape in a scrambled face.

Results. The data show that schizophrenia patients are as accurate as healthy control subjects at identifying direct gaze when it occurs but they are more likely to misinterpret averted gaze as directed at them. The pattern of results indicates that this tendency to endorse direct gaze is not a consequence of a perceptual deficit in judging angular displacement.

Conclusions. Schizophrenia patients have a self-referential bias in judging the direction of gaze that could lead to the misinterpretation of another person's intentions during the course of social interaction.

Understanding and interpreting another person's gaze direction is a critical element of social interactions. Gaze direction can indicate a person's direction of attention, intention, and mental state (Baron-Cohen, 1995). Studies on gaze perception indicate that we have an innate mechanism for attending to eyes (Haith, Bergman, & Moore, 1977; Maurer, 1985) and gaze direction (Haines & Muir, 1996; Hood, Willen, & Driver, 1998), and that we use this information to

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estimate the attentional focus of another person and infer what is on their mind (Baron-Cohen, 1995). Perceiving that someone else is looking at you is especially salient, since direct gaze can be a signal of either friendly or hostile interest to engage in social contact (Brothers, 1990).

Schizophrenia patients misinterpret a variety of social cues including facial and vocal expressions of emotion (Hooker & Park, 2002), interpersonal intentions from gestures (Corrigan, Green, & Toomey, 1994), and judgement of emotion from the eyes (Kington, Jones, Watt, Hopkin, & Williams, 2003). However, given the importance of correct interpretation of gaze direction for social development and social cognition, there are relatively few investigations of this ability in schizophrenia patients. At the same time, there are indications that gaze perception and interpretation might be an important aspect in understanding schizophrenia pathology and experience. For example, schizophrenia patients often have the subjective impression that others are directing their attention towards them, as in paranoid or persecutory delusions (American Psychiatric Association, 1994; Fenigstein & Venables, 1992). However, it is not known how aspects of social perception, such as identifying and understanding gaze direction, may contribute to these impressions and feelings for schizophrenia patients.

In addition, the relatively few gaze perception studies in schizophrenia patients indicate gaze perception abnormalities. Rosse, Kendrick, Wyatt, Isaac, and Deutsch (1994) investigated eye gaze direction perception using face slides of centre and averted gaze. Subjects were asked, with no time constraints, to identify whether or not the person in the picture was looking at them. Rosse et al. (1994) found that schizophrenia patients were more likely than control participants to say that the person in the picture was looking at them, even when the gaze was averted. These findings suggest a self-referential bias in that patients believe that others are referring to them or, in this case, looking at them. However, it was unclear from this study whether or not schizophrenia patients had specific gaze perception deficits, general perception deficits (Schwartz, Tomlin, Evans, & Ross, 2001), or whether this effect was due to cognitive distortions, such as persecutory delusions, that may be influenced by paranoia.

Franck et al. (1998) investigated fundamental gaze perception skills of schizophrenia patients by presenting right and left gaze portraits in a forced-choice paradigm. When direct gaze was not a choice, schizophrenia patients showed no deficits, suggesting that they have intact perceptual mechanisms but that erroneous gaze judgements may be influenced by higher level cognitive mechanisms.

On the other hand, making left/right judgements with no time constraints is an easy task (mean accuracy was near 100%), and might be accomplished by using low level perceptual contrast information that is not dependent on gaze discrimination. Furthermore, in real-life situations, direction of attention or intention from gaze direction can be communicated quickly.

In a more recent study, Franck et al. (2002) had patients identify the direction (right or left) or the mutuality (looking at me or not) of gaze on a set of stimuli, which included centre gaze plus six averted gaze positions (right and left). They found that schizophrenia patients took longer to decide whether the person in the stimuli picture was looking at them as compared to whether the person's gaze was to the right or left. They interpreted their results as evidence that schizophrenia patients have intact perceptual abilities and that their self-referential judgements in gaze direction are related to higher level analysis. Although the authors investigated the psychophysical threshold of direct gaze perception (i.e., the angle which differentiated direct vs. averted gaze), they did not find a difference in this threshold between schizophrenia patients and normal control subjects.

Understanding the exact nature of schizophrenia patients' gaze perception and interpretation abnormalities may provide clues to neurocognitive function, as well as causal factors contributing to broader problems in social cognition and social functioning. Neuroscience investigations are beginning to delineate brain regions involved in perceiving and interpreting gaze cues. For example, neuroimaging and neurophysiology data indicate that the superior temporal sulcus region is specifically responsive to meaningful gaze cues that indicate the direction of attention of another person (Haxby & Hoffman, 2000; Hooker et al., 2003; Perrett & Emery, 1994; Perrett et al., 1985), and neuropsychological patients with superior temporal lesions have difficulty identifying gaze direction (Campbell, Heywood, Cowey, Regard, & Landis, 1990). In addition, judging more complex emotional information from the eyes activates the ventral prefrontal and orbital frontal regions in normal subjects (Baron-Cohen et al., 1999; Russell et al., 2000). Russell et al. (2000) showed that schizophrenia patients have difficulty judging emotion from the eyes and they show less activity in the ventral prefrontal cortex as compared to normal control subjects during this task (Russell et al., 2000). It is unclear, from this study, whether neural dysfunction causes poor performance or whether poor performance on the task results in less neural activity. Nonetheless, in the light of these functional neuroimaging findings, it is interesting to note that schizophrenia patients have structural abnormalities in these same superior temporal (Shenton, 1996) and frontal regions (Harrison, 1999). The combined data suggests that neural dysfunction could be a contributing factor to the perception and interpretation of gaze. However, the behavioural and cognitive patterns of gaze perception abnormalities in schizophrenia patients need to be further delineated in order to understand brain-behaviour relationships in future neuroimaging investigations of gaze perception.

