Attention to Gaze and Emotion in Schizophrenia

Barbara L. Schwartz
Washington DC Veterans Affairs Medical Center and
Georgetown University Medical Center

Chandan J. Vaidya
Georgetown University and Children's National Medical Center

James H. Howard, Jr.
The Catholic University of America and Georgetown University

Stephen I. Deutsch
Eastern Virginia Medical School

Objective: Individuals with schizophrenia have difficulty interpreting social and emotional cues such as facial expression, gaze direction, body position, and voice intonation. Nonverbal cues are powerful social signals but are often processed implicitly, outside the focus of attention. The aim of this research was to assess implicit processing of social cues in individuals with schizophrenia. *Method:* Patients with schizophrenia or schizoaffective disorder and matched controls performed a primary task of word classification with social cues in the background. Participants were asked to classify target words (LEFT/RIGHT) by pressing a key that corresponded to the word, in the context of facial expressions with eye gaze averted to the left or right. *Results:* Although facial expression and gaze direction were irrelevant to the task, these facial cues influenced word classification performance. Participants were slower to classify target words (e.g., LEFT) that were incongruent to gaze direction (e.g., eyes averted to the right) compared to target words (e.g., LEFT) that were congruent to gaze direction (e.g., eyes averted to the left), but this only occurred for expressions of fear. This pattern did not differ for patients and controls. *Conclusion:* The results showed that threat-related signals capture the attention of individuals with schizophrenia. These data suggest that implicit processing of eye gaze and fearful expressions is intact in schizophrenia.

Keywords: social attention, gaze direction, facial expression, schizophrenia, implicit processing

Social isolation and poor interpersonal skills mark the lives of many people with schizophrenia. This impairment may stem in part from deficits in interpreting the meaning of social cues and drawing inferences about other people's thoughts, intentions, and feelings (Couture, Penn, & Roberts, 2006; Kee, Green, Mintz, & Brekke, 2003; Pijnenborg et al., 2009). In particular, individuals with schizophrenia have difficulty explicitly reporting social and emotional cues, such as identifying facial expressions (for reviews, see Edwards, Jackson, & Pattison, 2001; Kohler, Walker, Martin, Healey, & Moberg, 2009; Mandal, Pandey, & Prasad, 1998),

judging mood states from eye expression (Kington, Jones, Watt, Hopkin, & Williams, 2000), and identifying the direction of another person's gaze (Hooker & Park, 2005; Rosse, Kendrick, Wyatt, Isaac, & Deutsch, 1994). For example, when explicitly asked to decide whether another person's gaze is averted or direct, patients are more likely to misinterpret gaze as directed at them. Neuroimaging studies further indicate abnormalities in a network of regions involved in social processing in schizophrenia (for reviews, see Aleman & Kahn, 2005; Brunet-Gouet & Decety, 2006). In functional imaging studies, emotion recognition (Gur et al., 2002; Hempel, Hempel, Schonknecht, Stippich, & Schroder, 2003; Phillips et al., 1999; Russel et al., 2000) and decisions about gaze direction (Kohler et al., 2008) elicit abnormal activation in medial prefrontal cortex, superior temporal sulcus, and amygdala. These findings suggest that individuals with schizophrenia are impaired in making explicit social judgments about other people's emotions and gaze direction.

Much less is known about implicit processing of social cues in schizophrenia. Studies in social cognition suggest that some information is detected implicitly or automatically with little conscious effort, whereas other information requires greater effort and reflection to interpret (for review, see Lieberman, 2007). The study of implicit processing is important because emotional information can affect behavior without participants being aware of its influence. The aim of this research was to explore implicit processing of social cues in people with schizophrenia. We examined how facial features that were presented in the background, outside the focus of attention, affected performance of a task that participants were asked to attend to. The question was whether or not facial expression and gaze direction captured the attention of people with

schizophrenia when their attention was directed elsewhere. This allows us to study the impact of social and emotional cues on performance without asking participants to intentionally process these cues. The effects of eye gaze and facial expression on focal attention will tell us about the way patients implicitly process social information.

Studies in nonpatient populations suggest that people automatically shift attention in the direction of another person's gaze. The automatic nature of gaze perception has been studied in a cueing paradigm in which participants view a centrally presented face with gaze averted to the left or right. After a brief delay, a visual target (e.g., T) appears to the left or right of the face and participants are asked to identify the target as quickly as possible. Targets that appeared in the peripheral location cued by the direction of gaze were detected faster than targets presented in the uncued location (Driver et al., 1999; Friesen & Kingstone, 1998; Friesen, Ristic, & Kingstone, 2004; Langton & Bruce, 1999). Furthermore, these studies showed that participants had difficulty shifting attention away from the location cued by the direction of gaze even when the target was four times more likely to appear in the uncued position (Driver et al., 1999). These findings suggest that orienting attention in the direction of gaze is reflexive. People with schizophrenia are also driven to follow the gaze of another person. Langdon and colleagues used the cueing paradigm described above and found that individuals with schizophrenia were more sensitive, not less, to automatic shifts of attention to gaze direction (Langdon, Corner, McLaren, Coltheart, & Ward, 2006).

There is also evidence that threatening expressions can be processed with little conscious effort (Vuillemier, 2005; Whalen et al., 1998). Behavioral findings in nonpatient groups show that fearful and angry expressions capture attention more readily than happy or neutral expressions (Bannerman et al., 2009; Fox et al., 2000; Lundquist & Ohman, 2005; Yang et al., 2007). For example, in a visual search task, in which participants detect a target face in a display of distracter faces, threatening faces are detected faster than happy or neutral faces (Fox et al., 2000; Lundquist & Ohman, 2005). Neuroimaging studies in healthy volunteers provide further evidence of an attentional bias for threatening expressions under conditions of limited awareness (e.g., Whalen et al., 1998; Vuillemier, Armony, Driver, & Dolan, 2001). In one study (Whalen et al., 1998), masked presentations of faces with fearful expressions elicited greater activation in the amygdala relative to faces with happy expressions, even when participants could not report the occurrence of the stimuli.

Automatic processing of facial affect has also been studied in schizophrenia. In general, findings suggest that people with schizophrenia have comparable responses, if not a heightened sensitivity, to negative facial expressions relative to healthy volunteers (Hoschel & Irle, 2001; Kring, Kerr, & Earnst, 1999; Suslow, Droste, Roestel, & Arolt, 2005; Suslow, Roestel, & Arolt, 2003; van't Wout et al., 2007). Several of these experiments used a sequential priming task in which a facial expression (positive or negative) was used as a prime to bias the participant's interpretation of a neutral stimulus. The results showed that negative expressions influenced the way participants judged the neutral item even under conditions of restricted awareness of the prime's occurrence. For example, adults with schizophrenia rated neutral stimuli as more negative relative to controls when these stimuli were primed by subliminally presented negative expressions (e.g., disgust) (Hos-

chel & Irle, 2001; Suslow et al., 2003). In another study (van't Wout et al., 2007), participants with schizophrenia and controls viewed faces depicting different expressions and were asked to judge whether the face was male or female. Gender decisions for faces with fearful expressions were slower relative to those for neutral expressions, but the magnitude of slowing did not differ for patients and controls. These data suggested that automatic processing of fearful facial expressions was unimpaired in schizophrenia.

