



Sensorimotor gating, orienting and social perception in schizophrenia

Jonathan K. Wynn^{a,b,*}, Mark J. Sergi^{b,c}, Michael E. Dawson^d,
Anne M. Schell^e, Michael F. Green^{a,b}

^a*Department of Psychiatry and Biobehavioral Science, Geffen School of Medicine at UCLA, United States*

^b*VA Greater Los Angeles Healthcare System, United States*

^c*Department of Psychology, California State University, Northridge, United States*

^d*Department of Psychology, University of Southern California, United States*

^e*Department of Psychology, Occidental College, United States*

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Abstract

Basic neurocognition and social cognition appear to influence the social impairments of persons with schizophrenia. This study examined relationships between two very basic automatic processes (i.e., sensorimotor gating and orienting) and social perception in schizophrenic patients. Thirty outpatients with schizophrenia completed psychophysiological measures of sensorimotor gating (prepulse inhibition, PPI), orienting (prepulse facilitation, PPF), and social perception (the Half Profile of Nonverbal Sensitivity, Half PONS). A median split was used to divide patients into poor and good gaters and poor and good orienters. Analyses revealed that patients with good PPI scored significantly higher on the Half PONS than patients with poor PPI. PPI showed a significant correlation ($r=-0.54$) with Half PONS performance, indicating that schizophrenia patients who were better able to gate out competing stimuli (i.e., less startle) were also better at detecting relevant social cues. Orienting (PPF) and social perception were not related. This study is the first to our knowledge to demonstrate an association between sensorimotor gating and social perception. The findings are consistent with other studies that have demonstrated relationships between basic neurocognition and social cognition. By showing a link between sensorimotor gating and social perception, this study supports social cognition's potential role as a mediator of the relationship between neurocognition and social functioning in schizophrenia.

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* Corresponding author. VA Greater Los Angeles Healthcare System, 11301 Wilshire Boulevard (MIRECC 210A), Building 210, Los Angeles, CA 90073, United States. Tel.: +1 310 478 3711x44957; fax: +1 310 268 4056.

E-mail address: jkwynn@ucla.edu (J.K. Wynn).

1. Introduction

Persons with schizophrenia experience deficits in the modification of startle eyeblink response measures thought to index sensorimotor gating (Braff et al., 1978; 1992) and orienting/activation (Graham, 1975; Wynn et al., 2004). Prepulse inhibition is a measure of sensorimotor gating, which is the ability to block out, or gate, competing, non-relevant information from interfering with the ongoing processing of other stimuli. In a typical PPI paradigm, the presentation of a weak stimulus (the prepulse) approximately 30–500 ms prior to a startling stimulus inhibits the magnitude of the startle eyeblink relative to when the startling stimulus is presented by itself. Schizophrenia patients consistently show reduced prepulse inhibition in comparison to normal controls (Braff et al., 1978, 1992), suggesting dysfunction in their basic sensorimotor gating processes. Orienting or activation refers to underlying processes involved with passive attention to input (Siddle, 1991). Prepulse facilitation (PPF) is an operational measure of orienting/activation. In the PPF paradigm, the presentation of the weak prepulse stimulus at least 1000 ms before the startling stimulus enhances the amount of startle eyeblink, particularly when the prepulse and the startle stimulus are in the same sensory modality. A previous study from our laboratory found reduced prepulse facilitation in schizophrenia patients and their siblings compared to normal controls (Wynn et al., 2004), suggesting a dysfunction in the basic orienting response. While much is known about the neural substrates and neurophysiology of PPI (Geyer and Braff, 1987), and to a lesser extent PPF, little is known about how deficits in PPI or PPF affect the every day functioning of persons with schizophrenia.