Another line of evidence suggests that early visual processing deficits contribute to difficulties in social perception and social functioning. Performance on a facial emotion identification task correlated with early visual-processing performance as measured by the Span of Apprehension task (SPAN; Kee, Kern, & Green, 1998). In addition, accuracy in interpreting gestures in interpersonal contexts was significantly correlated with accuracy on a target detection task using forward and backward visual masking (Sergi & Green, 2002). Based on these data, Sergi and Green (2002) suggest that problems in social perception and interpretation may be explained by early visual processing dysfunction with the idea that disruptions in early visual processing may differentially impact social perception since social signals change in a rapid and dynamic fashion.

The current project investigates gaze perception in schizophrenia patients by employing a direct gaze detection paradigm where subjects answer the question—Is this person looking at you or not?—in response to face photographs with direct gaze and five different degrees of gaze deviation to the left and right. This paradigm is similar to paradigms used in neurophysiology (Perrett & Emery, 1994), neuroimaging (Hooker et al., 2003), and neuropsychological (Campbell et al., 1990) studies, as well as studies investigating gaze in schizophrenia patients (Franck et al., 2002), and thus provides continuity across investigations. However, we added three novel aspects to the task in order to address outstanding questions in the literature.

First, we incorporated a nongaze perceptual control task in which participants judged whether a black box was in the centre of a white rectangle (geometric control condition). The black box was presented in the centre and deviated to the left and right to the same degree as the gaze stimuli. This provides an assessment of perceptual abilities for nonsocial stimuli as well as a general measure of task performance—an important addition given that schizophrenia patients do not perform as well as normal control participants on many types of cognitive tasks (Chapman & Chapman, 1979). Second, in order to estimate the extent to which the schizophrenia patient's sense of being looked at might be guided by cognitive distortions independent of perceptual discrimination, we required subjects to make the same judgement about ambiguous stimuli that, under strict time constraints, had the appearance of the regular stimuli but did not provide any task-relevant (gaze or geometric shape) information. In other words, a direct gaze bias for the ambiguous stimuli would indicate that self-referential distortions may occur in a wide variety of social contexts and is not necessarily the result of specific problems misinterpreting gaze cues. Third, we used a backward masking technique to limit the amount of processing time and investigate whether shorter processing time would differentially affect schizophrenia patients relative to controls and social processing more than nonsocial processing.

We hypothesised that: (1) schizophrenia patients would endorse direct gaze more than control subjects; (2) this direct gaze bias would be greater with less processing time; (3) schizophrenia subjects would not show a centre bias for nongaze stimuli; (4) schizophrenia patients would show a direct gaze bias for the ambiguous stimuli in the gaze task but not a centre bias in the control task.

METHODS

Participants

A total of 15 schizophrenia patients (10 men, 5 women) and 19 normal control subjects (11 men, 8 women) participated in the study. The patients were recruited from a community residential psychiatric facility and the outpatient psychiatry service at Northwestern Memorial Hospital. All patients were diagnosed with schizophrenia according to the DSM-IV criteria, using a structured interview, the Schedule for Schizophrenia and Affective Disorder (SADS; Spitzer & Endicott, 1978) and medical chart reviews. Advanced clinical psychology graduate students as well as a licensed clinical psychologist conducted the interviews. All interviewers were blind to the purpose of the study at the time of the interview. Patients with comorbid Axis I or Axis II disorders, neurological disorder, or significant head injury were excluded from the study. The mean age of the schizophrenia subjects was 40.1 (*SD* = 9.3) years old, and they had an average of 13.5 (*SD* = 2) years of education. The mean duration of illness was 20.6 (*SD* = 9.2) years. All patients were receiving antipsychotic medication (primarily atypical antipsychotics) at the time of testing. The estimated mean chlorpromazine equivalent was 1156.8 mg (*SD* = 916). The normal control participants were recruited via campus and community postings and screened for history of psychiatric illness, neurological disorder, or head injury. Normal control participants were given the Schizotypal Personality Questionnaire (SPQ; Raine, 1995) and excluded if they had more than 45 positive responses. The control participants had a mean age of 40 (7.3) years and an average of 13.6 (1.7) years of education. There was no significant difference in age ($t = 0.05$, $p > .1$) or years of education ($t = 0.2$, $p < .1$) between the two groups.