Although automatic processing of facial emotion and gaze direction have been studied in people with schizophrenia, no study to date has explored how the combination of these cues influences social attention in this group. Here, we used a task designed by Barnes, Kaplan, and Vaidya (2007) that allowed us to study eye gaze and facial expression concurrently. In this task, participants were asked to classify target words (LEFT/RIGHT) in the context of faces with eyes averted to the left or right. Barnes et al. found that accuracy to classify words was reduced for targets (e.g., LEFT) that were incongruent to the direction of gaze displayed on the face (e.g., eyes averted to the right) compared with targets (e.g., LEFT) that were congruent to the direction of gaze (e.g., eyes averted to the left). This new eye-gaze paradigm offers the opportunity to examine how emotional expression modulates attention to gaze direction in people with schizophrenia.

We expected background social cues to capture attention and influence classification performance in people with schizophrenia. On the basis of prior findings that eye gaze elicits an automatic shift of attention in the direction cued by gaze, we expected attention to be drawn in the direction of averted gaze. Because fearful expressions can be processed involuntarily and capture attention more effectively than other facial expressions (Vuillemier, 2005), we expected sensitivity to averted gaze would be greatest for faces with fearful expressions. Prior findings showed that participants with schizophrenia have a normal or heightened sensitivity to social and emotional cues (Langdon et al., 2006; van't Wout et al., 2007). Therefore, we predict that automatic processing of eye gaze and facial expression will not be impaired.

Experiment 1

Before we examined performance in the eye gaze task described above, it was important to verify that participants could detect facial expressions under the rapid presentation conditions (1000 ms) required for the task. In this preliminary experiment, we examined facial expression identification for face stimuli presented for 1000 ms.

Method

Participants

Table 1 shows the characteristics for participants in Experiments 1, 2, and 3. All patients were recruited from the outpatient mental health services at the Washington DC Veterans Affairs (VA) Medical Center. All met diagnostic criteria for schizophrenia or schizoaffective disorder according to the *DSM–IV* on the basis of a structured clinical interview (SCID; First, Spitzer, Gibbon, & Williams, 1997) and chart review. All control participants in these experiments were recruited using ads posted at the Washington DC VA Medical Center. Most were employees of the hospital and approximately half were veterans themselves. Controls were

Table 1
Characteristics of Participants in Experiments 1, 2, and 3

	Age (yrs)	Education (yrs)	Mother's education (yrs)	Father's education (yrs)	NART-R
Experiment 1					
Control					
Mean	49.3	13.5	12.1	12.6	97.7
SD	8.0	1.9	2.3	2.4	7.1
Schizophrenia					
Mean	48.8	12.8	11.3	12.0	97.5
SD	6.4	1.1	1.4	2.0	5.5
Experiment 2					
Control					
Mean	49.2	13.2	12.7	12.0	97.6
SD	5.3	1.7	2.1	1.7	8.4
Schizophrenia					
Mean	46.7	12.9	12.1	12.1	98.3
SD	9.7	1.6	3.0	3.9	7.9
Experiment 3					
Control					
Mean	45.9	13.7	12.52	12.8	103.6
SD	7.0	2.3	2.8	3.4	10.7
Schizophrenia					
Mean	47.4	12.6	11.68	12.2	100.2
SD	9.0	1.5	3.9	4.1	7.4

screened first using a telephone interview and then in person using a detailed interview to obtain medical and psychiatric histories, drug and alcohol use, academic history, and family history of mental illness. Controls had no significant medical illnesses, no history or current psychiatric illness, no history or current diagnosis of substance abuse, and to the best of their knowledge, no family history of mental illness.

In this preliminary experiment, 20 patients with a diagnosis of schizophrenia ($N = 13$) or schizoaffective disorder ($N = 7$) and 20 healthy controls participated. All patients were medicated with atypical ($N = 18$), typical ($N = 1$), or a combination of atypical and typical antipsychotic medications ($N = 1$). Controls did not differ from patients in terms of age, education level, parental education, and performance on the revised National Adult Reading Test (NART, Blair & Spreen, 1989), all *p* values > .05.

Expression Identification Task

Sixteen faces (eight male/eight female) portrayed in four different expressions (Neutral, Happy, Angry, and Fear) were selected from the NimStim Set of Facial Expressions (Tottenham et al., 2009). The NimStim collection is a large set of posed photographs displaying facial expressions in a racially and ethnically diverse group of actors. Normative data suggest that participants accurately identify expressions based on the intended expression (high validity), and there is high intraparticipant test–retest reliability (Tottenham et al., 2009).

The 48 facial expressions used in this experiment were presented as they appeared in the NimStim collection, with eyes in a direct gaze. Faces were shown one at a time in a pseudorandom order such that no more than three faces with the same expression were presented consecutively. Each trial began with a fixation point presented for 500 ms followed by the facial expression

presented for 1000 ms. An index card with verbal labels of the expressions remained in full view during the task. Participants were asked to identify aloud the expression on each face and the experimenter recorded accuracy. This task was administered as part of a battery of other facial processing tasks.

Results and Discussion

For control participants, the mean proportion of errors to identify expressions were: Neutral = .01, Happy = .01, Angry = .08, and Fear = .15. The corresponding proportions for patients were: Neutral = .07, Happy = .03, Angry = .11, and Fear = .17. A two-way analysis of variance (ANOVA), with Group (Patient vs. Control) as a between-subjects factor and Expression (Neutral, Happy, Angry, Fear) as a within-subjects factor, was performed on the number of errors. The results indicated a main effect of Expression, $F(3, 114) = 53.38$, $p < .0001$, suggesting negative expressions were more difficult to identify than neutral or positive expressions, and a main effect of Group, $F(1, 38) = 4.74$, $p < .05$, indicating lower overall performance for patients. There was no interaction of Group x Expression, $p > .05$. These findings replicate many previous reports showing that patients are less accurate than controls when asked to label facial expressions (Kohler et al., 2009). More relevant to the present concern is that participants detected the expressed emotion when faces were presented rapidly. Although participants will not be asked to explicitly label facial expressions in the eye gaze task studied here, these data confirm that both patients and controls identify the facial expressions at a relatively high rate (above 80%).

Experiment 2

In this experiment, we examined the effects of peripheral gaze and expression cues on the performance of a primary, attended to, task of word classification. Prior studies have shown that eye gaze and facial expression interact to influence attention. For example, attention is shifted in the direction signaled by eye gaze more in faces with fearful expressions than in faces with neutral expressions, especially in anxious individuals (Fox, Mathews, Calder, & Yiend, 2007; Holmes, Richards, & Green, 2006; Matthews, Fox, Yiend, & Calder, 2003; Tipples, 2006; although see Hietanen & Leppänen, 2003). These findings suggest that threat-related expressions potentiate attention to gaze direction.