Impairments in social cognition—the ability to construct representations about others, oneself, and relations between others and oneself (Adolphs, 2001)—are common in persons with schizophrenia (Penn et al., 1997; Pinkham et al., 2003), and may contribute to impairments in social functioning (e.g., Corrigan and Toomey, 1995; Hooker and Park, 2002; Mueser et al., 1996; Penn et al., 1996, 2002). One key aspect of social cognition involves the perception of social cues such as facial expressions, voice tone, and gestures. Social cue perception may be assessed with emotion perception or social perception tasks. In

emotion perception tasks, participants label or select the emotional state of a person displaying one or more social cues. In social perception tasks, participants must appreciate the social context to accurately label or select the situational context that gave rise to the social cues (e.g., talking to a lost child, talking about the death of a friend) and questions may involve multiple interpersonal dimensions (e.g., mood state, intimacy, veracity, status). Impaired social cue perception has been observed when tasks involve affective facial expressions (e.g., Addington and Addington, 1998; Archer et al., 1994; Hellewell et al., 1994; Pollard et al., 1995) and when tasks involve dynamic displays of multiple social cues (e.g., Corrigan et al., 1990; Corrigan and Green, 1993).

Social cognitive variables such as social cue perception may mediate the frequently observed relationship between neurocognition and functional outcome in schizophrenia (Green, 1996; Green and Nuechterlein, 1999). The potential mediating role of social cue perception has been supported by associations between social cue perception and several aspects of neurocognition including early visual processing assessed with visual masking procedures (Sergi and Green, 2003) and the Span of Apprehension Test (Addington and Addington, 1998; Corrigan et al., 1994; Kee et al., 1998), visual attention as measured by the Continuous Performance Test (Addington and Addington, 1998; Bryson et al., 1997), verbal recognition memory assessed with the Rey Auditory Verbal Learning Test (Corrigan et al., 1994), and executive functioning as measured by the Wisconsin Card Sorting Test (Bryson et al., 1997). We are unaware of any studies that examined relations between social cue perception and mostly automatic processes such as sensorimotor gating or orienting in schizophrenia.

The objective of the present study was to examine relations between sensorimotor gating, orienting, and social perception in schizophrenia. Thirty outpatients with schizophrenia completed a PPI assessment of sensorimotor gating, a PPF assessment of orienting, and a videotape-based measure of social perception. Based on prior findings of relationships between varied aspects of neurocognition and social perception, we hypothesized that impaired sensorimotor gating (less prepulse inhibition) would be associated with impaired social perception in schizophrenia. We

further hypothesized that impaired social perception would be associated with impaired orienting (less prepulse facilitation).

2. Materials and methods

2.1. Participants

Thirty outpatients with schizophrenia (29 males and 1 female) participated in the present study after providing their written informed consent. Participants were part of the study “Early Visual Processing in Schizophrenia” (M.F. Green, P.I.) and were recruited from the treatment clinics of the VA Greater Los Angeles Healthcare System, which explains the high proportion of males. All patients met criteria for schizophrenia based on interview with the Structured Clinical Interview for DSM-IV Axis I Disorders (SCID; First et al., 1997). All SCID interviewers were trained to administer the SCID in the Diagnosis and Psychopathology Unit of the UCLA Clinical Research Center for the Study of Schizophrenia and demonstrated agreement between their ratings and the consensus ratings of the Center’s diagnosticians (minimum Kappa coefficient of 0.75). Patients were excluded for mental retardation, identifiable neurological conditions, and substance dependence in the last 6 months. Table 1

shows the age, education, and symptom ratings for patients with high and low PPI and high and low PPF (based on median splits).

2.2. Measures

2.2.1. Sensory gating and orienting

A prepulse inhibition task was used to assess sensory gating and a prepulse facilitation task was used to assess orienting (described in Wynn et al., 2004). Subjects were seated in a comfortable chair. Two miniature (4 mm) Ag–AgCl electrodes were placed on the surface of the skin of the left eye, the first under the pupil and the other approximately 1 cm lateral to the first. A ground electrode was placed on the left mastoid. Electrical resistances were less than 5000 Ω . Eyeblinks were recorded as electromyographic (EMG) activity using a Coulbourn S75-01 bioamplifier and digitized for later analysis. The EMG activity was filtered with an 8-Hz high pass filter and a 1000-Hz low pass filter, along with a 60-Hz notch filter. The data were collected as raw EMG at 2000 Hz beginning 200 ms prior to startle stimulus onset and 300 ms after startle stimulus onset.