The Institutional Review Board at Northwestern University approved the study protocol. After a complete description of the study, all subjects provided written, informed consent; they completed the experiment in one session on one day; they were debriefed after completing the experiment, and were paid for their participation.

Materials and procedure

Greyscale, 3 in × 5 in, 170 dots per inch (dpi) images of the face portraits and geometric stimuli were presented on the computer monitor. The face portraits used for the Gaze task were created by a professional photographer who photographed four different models (2 men and 2 women) directing their gaze to 11 different positions: eyes directed toward the camera (direct gaze/0°) and eyes averted 20°, 30°, 40°, 50°, and 55° to the left and right. The design of the geometric control stimuli was based on an earlier study of eye gaze direction detection in normal individuals (see Von Grunau & Anston, 1995), and was modified to approximately match the face portraits in visual complexity. The geometric control stimuli were created by ''cutting and pasting'' pieces of the face stimuli to create an equal size image of a scrambled face (in which face features were not recognisable), approximately the same luminance and contrast as the face stimuli. A white rectangle the height and width of an eye (11.5 mm) with a small black box inside it (size of the iris) was placed in the middle of the scrambled image. The black box shifted its position from centre to mirror the shifts in the cornea relative to the sclera for the eye gaze stimuli (i.e., centre/0° and 20°, 30°, 40°, 50°, and 55° to the left and right).

The ambiguous stimulus for the Gaze task was an outline of a face portrait (hairline and neckline) with no facial features (i.e., the main part of the face was blank grey), and the entire image was substantially degraded. The ambiguous stimuli for the Geometric Control task consisted of the scrambled face, which was used for the geometric stimuli, but without the white rectangle with the black box in the middle. In other words, the ambiguous stimuli for both tasks provide enough visual information to convince participants that it is the same type of image as in the rest of the task, but it does not provide the relevant perceptual information.

All stimuli were presented for 30 ms and then followed by a mask (a scrambled face with no visible facial features) which was presented for 75 ms. The interstimulus interval (ISI) between the stimulus and mask was one of three durations: 30 ms, 60 ms, or 180 ms. All ambiguous stimuli were presented with an ISI of 30 ms. The ambiguous stimuli were presented at the shortest ISI so that subjects would not be able to confidently ascertain that critical features were missing. After the mask, a blank screen with a fixation point appeared which signalled the participant to respond. The participants were instructed that they would see a face or geometric design flash quickly on the screen and that, in the Gaze task, they needed to identify whether or not the eyes were looking directly at them, and, in the Geometric Control task, they needed to identify whether or not the black box was in the centre of the rectangle. Participants responded ''Yes'' or ''No'' by pressing labelled keys on the keyboard. Participants were told that the images would be presented at varying speeds and that sometimes it would be so fast that they may not be able to tell whether or not the picture was present. They were instructed that, in those cases, to take their best guess. See Figures 1 and 2 for an illustration of the task and an example of each stimulus.

The experiment was administered in 16 separate blocks consisting of 96 randomly presented trials of one stimulus type. Thus subjects performed blocks of either the gaze or geometric control task. Block order was rotated across subjects. For each task, every angle was presented 32 times at each ISI condition, with the exception of the ambiguous trials that were presented for a total of 192 times at the same ISI. All participants were given a short block of 12 practice trials to ensure that they understood the directions. Instructions were repeated when necessary but no feedback regarding accuracy was given on the practice trials. Participants were encouraged to take breaks whenever necessary.