Three hypotheses were tested in this experiment. First, we expected gaze direction to affect word classification performance, on the basis of findings that averted gaze elicits automatic shifts of attention in the direction the eyes are looking (Driver et al., 1999; Friesen & Kingstone, 1998). Second, we expected gaze effects to be greatest for faces with fearful expressions, because fearful faces have a processing advantage when stimuli are presented outside the focus of attention (Vuilleumier, 2005) and because fearful expressions potentiate attention to gaze direction (e.g., Tipples, 2006). Third, we predicted that gaze direction and emotional expression would influence performance in the primary task for participants with schizophrenia, on the basis of findings that patients are sensitive to automatic processing of these social cues (Langdon et al., 2006; Suslow et al., 2005; van't Wout et al., 2007).

Method

Participants

Participants were 24 patients (22 male, 2 female) and 24 non-psychiatric controls (20 male, 4 female). Nineteen of the 24 patients were diagnosed with schizophrenia and five with schizoaffective disorder. All patients were medicated with typical ($N = 1$), atypical ($N = 22$), or a combination of both typical and atypical antipsychotic medications ($N = 1$). The duration of their illness was on average 18.6 years ($SD = 11.2$). Control participants did not differ reliably from the patient group in terms of age, years of education completed, parental education level, and scores on the revised NART (Blair & Spreen, 1989), all p values $> .05$. Six patients in this experiment had participated in the previous experiment, with at least 6 months intervening between experimental sessions.

Tasks and Stimulus Materials

Figure 1 illustrates the stimuli used in this experiment. In the eye gaze task, manual responses were made to target words in the context of facial expressions with eyes averted to the right or left. The target word RIGHT or LEFT was positioned directly above the eye brows (Barnes et al., 2007). Target words were combined with gaze direction to form two types of trials: Congruent trials, in which the direction indicated by the target word (e.g., RIGHT) was the same as the direction of gaze (e.g., eyes averted to the right), and Incongruent trials, in which the direction of the target word (e.g., RIGHT) was opposite to the direction of gaze (e.g., eyes averted to the left). Target word and gaze direction were counterbalanced, and gaze direction did not predict the target word. The 48 facial expressions used in Experiment 1 were used in this experiment. Adobe Photoshop 4.0 was used to create faces with averted gaze to the far right and far left. For each expression (Neutral, Happy, Angry, and Fear), 32 items were presented in the Congruent condition and 32 were presented in the Incongruent condition. A Direct Gaze condition with eyes pointing straight ahead was also included to determine if emotional expressions in and of themselves influenced word classification. An additional 32 items for each expression were presented in the Direct Gaze condition. Thus in total there were 384 faces.

Following the methods of Barnes et al. (2007), we also included a "nonsocial" control task in which target words were paired with arrows instead of faces (see Figure 1). This task was included to verify that participants were sensitive to task-irrelevant directional cues. The target word RIGHT or LEFT was shown directly above an arrow pointing to the right or left (Turken & Swick, 1999). Target words and arrows were configured to form Congruent and Incongruent trials. The target word and arrow indicated the same direction in Congruent trials and the opposite direction in Incongruent trials. Trials in which the target word was presented above a rectangular bar that provided no information about direction were also included. There were 32 items in each of the three conditions (Congruent, Incongruent, No Direction) for a total of 96 items.

In addition, performance on the Letter-Number Sequencing Test (Wechsler, 1997) was assessed to examine the relation between attention and working memory and sensitivity to background social cues in participants with schizophrenia.

Procedure

All participants were tested individually. Items from the eye gaze task and arrow task were presented together in a single
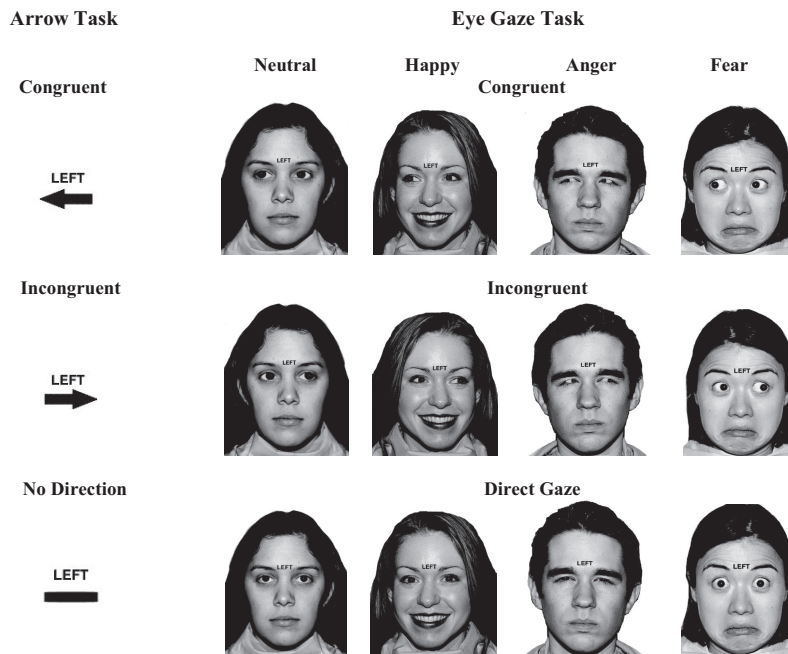

Figure 1. Examples of stimuli presented in the Congruent, Incongruent, and No Direction trials in the arrow task and the Congruent, Incongruent, and Direct Gaze trials for the eye gaze task. All faces were taken from the NimStim Face Stimulus Set.

pseudorandom order such that no more than three items of the same type were presented consecutively. The instructions, and the sequence and timing of events, were identical for both tasks. Participants were told that a word would appear on a face or with an object such as an arrow but that their only task was to press a key that corresponded to the word. Participants pressed the space bar to initiate the trial. A fixation point was shown for 500 ms followed by the stimulus for 1000 ms. The screen remained blank until the subject pressed a key labeled "R" for RIGHT on the right side of the keyboard ("/" key) or a key labeled "L" for LEFT on the left side of the keyboard ("z" key). Participants were told to respond as quickly as possible making as few mistakes as possible. Accuracy and reaction time were recorded for each trial.

Results

A trial was scored as correct if the participant pressed the key (R or L) that corresponded to the word. Accuracy was measured by summing the total number of errors across the 32 items in each condition for each participant. Reaction time (RT) was measured by calculating the mean of the median reaction time across the 32 items in each condition for each participant. Errors were excluded from RT analyses. Because the error rate was low in all conditions for both groups (i.e., mean number of errors ranged from .08 to 1.67), we focus on the response latency measure unless there is a significant difference in accuracy between the groups. A preliminary review of the data revealed a computer error which resulted in the repetition of a subset of items and the removal of one item in each condition in the arrow task and four items in each condition of the eye gaze task. Repeated items were removed and only the first instance of the item was scored. The final set of items, 30 per condition in the arrow task and 24 per condition in the eye gaze task, was counterbalanced across all conditions. We report the findings of the "nonsocial" arrow task separately from those of the eye gaze task.

Arrow Task

Accuracy. The mean number of errors ranged from .08 to 1.67 across all conditions. A two-way ANOVA on number of errors, with Group (Control vs. Patient) as a between-subjects factor and Congruency (Congruent, Incongruent, No Direction) as a within-subjects factor, showed effects of Group, $F(1, 46) = 5.33, p < .05$, and Congruency, $F(2, 92) = 11.79, p < .0001$. There was no interaction of Group $\times$ Congruency, $F < 1$. Post hoc pairwise comparisons (Bonferroni corrected) confirmed that errors on Incongruent trials (1.31) were higher than errors on both Congruent trials (.33), $t(47) = -4.00, p < .0001$, and No Direction trials (.56), $t(47) = 3.24, p < .01$. There was no difference in the number of errors between Congruent and No Direction trials.