Prepulses used to assess PPI consisted of four 20 ms presentations of 75 dB(A) SPL (sound pressure level) white noise bursts (20–20,000 Hz) with a near-instantaneous rise/fall time with a stimulus onset

Table 1
Demographics and results

| Measure | Good inhibitors | Poor inhibitors | Good facilitators | Poor facilitators |
|---|-----------------|-----------------|-------------------|-------------------|
| Age (SD) | 41.0 (11.0) | 42.4 (7.8) | 41.4 (7.7) | 42.1 (10.9) |
| Sex (M:F) | 14:1 | 15:0 | 15:0 | 14:1 |
| Half-PONS (total correct out of 110) (SD) | 85.0 (5.5)* | 78.4 (5.2) | 81.4 (7.2) | 82.0 (5.4) |
| Prepulse inhibition/facilitation (SD) | −89.7% (10.6)* | −35.7% (24.8) | +55.1% (62.1)* | −30.4% (18.3) |
| BPRS total (SD) | 52.6 (10.7) | 48.5 (10.5) | 52.1 (8.5) | 49.1 (12.5) |
| BPRS subscales | | | | |
| Thinking disturbance | 3.55 | 3.12 | 3.38 | 3.29 |
| Anxiety/depression | 3.14* | 2.45 | 2.69 | 2.90 |
| Withdrawal/retardation | 2.26 | 2.21 | 2.50 | 1.98 |
| Hostile/suspicious | 2.26 | 2.36 | 2.50 | 2.12 |
| SANS global ratings | | | | |
| Affective flattening | 2.21 | 1.92 | 2.15 | 2.00 |
| Alogia | 1.00 | 1.15 | 1.38 | 0.79 |
| Avolition | 2.79* | 1.77 | 2.00 | 2.57 |
| Anhedonia | 2.71 | 2.23 | 2.23 | 2.71 |
| Inattention | 1.36 | 1.75 | 1.75 | 1.36 |

* $p < 0.05$.

asynchrony (SOA) of 120 ms; for PPF there were four, 5000 ms presentations of 75 dB(A) 1000 Hz tones with a rise/fall time of 25 ms with an SOA of 4500 ms. The startle stimulus consisted of a 50 ms, near instantaneous rise/fall time, 105 dB(A) white noise burst (20–20,000 Hz). In addition to the startle stimuli used to assess PPI or PPF, there were also 15 intertrial interval (ITI) startle probes presented throughout the experiment, varying from 8 to 11 s into the ITI. All stimuli were presented in a mixed, pseudo-random order. Responses to these 15 ITI startle alone bursts were averaged to create a startle-alone baseline average for subjects. ITIs varied from 30 to 36 s. No imposed background noise was used. Auditory stimuli were digitized on a computer, presented through the computer's sound card, and presented binaurally through headphones. Decibel levels were recorded with a Realistic sound level meter using a Quest Electronics earphone coupler. Assessment of PPI and PPF took approximately 20 min to complete.

Eyeblinks were scored off line using the raw, rectified EMG signal. Prestartle EMG activity was defined as occurring 100 ms prior to startle stimulus onset. Peak startle activity was defined as a 20-ms average of the peak activity (10 ms pre-, 10 ms post-peak) occurring within a window of 20–120 ms after startle stimulus onset. Eyeblink amplitude was the difference between the peak startle activity and the prestartle EMG activity. Startle eyeblink modification scores were then calculated as percent change scores: [(prepulsed startle–startle alone)/(startle alone)*100]. Thus, a negative percent change score indicates inhibition of the startle eyeblink whereas a positive percent change score indicates facilitation of the startle eyeblink. Percent change units are preferred over difference scores because difference scores in absolute μV units are correlated with baseline startle blink amplitude whereas percent change scores are not, removing any dependence on baseline startle amplitude (Jennings et al., 1996).