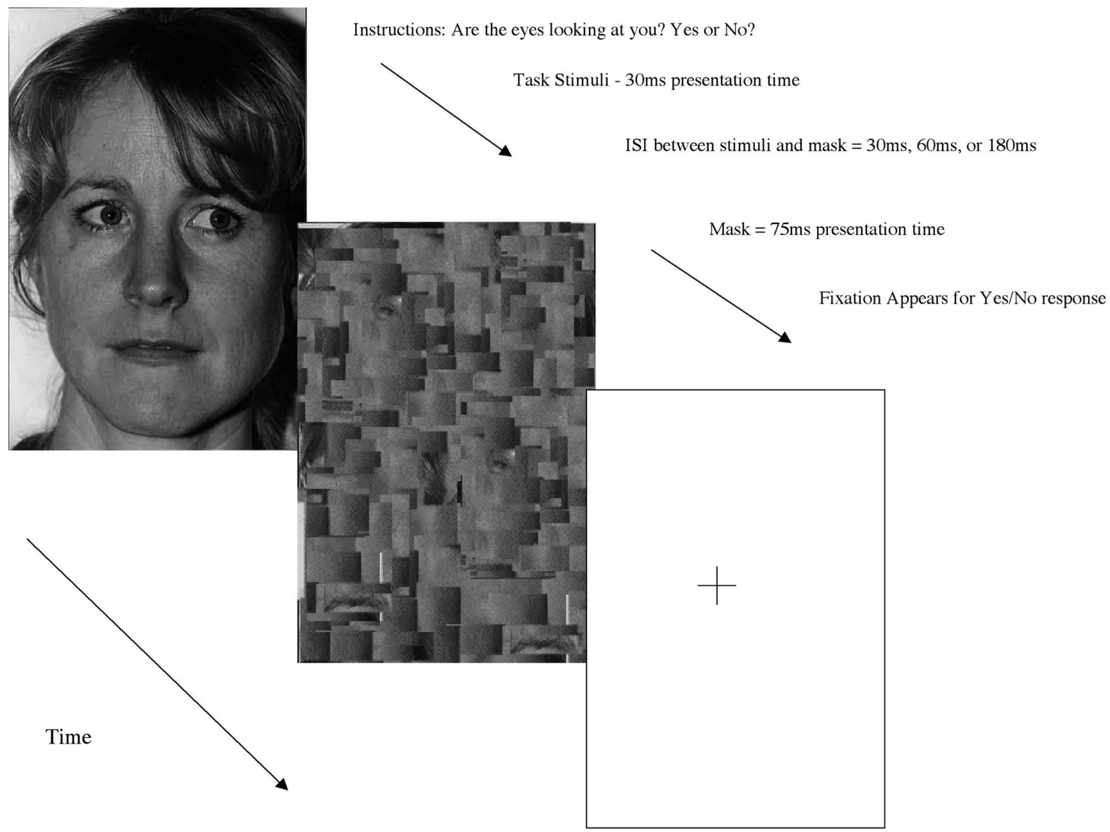
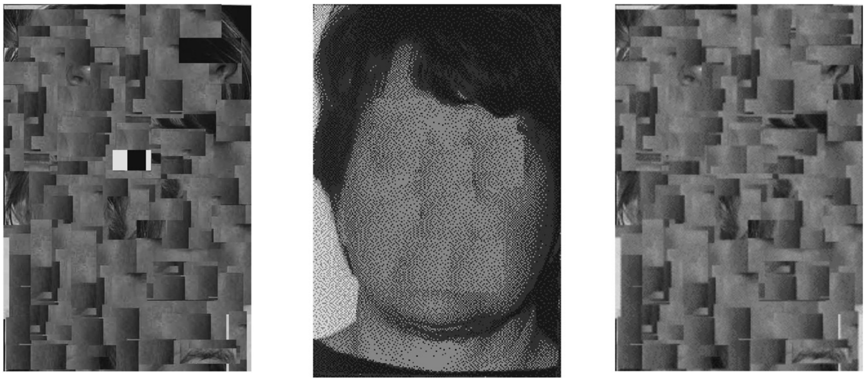


Figure 1. In the Gaze task, a face flashed on the screen; subjects had to judge whether or not the eyes were looking at them. In the Geometric Control task, a scrambled face with a white rectangle containing a small black box was flashed on the screen; subjects had to judge whether the black box was in the centre of the rectangle.



Geometric Stimulus: Geometric Control Task — Ambiguous Stimulus: Gaze Task — Ambiguous Stimulus: Control Task

Figure 2. Example of each stimulus type.

RESULTS

Four separate analyses were conducted on the data and described below.

Direct gaze and centre judgements

First, the number of direct gaze and centre judgements (i.e., ''yes'' responses) were entered as a dependent variable into a repeated-measures analysis of variance (ANOVA) with Task (Gaze and Geometric Control), ISI (30 ms, 60 ms, and 180 ms), and Angle (0°, 20°, 30°, 40°, 50°, and 55°) as within-subject variables, and Diagnosis as a between-subject variable. This analysis shows: (1) a main effect of Task, such that both schizophrenia patients and normal control participants were more likely to make a direct gaze judgement for gaze than a centre judgement for the geometric control condition, $F(1, 32) = 25.1$, $p < .001$; (2) a main effect of Angle, such that all participants make the most centre judgements at zero with the number of centre judgements decreasing as the angle of deviation becomes larger, $F(5, 160) = 299.2$, $p < .0001$; (3) a main effect of ISI, such that all participants were more likely to make a centre judgement (at all angles) at shorter ISIs, $F(2, 64) = 10.5$, $p < .0001$; and (4) a Task × Angle × Diagnosis interaction, $F(5, 160) = 3.1$, $p = .01$, such that the schizophrenia patients showed a different pattern of responses from the control group at specific angles (see Figure 3). Post hoc comparisons reveal interactions at two angles. In the direct/centre (0°) condition, schizophrenia patients perform as accurately as normal control subjects in correctly identifying direct gaze; however, schizophrenia patients are significantly worse at identifying whether the geometric shape is in the centre. There is no significant difference in the pattern of performance between normal control subjects and schizophrenia