Reaction time. A 2 (Group) $\times$ 3 (Congruency) ANOVA on RT data showed effects of Group, $F(1, 46) = 14.32, p < .0001$, and Congruency, $F(2, 92) = 22.07, p < .0001$. There was no interaction of Group $\times$ Congruency, $F < 1$. Post hoc pairwise comparisons (Bonferroni corrected) confirmed that RT for Incongruent trials (679 ms) was longer than RT for both Congruent trials (624 ms), $t(47) = -5.49, p < .0001$, and No Direction trials (645 ms), $t(47) = 4.49 p < .0001$, and RT for No Direction trials (645 ms) was longer than RT for Congruent trials (624 ms), $t(47) = -3.08, p < .01$.

Participants with schizophrenia made more errors overall and were slower to classify target words in the presence of arrows compared with controls. The key finding from this task is that participants with schizophrenia were neither more nor less sensitive to the effects of directional information provided by task-irrelevant arrow cues (see also Bustillo et al., 1997; Moran, Thaker, Smith, Cassidy, & Layne-Gedge, 1992).

Eye Gaze Task

A comparison between Congruent and Incongruent trials was conducted to test the effects of averted gaze on word classification performance. Direct Gaze trials were not included in this analysis because facial expressions with direct gaze are not neutral in terms of emotional valence or attentional demands. Perception of direct gaze involves different cognitive and neural processes than those in the perception of averted gaze (for reviews, see George & Conty, 2008; Senju & Johnson, 2009). Therefore, trials with direct gaze were not considered an appropriate comparison condition (Jonides & Mack, 1984). Direct Gaze trials were examined separately to provide an index of the effects of emotional expressions on word classification performance. Accuracy and RT data for averted gaze and direct gaze conditions are shown in Table 2.

Averted Eye Gaze

Accuracy. The mean number of errors ranged from .38 to 1.38 across all conditions, and did not differ between patients and controls, $F(1, 46) = 3.29, p > .05$. Therefore, the effect of averted gaze on word classification performance was examined using response latency.

Table 2

Reaction Times and Standard Deviations and % Error in the Averted Gaze Condition, for Incongruent and Congruent Trials, and the Direct Gaze Condition for Schizophrenia and Control Participants in Experiment 1

Facial expression	Averted gaze				Direct gaze	
	Control		Schizophrenia			
	I	C	I	C	Control	Schizophrenia
Neutral						
Mean RT	581	578	708	700	576	715
SD	66	75	159	170	55	172
% Error	2.1	2.6	4.3	5.8	1.9	4.0
Happy						
Mean RT	578	576	706	705	569	709
SD	62	60	168	160	55	164
% Error	1.6	1.6	5.2	3.3	5.0	6.3
Anger						
Mean RT	582	576	704	710	578	709
SD	59	68	154	165	65	182
% Error	3.0	1.8	5.8	3.5	3.3	6.1
Fear						
Mean RT	607	588	732	713	603	716
SD	75	61	170	164	67	171
% Error	3.1	2.4	4.0	2.6	1.9	4.7

Note. RT = reaction time; SD = standard deviation; I = incongruent trial; C = congruent trial.

Reaction time. A three-way ANOVA on RT data, with Group (Control vs. Patient) as a between-subjects factor, and Congruency (Incongruent vs. Congruent) and Expression (Neutral, Happy, Angry, and Fear) as within-subjects factors, showed an effect of Group, $F(1, 46) = 12.95$, $p = .001$, indicating slower responses for patients, an effect of Congruency, $F(1, 46) = 4.25$, $p < .05$, indicating slower responses for Incongruent trials relative to Congruent trials, and an effect of Expression, $F(3, 138) = 7.81$, $p < .0001$, suggesting slower responses overall on trials in the Fear condition. There were no interactions with Group, all $Fs < 1$. There was a trend toward a significant interaction of Congruency $\times$ Expression, $F(3, 138) = 2.46$, $p = .066$. Post hoc pairwise comparisons (Bonferroni corrected) indicated that RT for Incongruent trials was slower than RT for Congruent trials, but only for faces in the Fear condition, (Incongruent = 669 ms; Congruent = 651 ms), $t(47) = -3.01$, $p = .004$; all other p values $> .05$. The effect of averted gaze on primary task performance can also be shown as a difference score, calculated as RT for incongruent trials minus RT for congruent trials. The RT difference score provides an index of sensitivity to peripheral gaze and facial expression cues. As can be seen from Figure 2A, averted gaze affected primary task performance for items in the Fear condition.

As expected, patients' scores on the Letter-Number Sequencing Test ($M = 7.91$, $SD = 3.09$) were lower than those for controls ($M = 10.88$, $SD = 2.63$), T(45) = 3.55, $p < .001$. However, correlation analyses performed between Letter-Number Sequencing Test scores and the RT difference scores for patients showed that sensitivity to background social cues in the Neutral, Happy, Angry, and Fear conditions was not related to attention and working memory deficits measured in this test, all p values $> .05$.

Direct Eye Gaze

Accuracy. The mean number of errors ranged from .46 to 1.5 across all conditions. A 2 (Group) $\times$ 4 (Expression) ANOVA on number of errors yielded effects of Group, $F(1, 46) = 6.10$, $p < .05$, and Expression, $F(3, 138) = 5.88$, $p < .001$. There was no interaction of Group $\times$ Expression, F < 1. Post hoc pairwise comparisons (Bonferroni corrected) showed that errors were higher in the Happy condition (1.35) relative to those in both the Fear condition (.79), $p = .001$, and Neutral condition (.71), $p < .0001$.

Reaction time. A 2 (Group) $\times$ 4 (Expression) ANOVA on RT data showed effects of Group, $F(1, 46) = 12.95$, $p = .001$, and Expression, $F(3, 138) = 3.31$, $p < .05$. There was no interaction of Group $\times$ Expression, $p > .05$. Post hoc pairwise comparisons (Bonferroni corrected) indicated that responses were slower in the Fear condition (659 ms) relative to those in the Happy condition (639 ms), $p = .005$.