2.2.2. Social perception

Participants were administered the first 110 scenes (out of 220) of the Profile of Nonverbal Sensitivity (PONS, Rosenthal et al., 1979, which is referred to as the Half PONS, Ambady et al., 1995). The internal

consistency of the PONS ranges from 0.86 to 0.92 and its median test–retest reliability is 0.69 (Ambady et al., 1995). Scenes of this videotape-based measure last two seconds and contain the facial expressions, voice intonations, and/or bodily gestures of a Caucasian female. That is, some scenes contain only one of these social cues, others contain two, and others all three. After watching each scene, participants were asked to select from two labels (e.g., saying a prayer, talking to a lost child) the one that best described the most likely context for the social cue(s). As in prior studies that have used the PONS with schizophrenic patients (e.g., Monti and Fingeret, 1987; Toomey et al., 1997), the administration procedure was modified to reduce the measure's demands on sustained attention and reading comprehension. Prior to each scene, the videotape was paused as the experimenter read the two possible labels aloud and the participant read the labels silently from a 4×6 in. index card. To ensure that the participants understood the task, a practice sample of five scenes was randomly selected from the second 110 items of the PONS and administered prior to the scored scenes. Participants completed the Half PONS in approximately 35 min.

2.2.3. Psychiatric symptoms

Participants were administered two interview-based measures of symptomatology: the Brief Psychiatric Rating Scale (BPRS; Ventura et al., 1993) and the Scale for the Assessment of Negative Symptoms (SANS; Andreasen, 1984). Raters who conducted the interviews had been trained to minimum intraclass correlation coefficients of 0.80 for the BPRS and 0.75 for the SANS. BPRS ratings range from 1 (not present) to 7 (extremely severe). SANS ratings range from 0 (not at all) to 5 (severe).

2.3. Statistical analyses

Two patients were identified as outliers and excluded from the analyses based on their near chance performance on the Half PONS. The remaining 28 patients were divided into those with high and low sensory gating and high and low orienting based on median splits of the PPI and PPF scores, respectively. Separate *t*-tests were used to assess differences in social perception based on PPI status and PPF status.

3. Results

Patients with high and low PPI and high and low PPF were very similar in terms of age, education and symptom ratings (see Table 1). The only exception was that the good inhibitors showed higher levels of anxiety and depression based on the BPRS Anxiety/Depression Subscale, $t(26)=2.17$, $p<0.05$) and more avolition (SANS Avolition Global Rating, $t(26)=2.56$, $p<0.05$) than the poor inhibitors. However, these subscales were not correlated with PPI, PPF, or the social perception test and are not considered further. The two psychophysiological measures, PPI and PPF, were not significantly correlated ($r(28)=0.16$, ns) consistent with the idea that these two measures were indexing two separate mechanisms: gating and orienting.

The social perception performance of the patients with high and low PPI and high and low PPF are displayed in Table 1. Good inhibitors performed significantly better on the Half-PONS (mean=85.00) than poor inhibitors (mean=78.36), $t(26)=3.22$, $p<0.01$. Similarly, prepulse inhibition showed a significant negative correlation with scores on the Half-PONS, $r(28)=-0.54$, $p<0.01$, indicating that greater PPI was associated with better social perception skills of patients (Fig. 1). Good and poor facilitators did not differ in their performance on the Half PONS ($t(26)=0.27$, ns). PPF and performance on the Half-PONS were not related ($r(28)=0.25$, $p<0.20$).

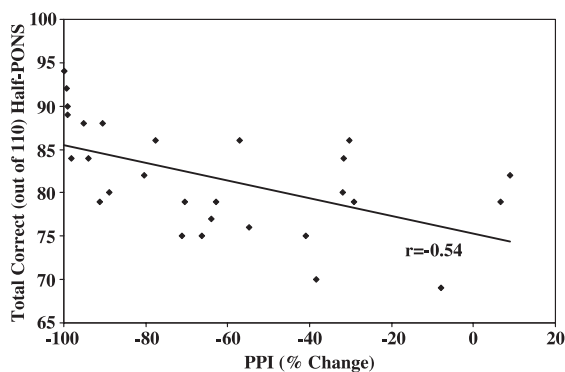


Fig. 1. Scatter plot demonstrating the relationship between sensorimotor gating (PPI) and social perception (scores out of 110 on the Half-PONS). Lower percent change scores (i.e., more negative scores) is indicative of better PPI. The correlation is significant at the 0.05 probability level.

