Processing sentence context in women with schizotypal personality disorder: An ERP study

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Abstract
Accumulating evidence suggests that schizophrenic patients do not use context efficiently. Also, studies suggest similarities in clinical and cognitive profiles between schizophrenic and schizotypal personality disorder (SPD) individuals, and epidemiological studies point to a genetic link between the two disorders. This study examined electrophysiological correlates of processing sentence context in a group of SPD women in a classical N400 sentence paradigm. The study assessed if the dysfunction in context use found previously in schizophrenia and male SPD also exists in female SPD. We tested 17 SPD and 16 matched normal control women. The results suggest the presence of abnormality in context use in female SPD similar to that previously reported for male schizophrenic and SPD individuals, but of lesser degree of severity. In SPD women, relative to their comparison group, a more negative N400 was found only to auditory congruent sentences.

Descriptors: Sentence processing, Schizotypal personality disorder women, Context, Event-related potentials, Language, N400

Language dysfunction in schizophrenia is regarded as one of the primary features of this disease. Speech in schizophrenic patients is often characterized by loose and bizarre associations, lack of coherence, and inability to maintain a theme. It has been recently proposed that these features of schizophrenic speech are the result of dysfunction in semantic memory operations. The two processes suggested to be abnormal are the activation in semantic memory networks (Manschreck et al., 1988; Moritz et al., 1999; Spitzer, Braun, Maier, Hermle, & Maher, 1993) and the use of context (Cohen, Barch, Carter, & Servan-Schreiber, 1999; Servan-Schreiber, Cohen, & Steingard, 1996). Both epidemiological and genetic evidence suggests a similar genetic vulnerability for schizophrenia and schizotypal personality disorder (Kendler, 1988; Kety, Rosenthal, Wendler, & Schulsinger, 1968). Also, similar but less severe impairments have been found in several areas of language function such as semantic categorization, semantic clustering, and levels of recall (Condray and Steinhauser, 1992; Trestman et al., 1995; Voglmaier, Seidman, Salisbury, & McCarley, 1997). This study focused on the processes of reconciling word meaning with sentence context in a group of Schizotypal Personality Disorder (SPD) women. Previously, abnormal context use has been observed in schizophrenia both in behavioral (Barch et al., 1999; Cohen et al., 1999; Braver et al., 2001) and event-related brain potential (ERP) studies of language processing (Condray, Steinhauser, Cohen, van Kammen, & Kasparek, 1999; Niznikiewicz et al., 1997, 1999; Salisbury, O'Donnell, McCarley, Nestor, & Shenton, 2000; Stinikova, Salisbury, Kuperberg, & Holcomb, 2002). Context processing in sentences is a complex operation that involves both working memory resources as well as complex computations allowing us to fit upcoming words into available sentence meaning and make judgments about it (e.g., Federmeier & Kutas, 1999; Gaskell & Marlsen-Wilson, 2001; Holcomb, Kounios, Anderson, & West, 1999; Van Berkum, Hagoort, & Brown, 1999).
**Methods**

**Participants**

Seventeen right-handed women were diagnosed with Schizotypal Personality Disorder using the SCID (Spitzer, Williams, Gibbon, & First, 1990a) and DSM-III-R (American Psychiatric Association, 1987) criteria. Diagnostic reliability was evaluated using the kappa statistics; the reliability between the raters was .87. The SPD women were included in the study based on a newspaper advertisement soliciting individuals who were shy, had few friends, and felt they had special powers. Overall, 472 responders to the advertisement were screened. The 17 women who participated in this study met full SPD criteria, that is, they fulfilled five or more of the nine DSM-IIIR items (they also met DMS-IV criteria). Sixteen comparison women, matched for age and IQ, participated in the study, and were selected from a pool of volunteers recruited from a newspaper advertisement. They were also screened with the SCID (Spitzer, Williams, Gibbon, & First, 1990b). All participants spoke English as their first language. All study participants signed a written consent form after familiarizing themselves with a detailed description of the study. The inclusion and exclusion criteria were the same as in Niznikiewicz et al. (1997, 1999).