There was no correlation between Letter-Number Sequencing Test scores and RT in the Neutral, Happy, Angry, and Fear conditions for items in the Direct Gaze condition, all p values $> .05$. There was also no correlation between this test and accuracy in the Happy, Angry, and Fear conditions, all p values $> .05$. However, the number of errors in the Neutral condition was correlated to Letter-Number Sequencing Test performance, $r = .45$, $p = .03$, suggesting that patients with better attention and working memory made more errors. Given the direction of this correlation, it was interpreted as a spurious result.
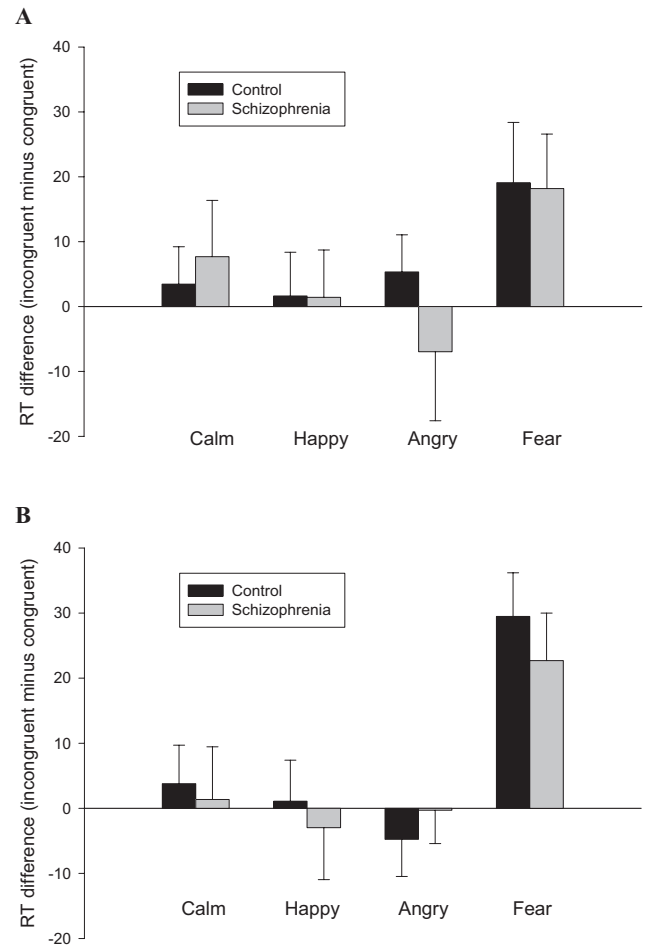
Figure 2. Reaction time (RT) difference in word classification performance between Incongruent trials and Congruent trials (calculated as mean of the median RT on Incongruent trials minus mean of the median RT on Congruent trials) as a function of facial expression in Experiment 2 (A) and eye expression in Experiment 3 (B). Error bars are plotted as standard errors.

Participants with schizophrenia were less accurate and slower to perform the primary task in the presence of faces with direct gaze relative to controls. For both groups, accuracy was reduced on trials with happy expressions and response latency was longer on trials with fearful expressions. These data show that facial expressions in and of themselves influence word classification performance in the absence of directional information from averted gaze.

Discussion

The main finding of this experiment was that background social information influenced the ability of participants with schizophrenia to perform the primary task of word classification. Responses to target words that were incongruent to the direction of gaze were slower than responses to target words that were congruent to the direction of gaze. Participants with schizophrenia were not more or less sensitive to averted gaze compared with controls. They were, however, more error-prone performing the primary task in the

context of faces with direct gaze. Deficits in attention and working memory observed in participants with schizophrenia did not appear to relate to their sensitivity to averted or direct gaze in facial expressions.

In this experiment, there was a trend for gaze direction to interact with facial expression. Follow-up analyses suggested that faces in the Fear condition potentiated attention to averted gaze. These findings make sense from an evolutionary perspective as averted gaze in fearful expressions may signal the direction of potential danger in the environment. In this regard, an automatic shift of attentional resources in the direction of gaze is adaptive.

However, we also observed that response latency to classify target words was longer on Incongruent, Congruent, and Direct Gaze trials with fearful facial expressions in the background. Studies in healthy volunteers have shown that threat-related stimuli capture and hold attention, and affect the ability of individuals to "disengage" their attention (Fox, Russo, Bowles, & Dutton, 2001). Similarly, responses to threat-related stimuli are slower in delusion-prone individuals (Green, Williams, & Davidson, 2000) and individuals with schizophrenia (van't Wout et al., 2007). Thus it is possible that attention to averted gaze in faces with fearful expressions was affected by general slowing in processing these faces. In the next experiment, we present only the eye region of the face to narrow the effects observed in this experiment to gaze direction.

Experiment 3

In this study we examined the effects of gaze direction on word classification by presenting only the eye region of each facial expression. The objective was to reduce the amount and complexity of details in the face stimuli that potentially draw and hold attention. We expected averted gaze in fearful eye expressions to influence word classification performance. This prediction is based on findings that the eyes in fearful expressions are the significant feature that communicate the expression of fear (Adolphs et al., 2005; Morris, de Bonis, & Dolan, 2002; Whalen, 1998).

Method

Participants

Twenty-five patients (19 male, 6 female) and 21 controls (15 male, 6 female) participated in this experiment. Three patients and two controls had also participated in Experiment 2 but more than a year had passed between the two experimental sessions in all cases. Of the 25 patients, 18 were diagnosed with schizophrenia and seven with schizoaffective disorder. Twenty-three patients were medicated with atypical antipsychotic medications and two were not receiving antipsychotic medications. The average length of their illness was 22.5 years (SD = 10.9). Controls did not differ from patients on the variables of age, education, parental education, or NART scores, all p values > .05.

Eye Gaze Task

The materials and procedure for this task were identical to those described in Experiment 1, with the exception that only the eye region of the face with the target word (RIGHT/LEFT) above the brow was presented. Each stimulus was fit into a standard rectan-

gular box with dimensions 1[1/8] × 2[1/2] inches presented in the center of the screen. As in the previous experiment, target words were combined with gaze direction to form Congruent and Incongruent trials. There were 32 Congruent trials and 32 Incongruent trials for each eye expression. An additional 32 Direct Gaze trials were included to test whether the expression conveyed in the eyes influenced word classification performance. There were a total of 384 trials in this task. In addition, the Letter-Numbering Sequencing Test was administered.

Results

As in Experiment 2, the trial was scored as correct if the subject pressed the key (R or L) corresponding to the target word. For each participant, accuracy (mean number of errors) and RT (mean of the median RT) were calculated for each condition. The mean number of errors ranged from .48 to 2.16 across all conditions for both groups. Accuracy and response latency data are shown in Table 3.

Averted Eye Gaze

Accuracy. The mean number of errors did not differ between the groups, $F(1, 44) = 1.72$, $p > .05$. Therefore, the effect of averted gaze was examined using response latency.

Reaction time. A 2 (Group) × 2 (Congruency) × 4 (Expression) ANOVA on RT data revealed an effect of Congruency, $F(1, 44) = 8.81$, $p < .01$, indicating longer RT for Incongruent relative to Congruent trials, and a trend toward a main effect of Group, $F(1, 44) = 3.84$, $p = .056$, suggesting slower responses for patients. There was an interaction of Congruency × Expression, $F(3, 132) = 6.91$, $p < .0001$, indicating that the effect of averted gaze

Table 3

Reaction Times and Standard Deviations and % Error in the Averted Gaze Condition for Incongruent and Congruent Trials, and the Direct Gaze Condition for Schizophrenia and Control Participants in Experiment 2

| Facial expression | Averted gaze | | | | Direct gaze | |
| | Control | | Schizophrenia | | | |
	I	C	I	C	Control	Schizophrenia
Neutral						
Mean RT	547	544	587	586	545	601
SD	71	60	88	91	76	133
% Error	1.9	1.9	5.0	3.0	2.1	3.3
Happy						
Mean RT	542	541	595	598	540	592
SD	64	71	97	102	67	122
% Error	1.5	2.1	6.1	2.9	1.9	2.8
Anger						
Mean RT	541	545	585	585	534	585
SD	59	63	86	87	51	97
% Error	1.9	2.5	6.1	2.3	1.8	3.4
Fear						
Mean RT	560	530	600	577	535	593
SD	78	60	93	95	66	104
% Error	3.4	1.6	6.8	2.3	1.6	3.1

Note. RT = reaction time; SD = standard deviation; I = incongruent trial; C = congruent trial.

varied as a function of eye expression. Post hoc comparisons (Bonferroni corrected) showed that RT for Incongruent trials was longer than RT for Congruent trials only in the Fear condition (Incongruent = 582; Congruent = 556), $T(45) = -5.13$, $p < .0001$, all other comparisons, $p > .05$. Figure 2B shows the RT difference score as a function of Expression (RT incongruent minus RT congruent). This measure provides an index of the sensitivity to background social cues. As can be seen, participants were sensitive to background gaze cues in the Fear condition.