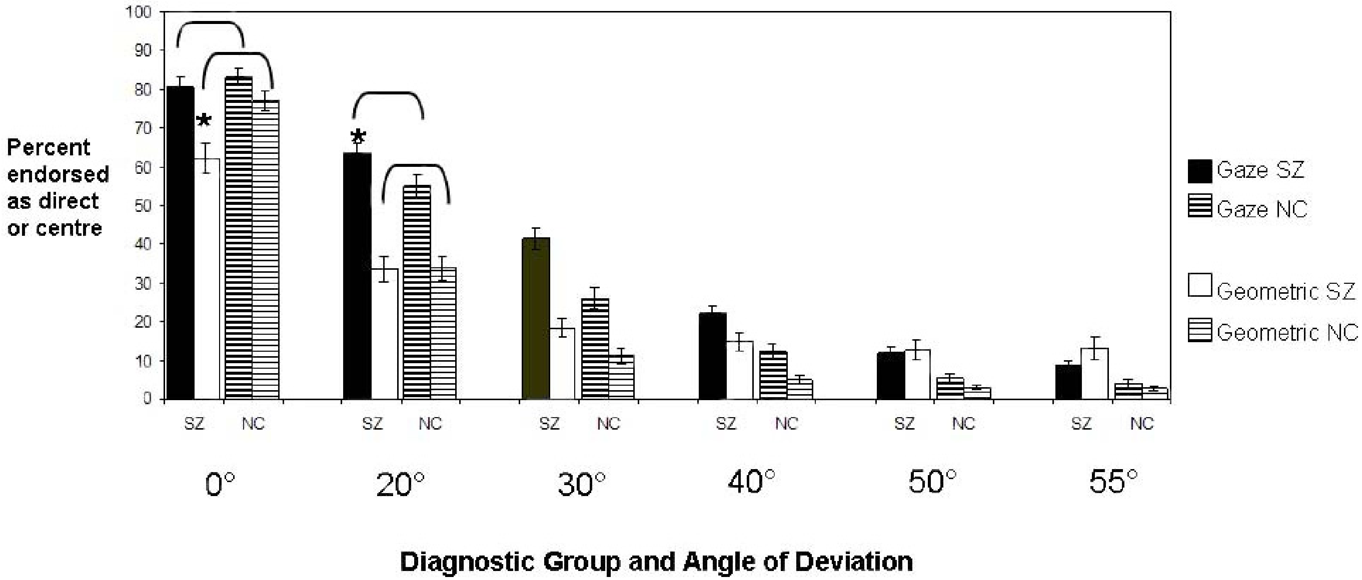


Figure 3. The percentage of direct and centre responses for each group at each angle in the Gaze and Geometric Control tasks. The pattern of responses shows an interaction at 0° where schizophrenia patients (SZ) perform as well as normal controls (NC) at correctly identifying direct gaze but are worse than normal controls at correctly identifying geometric centre (*) and at 30° where schizophrenia patients incorrectly identify averted gaze as direct significantly more than normal control participants (*) but perform as well as normal control participants on the Geometric Control task.

patients at twenty degrees of deviation. However, at thirty degrees of deviation, schizophrenia patients endorse direct gaze significantly more than control subjects, but there is no difference in their performance on the geometric control task.

The only other significant factor in this analysis was an interaction of Task $\times$ ISI $\times$ Angle, $F(10, 320) = 3.9$, $p < .0001$, indicating a different pattern of responding for Gaze as compared to the Geometric Control task, across subject groups, for each ISI and angle of deviation. An evaluation of mean performance for each condition suggests that performance, especially in the centre condition, on the Geometric Control task improves at longer ISIs. However, longer processing time does not enhance performance on the Gaze task. That is, performance on the Gaze task remains stable across ISI.

Responses for the ambiguous trials were analysed in a separate repeated-measures ANOVA with the percentage of direct/centre responses as the dependent variable, Task as the within-subject variable, and Diagnosis as the between-subjects variable. This analysis showed a main effect of task and a main effect of diagnosis but no interaction. Both schizophrenia patients and normal control participants were more likely to endorse direct gaze when presented with ambiguous stimuli in the Gaze task: schizophrenia patients, M = 32.4% (SD = 27); Normal Control, M = 19.2% (SD = 25), than they were to endorse that the square was in the centre in the Geometric Control task: schizophrenia patients, M = 21.1% (SD = 25); Normal Control, M = 6.2% (SD = 10), $F(1, 1) = 8.7$, $p < .05$. In addition, schizophrenia patients were more likely to respond that gaze was direct and that the black box was in the centre in both conditions: main effect of diagnosis, $F(1, 32) = 4.6$, $p < .05$. However, there was no evidence of an interaction, such that schizophrenia patients were responding ''yes'' significantly more in the Gaze task than the Geometric Control task relative to normal control participants: Task $\times$ Diagnosis interaction, $F(1, 32) = 0.05$, $p > .1$.

Angle of deviation

For the second analysis we identified the angle of deviation in which subjects continued to endorse direct gaze (and make a centre judgement) at least 30% of the time and tested whether this angle was significantly different between the groups. The purpose of this analysis was to simplify the data by identifying the angle of deviation at which participants continued to endorse direct gaze a significant amount of the time. We chose the angle at which subjects continued to respond that gaze was directed at them (or the black box was in the centre) 30% of the time because this was the base rate of direct/centre responses across individual subjects, and therefore all subjects were included. For this analysis, we computed the most deviated angle at which the participant continued to make a direct gaze or centre judgement at least 30% of the time averaged across ISIs, for each task. This calculation is based on psychophysical methodology (e.g., Gesheider, 1976). The analysis did not include ambiguous trials.