The average age of the SPD participants was 30.0 years (range 22–53 years, SD = 5.87), while the average IQ was 108 (range 80–131, SD = 13.5), and parental SES was 3.4 (range 1–5, SD = 1.3). IQ was estimated based on the WAIS verbal score and block design scores, and the SES was computed based on Hollingshead Four Factor Index of Social Status. The comparison group’s age was 35.8 years (range 22–51 years, SD = 8.8), IQ was 117.7 (range 109–135, SD = 14.3), and parental SES was 3.75 (range 2–5, SD = 1.1). The two groups did not differ statistically on any of these measures.

**Stimuli**

Two hundred sentences were presented visually and auditorily. The sentences were 5-8 words long, and were identical to the sentences used in a previous study of male SPD subjects (Niznikiewicz et al., 1999). For the full description of language materials and mode of presentation, see Niznikiewicz et al. (1997, 1999). Briefly, half of the sentences ended with a word that fit previously presented context, and half of them ended with a word that did not fit the context; the sentences were presented one word at a time, with an 800-ms offset to onset interval (ISI). In the auditory modality, the words were spoken by a male voice. The mean length of words in the auditory modality was 497.5 ms including final words. All words in the visual modality were presented for 300 ms. The mean length of auditory and visual sentences was 7.633.75 ms and 6.350 ms, respectively. Two sets of sentences were constructed such that each participant was exposed to two different sets in the two modalities, but across participants, the same sentences were presented auditorily and visually. Participants were asked to make a decision if the sentence just presented made sense by pressing a “yes” or “no” response button (right and left hand counterbalanced), after they “saw a star on the screen,” 800 ms after the sentence ended. The accuracy data, that is, the error rates, recorded along with the response time data, did not differ statistically in the two groups; for auditory modality, t(21) = −1.3, p < .21, (accuracy: NC = 96.75%, SPD = 94.75%), for visual modality t(20) = −1.74, p < .098 (accuracy: NC = 97.05%, SPDs = 94.7%).

**EEG Recording Procedures**

The EEG was recorded using 28 tin-plate electrodes housed in a Neuroscience Electrocap with a left earlobe reference and positioned according to the International 10–20 system, plus 8 additional interpolated electrodes (Niznikiewicz et al., 1997). Separate electrodes were placed at the left and right canthi and at supra and infraorbital sites to record horizontal and vertical eye movements. The electrode impedance was maintained below 4.0 kΩ, and care was taken that the difference in impedance between right and left ears was less than 0.5 kΩ. The EEG was recorded using a DC to 40 Hz bandpass (Neuroscan Inc., EEG amplifiers; 24 dB/octave low-pass slope and 24 dB/octave high-pass slope). The EEG was sampled over the epoch of 924 ms, with 100-ms prestimulus baseline relative to the onset of a target word, and was digitized at the rate of 256 samples/s. Linked earlobes reference was constructed off-line and the rereferenced data were used in all analyses.

**Data Processing**

For the details of data processing we refer the reader to Niznikiewicz et al. (1999). Single-subject averages were constructed from the EEG epochs recorded to the last words (congruent and incongruent relative to the context) of presented sentences, and filtered using a digital filter of 0.01–8 Hz. The N400 was measured as a mean amplitude under the curve and as peak amplitude to get a measure of peak latency within the window of 300–450 ms poststimulus.

**Statistical Analyses**

The group differences were most prominent at fronto-central sites. Therefore, the N400 was measured at Fz, Cz, F3/4, FTCl/2, C3/4, CP1/2, and T3/4. The N400 amplitude and latency were submitted to mixed model MANOVA with group as a between variable (2 levels: NC and SPD), and within factors of modality.
(2 levels: auditory and visual), sentence type (2 levels: congruent and incongruent sentence final word), and electrode (12 levels). This omnibus MANOVA was followed by modality-specific MANOVAs to follow up on the interactions. For N400 latency, only the results for midline are reported here.