Direct Eye Gaze

The error rate did not differ between the groups, $F(1, 44) = 1.58$, $p > .05$. In addition, the 2 (Group) × 4 (Expression) ANOVA on RT data for Direct Gaze trials showed no effect of Expression, $F(3, 132) = 2.02$, $p > .05$, and no Group × Expression interaction, $F < 1$. There was a trend for a main effect of Group, $F(1, 44) = 3.88$, $p = .055$, suggesting slower responses for patients overall.

As expected, scores on the Letter-Number Sequencing Test were lower for patients ($M = 9.6$, $SD = 2.18$) relative to those for controls ($M = 11.4$, $SD = 3.20$), $T(44) = 2.29$, $p < .05$. However, there was no correlation between performance on the Letter-Number Sequencing Test and performance in the averted gaze or direct gaze conditions, all p values $> .05$.

Discussion

In this experiment, we confirmed the finding that averted gaze influenced primary task performance in the Fear condition. These data indicate that the effect of averted gaze on focal attention could not be attributed to general slowing in the processing of faces with fearful expressions. The eye region of fearful expressions was sufficient to capture attention in this task for both participants with schizophrenia and controls. As in Experiment 2, sensitivity to background social and emotional cues was not correlated to attention and working memory performance in the Letter-Number Sequencing Test. However, this does not rule out the possibility that other neuropsychological deficits found in individuals with schizophrenia might relate to the processing of social and emotional cues in this task.

General Discussion

In this research, we examined whether patients with schizophrenia were sensitive to background social cues when their attention was directed to another task. The results showed that gaze cues influenced performance on the primary task, but this effect was modulated by emotional expression. Sensitivity to averted gaze occurred only for faces or eyes that expressed fear. This pattern of results did not differ for patients and control participants.

Heightened sensitivity to averted gaze in fearful expressions could be attributed to a number of factors. First, fearful expressions draw attention with little conscious effort (Vuilleumier, 2005; Whalen et al., 1998). Therefore, when there is competition for attention, threatening stimuli have a processing advantage relative to neutral stimuli. Second, fearful expressions with averted gaze are rated as more emotionally intense than angry expressions with averted gaze (Adams & Kleck, 2005). The coupling of

averted gaze in faces or eyes expressing fear might have made these faces more emotionally intense and therefore harder to ignore. A third possibility relates to the physical properties of the widened eyes in fear expressions. The distinct contrast between the dark iris and white sclera conveys essential information about gaze direction (Riciardelli, Bayliss, & Driver, 2000; Tipples, 2005). Similarly, widened eyes in fearful facial expressions communicate the most important information about the expression of fear (Morris et al., 2002). Neuroimaging shows that eyes expressing fear elicit greater activation in the amygdala relative to eyes expressing happiness (Whalen et al., 2004). Our findings suggest that participants selectively attend to gaze and emotion cues that provide information about potential sources of threat.

The data also indicate that the patients were as sensitive to threat-related signals as were controls. These findings are consistent with a growing literature suggesting that patients with schizophrenia have normal or heightened reactivity to emotional stimuli (Hoschel & Irle, 2001; Suslow et al., 2003; Suslow et al., 2005; van't Wout et al., 2007), despite many findings that explicit processing of social information is impaired. This pattern may be understood within models that describe a stream of processing involved in encoding and responding to social and emotional information (Lieberman, Gaunt, Gilbert, & Trope, 2002; Ochsner, 2008; Speechley & Ngan, 2008). According to dual-stream processing models, there are two separate but interacting processes that represent endpoints on a continuum of processes (e.g., Lieberman et al., 2002). One process is automatic, experiential, and effortless (reflexive), whereas the other is conscious, sequential, and controlled (reflective). It appears that automatic or effortless processing of emotional cues is not impaired in schizophrenia, whereas controlled reflective judgments of others' emotions, moods, and traits are impaired (e.g., Edwards et al., 2001; Kingston et al., 2000).

The data reported here have implications for understanding the neural systems involved in social attention in schizophrenia. The amygdala and superior temporal sulcus are involved in gaze processing and orienting attention to emotionally significant stimuli (Hoffman & Haxby, 2000; Kawashima et al., 1999; Hooker et al., 2003). These structures are also fundamental components of the neural system involved in complex social judgments. Research has indicated that patients with schizophrenia have structural pathology and abnormal brain activity in regions that mediate the processing of gaze and threat, such as the amygdala and superior temporal sulcus (e.g., Aleman & Kahn, 2005; Brunet-Gouet & Decety, 2006; Kohler et al., 2008). However, the data here do not reflect a functional impairment in processing averted gaze in faces or eyes that express fear. It remains to be seen whether such automatic responses are supported by the amygdala and/or the superior temporal sulcus. Neuroimaging may help to elucidate whether individuals with schizophrenia process averted gaze in fearful expressions as emotional cues that signal a potential source of threat or as symbolic cues that lack affective significance.

Unexpectedly, participants with schizophrenia were more error-prone performing the primary task in the context of faces with direct gaze, albeit errors overall were low in this task. In previous studies of gaze discrimination, in which participants are asked to make explicit judgments about the direction of another's gaze, people with schizophrenia show the tendency to misinterpret deviated gaze as gaze directed at them (Hooker & Park, 2005; Rosse

et al., 1994). In contrast to these two previous reports, Franck et al. (2002) did not find this error pattern using a threshold measure of the angle that distinguished direct from averted gaze. However, they did find that patients took longer to decide "direct versus averted" gaze compared with "right versus left" gaze. There was no difference in response latency for these two gaze decisions for controls. Franck et al. suggested that low-level perceptual processes of gaze discrimination were intact in schizophrenia, but that patients' slower responses to judge whether or not someone was looking at them reflected the need for greater top-down control to judge mutual gaze. The eye gaze task used here did not require intentional judgments about gaze direction. Nonetheless, direct gaze seemed to interfere with cognitive activity in schizophrenia even when gaze was irrelevant to the task.

One limitation of the study is that we were unable to assess the role of individual differences and symptom variables in attention to social cues in people with schizophrenia. Negative symptoms (e.g., flat affect and anhedonia) have been associated with automatic processing of facial affect in schizophrenia (Suslow et al., 2003; Suslow et al., 2005) and a recent meta-analysis has suggested that both positive and negative symptoms of schizophrenia moderate impairments in facial expression identification (Kohler et al., 2009). In addition, trait anxiety is related to sensitivity to gaze cues in fearful expressions (Matthews et al., 2003; Tipples, 2006). Future work is needed to examine the role of positive and negative symptoms, as well as symptoms of anxiety, in the automatic processing of gaze and emotional expressions in people with schizophrenia.