Our hypothesis predicts that schizophrenia patients will endorse direct gaze when the target eye position is at a larger angle of deviation than normal control participants, but that the two groups would not differ significantly on the Geometric Control task.

One angle measurement for each subject and each task was used as the dependent variable. A repeated-measures ANOVA analysis using this angle of deviation showed a significant Task $\times$ Diagnosis interaction: $F(1, 32) = 5.0$, $p <$ .05, such that schizophrenia patients were endorsing direct gaze at significantly more deviated angles: $M = 36.5^\circ$ (7.2), than control participants: $M = 28.0^\circ$ (8.0), but the two groups did not differ on the angle of deviation for the Geometric Control condition: schizophrenia, $M = 20.5^\circ$ (10.8); Normal Control, $M = 20.8^\circ$ (8.5) (see Figure 4).

Reaction time

We computed mean reaction time for each response type: Hits (correct identification of gaze as direct or centre square as centre), Correct Rejections (correctly judging that gaze was not direct and the square was not in the centre), False Positive responses (incorrectly judging the stimulus as direct or centre), and False Negative responses (incorrectly judging that gaze was not direct or square was not centred). Mean reaction times for each response type were entered into a repeated-measures ANOVA with Response Type (Hit, Correct Rejection, False Positive, and False Negative) and Task (Gaze and Geometric Control) as within-subject variables and Diagnosis as a between subject variable. (Reaction times for ambiguous trials are analysed separately and discussed below.)

The reaction time analysis showed a main effect of response type such that subjects across groups were quicker for correct responses (Hits and Correct Rejections) than incorrect responses (False Positives and False Negatives), $F(3, 96) = 9.5$, $p < .0001$.

There were no significant effects of diagnosis at the a priori statistical threshold of $p < .05$.

However, because gaze perception is an emerging field of study, we report two effects of diagnosis that reach statistical significance at the trend level for the purpose of comparison across closely related studies in the literature. Schizophrenia patients had slower reaction times, overall, than normal control participants, $F(1, 32) = 3.3$, $p = .07$. More interestingly, a Task $\times$ Diagnosis interaction, $F(1, 32) = 3.4$, $p = .07$, indicates that schizophrenia patients had slower reaction times on the Gaze task: RT = 743 ms ($SD = 395$), as compared to the Geometric Control task: RT = 704 ($SD = 279$), whereas normal control subjects had faster reaction times to the Gaze task: RT = 537 ms ($SD = 227$), as

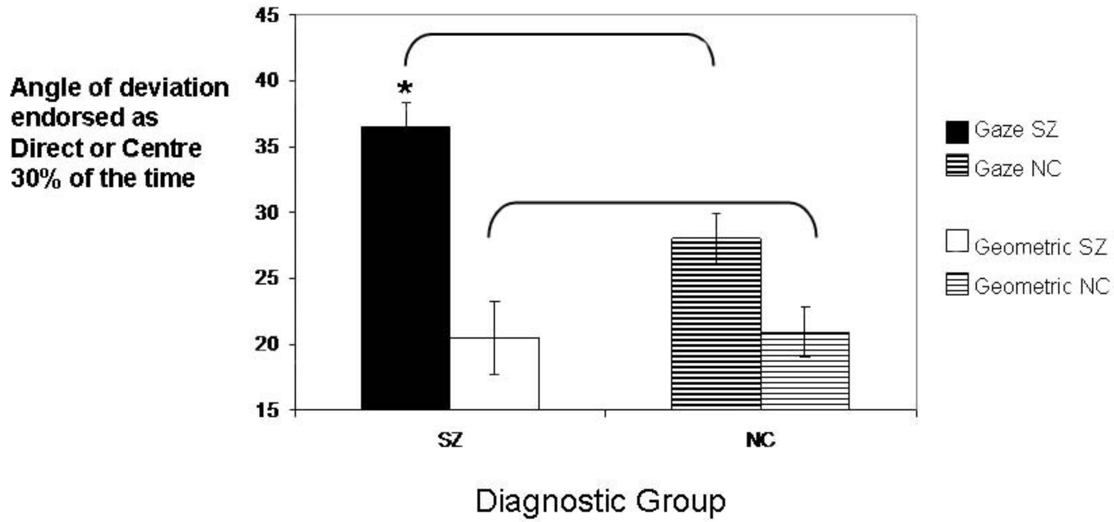


Figure 4. The angle of deviation that subjects still endorse as direct gaze or geometric centre 30% of the time. The angle of deviation is significantly greater for schizophrenia patients (SZ) than normal control participants (NC) in the Gaze task (*) but there is no difference between the groups in the Geometric Control task.

compared to the Geometric Control task: RT = 597 ms (*SD* = 332). Because incorrect responses are generally slower than correct responses and schizophrenia subjects had more incorrect responses, we did a repeated-measures ANOVA of just correct responses (Hits and Correct Rejections). This Response Type × Diagnosis interaction, $F(1, 32) = 3.8$, $p = .06$, suggests that schizophrenia patients had a quicker response to hits (correctly identifying direct as direct and centre as centre) as compared to correct rejections, whereas normal control participants had a quicker response to correct rejections than to hits.