Results

N400 amplitude
There was a three-way interaction between modality, sentence type, and group, $F(1,24) = 7.08, p < .014$. Modality-specific MANOVAs revealed a Group × Sentence Type interaction for the auditory modality, $F(1,25) = 5.35, p < .028$, and no significant group effects for the visual modality. There was the main effect of sentence type for both the auditory, $F(1,28) = 97.00, p < .0001$, and visual modalities, $F(1,24) = 58.54, p < .0001$.

In the auditory modality, congruent condition, there was a main effect of group, $F(1,28) = 4.54, p < .042$; N400 amplitude was more negative (larger) in SPD women relative to the normal comparison group. No group differences existed in the incongruent condition.

N400 Latency
In the overall MANOVA, including both auditory and visual modalities, there was a main effect of group, $F(1,25) = 19.23, p < .0001$, and a three-way interaction between group, modality, and sentence type, $F(1,25) = 9.19, p < .006$. There was a main effect of group in the auditory modality, $F(1,27) = 12.433, p < .002$, and a trend level interaction between group and sentence type in the auditory modality, $F(1,27) = 4.02, p < .055$. Longer N400 latencies were found in the SPD group (see Figures 1–3).

In the visual modality, there was an interaction between group and sentence type, $F(1,26) = 8.31, p < .008$. In the follow-up MANOVA, the main effect of group was found for the congruent sentence type, $F(1,26) = 7.47, p < .01$, and no group differences were found in the incongruent sentence type condition. Again, the N400 latency was prolonged in the SPD relative to normal comparison subjects.

Discussion

In this study of processing final words in sentences, more negative N400 amplitude was found in the SPD women relative to normal women. This group difference was limited to auditory, congruent sentences. Prolonged N400 latencies were found in the SPD relative to the normal women in both modalities.

The results reported in this study represent an extension of previous studies on the processing of context in schizophrenia spectrum disorder within the confines of an identical paradigm. The one technical difference relates to the replacement of one Neuroscan amplifier (used to acquire male SPD data) with another (used to acquire female SPD data). The present results are similar to the ones reported for male schizophrenic subjects (Niznikiewicz et al., 1997), and for male SPD subjects (Niznikiewicz et al., 1999). The differences among these studies relate to the degree of dysfunction as documented with the N400 response. In the schizophrenic male patients, more negative N400 was found to both congruent and incongruent sentence endings in both visual and auditory modality as compared to the normal males. In male SPD subjects, the more negative N400 amplitude was found only to the congruent sentence final words in both modalities. In the current study, the group differences were found only in the auditory modality for congruent sentence final words.

Thus, across these three studies, varying degrees of dysfunction, as indexed by the N400, were found, with the most severe impairment in the male schizophrenic patients and the least severe impairment in the SPD women. It is therefore possible that a type of impairment represented by SPD women is primary or “core,” and that as the cognitive system breaks down further, more severe symptoms emerge. As sentential context processing involves both matching semantic information and working

Grand average waveforms to final words in sentences. Auditory, congruent condition.

Figure 1. Grand average waveforms of 17 SPD and 16 normal comparison women recorded to the congruent sentence final words presented in the auditory modality.
Grand average waveforms to final words in sentences. Auditory, incongruent condition.

Figure 2. Grand average waveforms of 17 SPD and 16 normal comparison women recorded to the incongruent sentence final words presented in the auditory modality.

Grand average waveforms to final words in sentences. Visual modality.

Congruent condition

Incongruent condition

Figure 3. Grand average waveforms of 17 SPD and 16 normal comparison women recorded to the congruent and incongruent sentence final words presented in the visual modality.
memory operations, this and previous studies suggest a scenario where auditory based operations of matching semantic information with the previous context are compromised first by a schizophrenia-like disease process. At subsequent stages the dysfunction includes both the auditory and visual mode of language processing, and then goes beyond a dysfunction in semantic matching operations. For example, it is possible that working memory function as related to maintaining sentence context becomes compromised at more severe stages, as the results of the study in male schizophrenia patients (Niznikiewicz et al., 1997) would suggest. Future studies including both men and women from among SPD and schizophrenia sufferers, in various linguistic tasks, are needed to elucidate this model.

REFERENCES


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