Attention to gaze and facial expression are important to the regulation of interpersonal communication. In this research, we showed that patients had a normal response to these cues, under conditions that did not require conscious reflection. Cues that signal potential danger attracted attention and guided responses in people with schizophrenia. Although many findings indicate impairments in explicit social processing, such as inferring the feelings and mental states of others, these data suggest that implicit or automatic processing of emotional cues is intact in schizophrenia. A clearer understanding of the interplay between conscious and nonconscious modes of affective processing may help to address the social impairments in schizophrenia.

References

Adams, R. B., & Kleck, R. E. (2005). Effects of direct and averted gaze on the perception of facially communicated emotion. *Emotion, 5,* 3–11.

Adolphs, R., Gosselin, F., Buchanan, T. W., Tranel, D., Schyns, P., & Damasio, A. R. (2005). A mechanism for impaired fear recognition after amygdala damage. *Nature, 433,* 68–72.

Aleman, A., & Kahn, R. S. (2005). Strange feelings: Do amygdala abnormalities dysregulate the emotional brain in schizophrenia? *Progress in Neurobiology, 77,* 283–298.

Bannerman, R. L., Milders, M., de Gelder, B. & Sahraie, A. (2009). Orienting to threat: Faster localization of fearful facial expressions and body postures revealed by saccadic eye movements. *Proceedings of the Royal Society B:Biological Sciences, 276,* 1635–1641.

Barnes, K. A., Kaplan, L. A., & Vaidya, C. J. (2007). Developmental differences in cognitive control of socio-affective processing. *Developmental Neuropsychology, 32,* 787–807.

Blair, J. R., & Spreen, O. (1989). Predicting premorbid I.Q.: A revision of the National Adult Reading Test. *Clinical Neuropsychologist, 43,* 129–136.

Brunet-Gouet, E., & Decety, J. (2006). Social brain dysfunctions in schizophrenia: A review of neuroimaging studies. *Psychiatry Research: Neuroimaging, 148,* 75–92.

Bustillo, J. R., Thaker, G., Buchanan, R. W., Moran, M., Kirkpatrick, B., & Carpenter, W. T. Jr. (1997). Visual information-processing impairments in deficit and nondeficit schizophrenia. *American Journal of Psychiatry, 154,* 647–654.

Couture, S. M., Penn, D. L., & Roberts, D. L. (2006). The functional significance of social cognition in schizophrenia: A review. *Schizophrenia Bulletin, 31,* 21–42.

Driver, J., Davis, G., Ricciardelli, P., Kidd, P., Maxwell, E., & Baron-Cohen, S. (1999). Gaze perception triggers reflexive visuospatial orienting. *Visual Cognition, 6,* 509–540.

Edwards, J., Jackson, H. J., & Pattison, P. E. (2001). Emotion recognition via facial expression and affective prosody in schizophrenia: A methodological review. *Clinical Psychology Review, 22,* 789–832.

First, M. B., Spitzer, R. L., Gibbon, M., & Williams, J. B. W. (1997). *User's guide for the Structured Clinical Interview forDSM-IV Axis 1 Disorders—Clinician Version (SCID–CV).* Washington, DC: American Psychiatric Press.

Fox, E., Lester, V., Russo, R., Bowles, R. J., Pichler, A., & Dutton, K. (2000). Facial expressions of emotion: Are faces detected more efficiently? *Cognition & Emotion, 14,* 61–92.

Fox, E., Mathews, A., Calder, A. J., & Yiend, J. (2007). Anxiety and sensitivity to gaze direction in emotionally expressive faces. *Emotion, 7,* 478–486.

Fox, E., Russo, R., Bowles, R., & Dutton, K. (2001). Do threatening stimuli draw or hold visual attention in subclinical anxiety? *Journal of Experimental Psychology: General, 130,* 681–700.

Franck, N., Montoute, T., Labruyère, N., Tiberghien, G., Marie-Cardine, M., Daléry, J., . . . Georgieff, N. (2002). Gaze direction determination in schizophrenia. *Schizophrenia Research, 56,* 225–234.

Friesen, C. K., & Kingstone, A. (1998). The eyes have it! Reflexive orienting is triggered by nonpredictive gaze. *Psychonomic Bulletin & Review, 5,* 490–495.

Friesen, C. K., Ristic, J., & Kingstone, A. (2004). Attentional effects of counterpredictive gaze and arrow cues. *Journal of Experimental Psychology: Human Perception and Performance, 30,* 319–329.

George, N., & Conty, L. (2008). Facing the gaze of others. *Clinical Neurophysiology, 38,* 197–207.

Green, M. J., Williams, L. M., & Davidson, D. J. (2001). Processing of threat related affect is delayed in delusion prone individuals. *British Journal of Clinical Psychology, 40,* 157–165.

Gur, R. E., McGrath, C., Chan, R. M., Schroeder, L., Turner, T., Turetsky, B. I., . . . Gur, R. C. (2002). An fMRI study of facial emotion processing in patients with schizophrenia. *American Journal of Psychiatry, 159,* 1992–1999.

Hempel, A., Hempel, E., Schonknecht, P., Stippich, C., & Schroder, J. (2003). Impairment in basal limbic function in schizophrenia during affect recognition. *Psychiatry Research: Neuroimaging, 122,* 115–124.

Hietanen, J. K., & Leppänen, J. M. (2003). Does facial expression affect attention orienting by gaze direction cues? *Journal of Experimental Psychology: Human Perception and Performance, 29,* 1228–1243.

Hoffman, E. A., & Haxby, J. V. (2000). Distinct representation of eye gaze and identity in the distributed human neural system for face perception. *Nature Neuroscience, 3,* 80–84.

Holmes, A., Richards, A., & Green, S. (2006). Anxiety and sensitivity to eye gaze in emotional faces. *Brain and Cognition, 60,* 282–294.

Hooker, C., & Park, S. (2005). You must be looking at me: The nature of gaze perception in schizophrenia patients. *Cognitive Neuropsychiatry, 10,* 327–345.

Hooker, C. I., Paller, K. A., Gitelman, D. R., Parrish, T. B., Mesulam, M. M., & Reber, P. J. (2003). Brain networks for analyzing eye gaze. *Brain Research Cognitive Brain Research, 17,* 406–418.

Hoschel, K., & Irle, E. (2001). Emotional priming of facial affect identification in schizophrenia. *Schizophrenia Bulletin, 27,* 317–327.

Jonides, J., & Mack, R. (1984). On the cost and benefit of cost and benefit. *Psychological Bulletin, 96,* 29–44.

Kawashima, R., Sugiura, M., Kato, T., Nakamura, A., Hatano, K., Ito, K., . . . Nakamura, K. (1999). The human amygdala plays an important role in gaze monitoring-A PET study. *Brain, 122,* 779–783.

Kee, K. S., Green, M. F., Mintz, J., & Brekke, J. S. (2003). Is emotion processing a predictor of outcome in schizophrenia? *Schizophrenia Bulletin, 29,* 487–497.