A repeated-measures ANOVA of reaction time for the Ambiguous trials shows a significant effect of diagnosis, such that schizophrenia patients were slower than normal controls, $F(1, 32) = 5.5$, $p = .03$, and a significant effect of response type such that subjects were slower to make a ''yes'' judgement than a ''no'' judgement, $F(1, 32) = 30$, $p < .001$. No other effects were significant.

Correlational analyses

Finally, in a separate correlational analysis, none of the patient variables, such as chlorpromazine equivalent dose, duration of illness, age, and education level showed a significant correlation with the dependent variables of interest. This suggests that the findings outlined are not due to an artifact of illness.

CONCLUSIONS

This study indicates that schizophrenia patients have a tendency to judge that other people are looking at them when, in fact, they are not. In this study, schizophrenia patient and normal control participants had to discriminate angular displacement from centre in two forced-choice behavioural tasks. In the gaze task, participants identified whether a person in a stimulus photo was looking at them or not. In the geometric control task, participants identified whether a black box was in the centre of a white rectangle—a stimulus that had the same luminance, contrast, and dimensions as the gaze stimulus.

Two separate analyses confirm that schizophrenia patients are more likely than normal control participants to identify averted gaze as directed at them and that this tendency is not solely due to poor task performance or general perceptual difficulties. In an analysis of percentage of direct gaze and geometric centre responses, schizophrenia patients are as accurate as normal control participants in correctly identifying direct gaze, but they are worse than normal controls in correctly identifying geometric centre in the control task. However, at thirty degrees of deviation from center, schizophrenia patients judge that the person in the photograph is looking at them significantly more than normal control participants, yet the two groups are equally accurate in identifying that the geometric stimuli is not centred. This interaction indicates that schizophrenia patients have a direct gaze bias which increases accurate detection of direct gaze when it truly occurs but leads to misinterpretations when gaze is averted.

Furthermore, the analysis confirms that the results are not an artifact of response bias since schizophrenia patients did not have more ''yes'' responses across both tasks, and they did not have significantly more ''yes'' responses in the Gaze task than the Geometric Control task compared to normal subjects across all angles.

A separate analysis shows that schizophrenia patients continue to endorse direct gaze 30% of the time at a higher angle of deviation (36.5° averted) than control subjects (28° averted); however, the angle of deviation that each group endorses as geometric centre, at this same rate, does not differ between groups. This analysis confirms the idea that schizophrenia patients specifically misinterpret gaze in a self-referential manner.

To investigate the possibility that schizophrenia patients may be projecting a pervasive self-referential cognitive distortion on all social stimuli, we included ambiguous stimuli that did not contain pertinent task-relevant information. We found that when schizophrenia patients were forced to make a judgement on ambiguous stimuli, they made more direct gaze and centre judgements as compared to nonschizophrenic subjects. Thus, when given no task-relevant perceptual information, schizophrenia patients' judgement criteria is more lax but does not show an elevated bias specific for eye gaze. The meaning and significance of these data are not clear. If cognitive distortions were responsible for their self-referential bias in the gaze task, one would expect an interaction such that they endorsed direct gaze more than normal controls on the gaze task but not the geometric control task. This pattern was not evident in the ambiguous trials.

Rather than a pervasive self-referential bias that applies to all social stimuli, it appears, from this study and others (Franck et al., 2002), that if schizophrenia patients suspect the possibility exists that someone *could* be watching them, they are more likely to decide that someone *is* watching them and act accordingly.

Although the analysis of reaction time did not produce significant effects, the trends in the data were consistent with the idea that schizophrenia patients are relatively efficient at correctly identifying direct gaze, but, as evidenced by longer reaction times for the gaze task across all angles of deviation, they seem to be less confident when deciding whether the gaze is looking at them or not. This finding is similar to Franck et al. (2002), who found that schizophrenia patients had longer reaction times when deciding whether someone is looking at them or not than they did when judging whether the gaze was left or right from the same photographs. Together, these findings suggest that schizophrenia patients have more difficulty identifying the intention of another person in relation to themselves as opposed to just difficulty with directional or angular judgements, per se, independent of the possibility of social engagement.

We did not find that shorter processing time, as controlled by backward masking, differentially affected schizophrenia patients as compared to control participants. Interestingly, the results indicated that shorter processing time may disrupt the evaluation of nonsocial stimuli more than social stimuli for both groups. This finding could indicate that social information is processed more quickly or has parallel channels that make it more resistant to disruption. However, this was not a main focus of the present experiment and more work needs to be done to investigate the effect of backward masking on different types of stimuli.