4. Discussion

This study, to our knowledge, is the first to find an association between a largely automatic process, sensorimotor gating, and social cognition in schizophrenia. As hypothesized, patients who performed poorer on a prepulse inhibition task of sensorimotor gating tended to perform poorer on a videotape-based measure of social perception. The current findings are consistent with prior studies showing relationships between early visual processing and premorbid social functioning in schizophrenia patients (e.g., Silverstein et al., 1996), suggesting that deficits in early information processing can negatively impact high-level processes necessary for normal social perception and social functioning. Specifically, these results suggest that deficits in early perceptual processes, such as sensorimotor gating or visual backward masking (Sergi and Green, 2003), can have downstream effects in perception of complex social information. Thus, perceptual deficits in the auditory or visual modalities, using very basic stimuli, reflect fundamental information processing abnormalities that can contribute to impaired processing of information from social interactions.

Our data, however, do not support the expected association between poor orienting, as indexed by PPF, and poor social perception. The lack of an association may have been due to the structured nature of the social perception task used with these patients. In this study, demands of sustained attention and reading comprehension were reduced by having the subject read the two possible choices while the experimenter paused the tape and read aloud the two choices immediately before the subject viewed each scene. Orienting is generally viewed as reflecting the process of directing attentional resources toward some stimulus or task. This process is generally thought to be deficient in schizophrenia, with patients having difficulty in allocating resources or fewer available resources to allocate (Nuechterlein and Dawson, 1984; Wynn et al., 2004). Although we hypothesized that this deficit would be reflected in social perception, the fact that the tester focused the subject on the scene and on the two possible answers may have compensated for the patients' difficulty in appropriately allocating resources. It may be that other tests of social perception that give patients less assistance in

resource allocation will reveal a relationship with PPF by better tapping into deficits in orienting.

The lack of a relationship between PPF and social perception may also be due to the paradigm used to collect PPF. This study used a passive attention paradigm, whereas active attention paradigms generally result in more facilitation. As Table 1 shows, PPF was not as strong as PPI in this study (approximately half of the subjects in fact showed inhibition). While the correlation between PPF and the Half-PONS was not significant, it was in the right direction (i.e., better facilitation/orienting related to better social perception). Perhaps if an active attention paradigm had been used, PPF would be much larger and the relationship between PPF and social perception would have been clearer.

The study had a few limitations. First, the sample was relatively small, almost entirely male, and limited to outpatients. The results need to be replicated in a larger sample, including inpatients, that has a more equal gender distribution. Second, the stimulus parameters used to measure PPI in the current study differed somewhat from those of other studies of PPI deficits in schizophrenia (for a review of these methods, see Braff et al., 2001). For example, the PPI in this current study did not use background noise and was recorded only from the left eye. It would be beneficial to confirm the findings of the current study using other commonly used PPI methodologies.

This study is one of several studies to find that aspects of neurocognition (e.g., early visual processing, visual attention, verbal recognition memory, executive functioning) are associated with social cognition in schizophrenia (Addington and Addington, 1998; Bryson et al., 1997; Kee et al., 1998; Kohler et al., 2000; Sergi and Green, 2003). By demonstrating a link to much more basic, automatic processes such as sensorimotor gating, this study expands the existing literature. The findings are also consistent with the possibility that social cognition may be an important intervening variable between neurocognition and functional outcome in persons with schizophrenia (Green and Nuechterlein, 1999). Links between social cognition and social functioning are not as well documented, although data are accumulating in this area as well (Corrigan and Toomey, 1995; Kee et al., 2003; Penn et al., 1996).

Future studies that include assessments of basic neurocognition, social cognition, and social functioning will be better able to map out these important causal pathways between neurocognition and social functioning.

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