Kington, J. M., Jones, L. A., Watt, A. A., Hopkin, E. J., & Williams, J. (2000). Impaired eye expression recognition in schizophrenia. *Journal of Psychiatry Research, 34,* 341–347.

Kohler, C. G., Loughead, J., Ruparel, K., Indersmitten, T., Barrett, F. S., Gur, R. E., & Gur, R. C. (2008). Brain activation during eye gaze discrimination in stable schizophrenia. *Schizophrenia Research, 99,* 286–293.

Kohler, C. G., Walker, J. B., Martin, E. A., Healey, K. M., & Moberg, P. J. (2009). Facial emotion perception in schizophrenia: A Meta-analytic review. *Schizophrenia Bulletin,* 2009 Mar 27 [Epub ahead of print].

Kring, A. M., Kerr, S. L., & Earnst, K. S. (1999). Schizophrenic patients show facial reactions to emotional facial expressions. *Psychophysiology, 36,* 186–192.

Langdon, R., Corner, T., McLaren, J., Coltheart, M., & Ward, P. B. (2006). Attentional orienting triggered by gaze in schizophrenia. *Neuropsychologia, 44,* 417–429.

Langton, S. R., & Bruce, V. (1999). Reflexive visual orienting in response to the social attention of others. *Visual Cognition, 6,* 541–567.

Lieberman, M. D. (2007). Social cognitive neuroscience: A review of core processes. *Annual Review of Psychology, 58,* 259–289.

Lieberman, M. D., Gaunt, R., Gilbert, D. T., & Trope, Y. (2002). Reflection and reflexion: A social cognitive neuroscience approach to attributional inference. In: M. Zanna (Ed.), *Advances in experimental social psychology* (pp. 199–249). New York: Academic Press.

Lundqvist, D., & Öhman, A. (2005). Emotion regulates attention: The relation between facial configurations, facial emotion, and visual attention. *Visual Cognition, 12,* 51–84.

Mandal, M. K., Pandey, R., & Prasad, A. B. (1998). Facial expressions of emotions and schizophrenia: A review. *Schizophrenia Bulletin, 24,* 399–412.

Mathews, A., Fox, E., Yiend, J., & Calder, A. (2003). The face of fear: Effects of eye gaze and emotion on visual attention. *Visual Cognition, 10,* 823–835.

Moran, J. M., Thaker, J. K., Smith, D., Cassidy, S., & Layne-Gedge, J. (1992). Shifts in covert visual attention in schizophrenic patients and normal controls. *Biological Psychiatry, 32,* 617–620.

Morris, J. S., deBonis, M., & Dolan, R. J. (2002). Human amygdala responses to fearful eyes. *Neuroimage, 28,* 249–255.

Ochsner, K. N. (2008). The social-emotional processing stream: Five core constructs and their translational potential for schizophrenia and beyond. *Biological Psychiatry, 64,* 48–61.

Phillips, M. L., Williams, L., Senior, C., Bullmore, B. T., Brammer, M. J., Andrew, C., . . . David, A. S. (1999). A differential neural response to threatening and non-threatening negative facial expressions in paranoid and non-paranoid schizophrenics. *Psychiatry Research, 92,* 11–31.

Pijnenborg, G. H. M., Withaar, F. K., Evans, J. J., Van Den Bosch, R. J., Timmerman, M. E., & Brouwer, W. H. (2009). The predictive value of measures of social cognition for community functioning in schizophrenia: Implications for neuropsychological assessment. *Journal of the International Neuropsychological Society, 15,* 239–247.

Riciardelli, P., Bayliss, G., & Driver, G. (2000). The positive and negative of human expertise in gaze perception. *Cognition, 77,* B1–B14.

Rosse, R. B., Kendrick, K., Wyatt, R. J., Isaac, A., & Deutsch, S. I. (1994). Gaze discrimination in patients with schizophrenia: Preliminary report. *American Journal of Psychiatry, 151,* 919–921.

Russel, T. A., Rubia, K., Bullmore, E. T., Soni, W., Suckling, J., Brammer, M. J., . . . Sharma, T. (2000). Exploring the social brain in schizophrenia: Left prefrontal underactivation during mental state attribution. *Amercan Journal of Psychiatry, 157,* 2040–2042.

Senju, A., & Johnson, M. H. (2009). The eye contact effect: Mechanisms and development. *Trends in Cognitive Sciences, 13,* 127–134.

Speechley, W. J., & Ngan, E. T. (2008). Dual-stream modulation failure: A novel hypothesis for the formation and maintenance of delusions in schizophrenia. *Medical Hypotheses, 70,* 1210–1214.

Suslow, T., Droste, T., Roestel, C., & Arolt, V. (2005). Automatic processing of facial emotion in schizophrenia with and without affective negative symptoms. *Cognitive Neuropsychiatry, 10,* 35–56.

Suslow, T., Roestel, C., & Arolt, V. (2003). Affective priming in schizophrenia with and without affective negative symptoms. *European Archives of Psychiatry and Clinical Neuroscience, 253,* 292–300.

Tipples, J. (2005). Orienting to eye gaze and face processing. *Journal of Experimental Psychology: Human Perception and Performance, 31,* 843–856.

Tipples, J. (2006). Fear and fearfulness potentiate automatic orienting to eye gaze. *Cognition & Emotion, 20,* 309–320.

Tottenham, N., Tanaka, J., Leon, A. C., McCarry, T., Nurse, M., Hare, T. A., . . . Nelson, C. (2009). The NimStim set of facial expressions: Judgments from untrained research participants. *Psychiatry Research, 168,* 242–249.

Turken, A. U., & Swick, D. (1999). Response selection in the human anterior cingulate cortex. *Nature Neuroscience, 2,* 920–924.

van't Wout, M., Aleman, A., Kessels, R. P., Cahn, W., de Haan, E. H., & Kahn, R. S. (2007). Exploring the nature of facial affect processing deficits in schizophrenia. *Psychiatry Research, 150,* 227–235.

Vuilleumier, P. (2005). How brains beware: Neural mechanisms of emotional attention. *Trends in Cognitive Science, 9,* 585–594.

Vuilleumier, P., Armony, J. L., Driver, J., & Dolan, R. J. (2001). Effects of attention and emotion on face processing in the human brain: An event-related fMRI study. *Neuron, 30,* 829–841.

Wechsler, D. (1997). *Wechsler Memory Scale* (3rd Ed). San Antonio, TX: The Psychological Corporation.

Whalen, P. J., Kagan, J., Cook, R. G., Davis, F. C., Kim, H., Polis, S., . . . Johnstone, T. (2004). Human amygdala responsivity to masked fearful eye whites. *Science, 306,* 2061.

Whalen, P. J., Rauch, S. L., Etcoff, N. L., McInerney, S. C., Lee, M. B., & Jenike, M. A. (1998). Masked presentations of emotional facial expressions modulate amygdala activity without explicit knowledge. *Journal of Neuroscience, 18,* 411–418.

Yang, E., Zald, D. H. & Blake, R. (2007). Fearful expressions gain preferential access to awareness during continuous flash suppression. *Emotion, 7,* 882–886.