In conclusion, our results indicate that schizophrenia patients have a self-referential bias when judging whether someone is looking at them, and that this bias is not the result of a severe perceptual deficit (Franck et al., 1998, 2002), nor a difficulty in judging angular displacement of stimuli, nor an artifact of poor task performance.

Further research needs to be done to determine the cause and consequence of this direct gaze bias. It is possible that the tendency for schizophrenia patients to incorrectly endorse direct gaze is the result of an interaction between faulty neurobiological systems and distorted cognitive beliefs. Future research may want to investigate this interaction of cognitive structure (e.g., identified paranoid beliefs) and perceptual information, especially of a social nature, in order to understand the nature of the effect more specifically. In addition, future research could investigate neural correlates of this bias, since dysfunctional processing in the frontal and temporal lobe regions may contribute to gaze perception abnormalities. Using the current paradigm in a functional magnetic resonance imaging (fMRI) investigation may provide the opportunity to disentangle the contribution of cognitive bias and hyper- or hypoactivity on performance, since the ample number of response types (hits, correct rejections, false positives, and false negatives) would allow for separate analyses of brain activity correlating with specific error types. For example, if gaze direction perception problems are caused by dysfunction, such as hypoactivity, in the superior temporal region, one might expect the same pattern of brain activity for all types of gaze perception errors. However, if there is an additional process contributing to self-referential bias in gaze perception and interpretation, one would expect a difference between errors congruent with a direct gaze bias (false positive) as compared to errors caused from missing direct gaze detection (false negative).

Limitations

There are several limitations to the current study that need to be acknowledged. First, the paradigm we used was difficult; we required participants to sustain attention over many repetitive trials and asked them to make fine discrimination judgements with limited viewing time. We encouraged participants to take breaks whenever necessary, which they did, but it was, nonetheless, quite taxing on both normal control participants as well as the patients. Initial studies in our laboratory using an easier task with longer processing time (i.e., no backward masking) and basic (i.e., right, left, and centre) gaze judgements showed a trend toward a centre gaze bias but not a significant effect (Hooker & Park, 1999). Thus, we designed a challenging task that would provide ample variability and allow for the analysis of different response types. Given the predicted pattern of results that emerged from the data, we do not believe that difficulty was a confounding variable in the design. In addition, although the backward masking paradigm, has been shown to be especially difficult for schizophrenia patients (Green, Nuechterlein, & Mintz, 1994), we used this method purposefully, in order to control processing time and create a challenging task. There was no indication in the data that the backward masking affected the schizophrenia patients differently than normal controls or that the masking affected stimulus type differently for the different subject groups. Therefore, we do not believe that differential sensitivity to masking could explain the results. One reason that we may not have found a difference between groups, as has been found in the past, is because the masking tasks that are specifically assessing early visual processing generally have much shorter presentation times and ISIs.

Interestingly, the controlled processing time may have accentuated the direct gaze bias. Franck et al. (2002) used a psychophysical measure in their analysis of direct gaze but did not find a significant difference between schizophrenia patients and normal control participants. In their study, participants identified direct gaze among averted gaze distractors that were various degrees from centre. The stimuli were not masked and participants had unlimited time to respond. The authors found a reaction time difference between judging direct gaze perception as compared to right/left gaze direction. However, they did not find a difference in the angle at which subjects endorsed direct gaze 50% of the time (the absolute difference threshold). Our study indicates that a bias for behaviourally endorsing direct gaze is evident when using modified threshold criteria under more challenging perceptual conditions.

In addition, schizophrenia patients have demonstrated abnormalities in visual scanning of scenes and faces (Phillips & David, 1997; Phillips, Senior, & David, 2000). Research shows that they do not focus on the primary features of a face, such as the eyes and mouth, when judging facial expressions (Loughland, Williams, & Gordon, 2002). These studies often have use long stimulus exposure times and are aimed at investigating a person's natural scanning tendencies. We cannot be certain that poor scanning is not a contributing factor. Though given the trial repetition and time limits of this task, it is most likely that subjects would develop a strategy to look immediately at the salient information in order to complete the task. Furthermore, the pattern of the data suggests that they were perceiving and evaluating the gaze and geometric stimuli. However, we did not test visual scanning, so future investigations could explore the possible contribution of scanning abnormalities to gaze deficits.

Summary and implications

The findings illustrated in this study and others (Franck et al., 2002; Rosse et al., 1994), that schizophrenia patients tend to misperceive gaze in a self-referential manner, are potentially important for several reasons. The direction of gaze is an important social cue. In a social interaction, using gaze as a primary cue, one person will respond to another based on their interpretations of social intention (Baron-Cohen, 1995). In addition, the ability to detect direction of gaze is a pivotal skill in the development of social cognition (Loveland & Landry, 1986; Mundy & Crowson, 1997) and provides the foundation for later social interactions. Thus, deficits or delays in this skill may cause disruption in developing an understanding of others and ultimately interfere with social relationships. This study illustrates one way to isolate and investigate the specific contributions of gaze perception in relation to other aspects of social cognition and social functioning.

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