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Neurophysiological responses to schizophrenia-associated communication abnormalities

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ABSTRACT

Background: Individuals with schizophrenia experience difficulty with interpersonal interactions, in part resulting from communication abnormalities that are common in the disorder, and to the expectancy effects from knowledge of the person's diagnosis. The auditory N400 event-related potential provides an objective measure of recognition of incongruent speech and thus is a potential tool to understand how listeners respond to disordered speech as a function of awareness of diagnosis.
Methods: In this study, participants listened to segments of conversation between two people in which the sentence final word was a normal ending, a word approximation, or a neologism while EEG was recorded. Participants were randomized to two groups: told that the speaker had a diagnosis of schizophrenia or not told about a diagnosis.
Results: Participants who were not told that the speaker had schizophrenia displayed a significant N400 during both word approximations and neologisms. However, no significant N400 was observed for participants who were told that the speaker had schizophrenia.
Conclusions: Differential neurological responses to the same abnormal speech depending on whether the diagnosis of the speaker was known, indicate an early processing expectancy effect for abnormal communication to come from someone with schizophrenia. Such responses to abnormal speech in schizophrenia indicate an expectation of abnormality from individuals with schizophrenia, which has implications for understanding social exclusion of individuals with the disorder.

1. Introduction

Early and sustained social functioning deficits are observed in schizophrenia, reducing quality of life (Norman et al., 2000) and limiting productivity in social and work settings (Bowie et al., 2008). Recently, we have identified environmental factors that appear to affect whether those with schizophrenia make full use of the adaptive life skills they have in everyday settings (Gupta et al., 2012), suggesting that functional impairment is not solely a function of intrinsic deficits. One important extrinsic factor that can affect community opportunities is social exclusion. Individuals with schizophrenia tend to have fewer and less satisfactory interpersonal relationships (Erickson et al., 1989). Individuals with schizophrenia may be socially excluded due to stigmatizing beliefs regarding dangerousness or unpredictability (Angermeyer and Matschinger, 2004; Hayward and Bright, 1997), however this line of research has focused on using self-report questionnaires as opposed to objective measures to determine why social exclusion occurs. Individuals with schizophrenia may also be excluded as a result of communication style during interpersonal interactions.

Word choice is an integral component to social interactions (Pennebaker et al., 2003). People with schizophrenia often use abnormal communication (Andreasen, 1986), long considered core features of the disorder (Bleuler, 1911; Chapman and Chapman, 1973). Some more severe forms of communication abnormalities include the use of neologisms (a completely new word whose derivation cannot be understood), and word approximations (the use of a common word in an inappropriate context; Andreasen, 1986). The use of these communication abnormalities is associated with impaired social functions (Bowie and Harvey, 2008; Bowie et al., 2011) and thus may contribute to individuals with schizophrenia being socially excluded, yet little is known about the responses that healthy individuals have to hearing communication abnormalities. Understanding how these abnormalities are integrated into semantic processing, contingent upon knowing the person's diagnosis, would provide evidence that awareness of the label of a mental illness influences how one responds to those individuals. Quasi-experimental methods find that only 10% of the variance in behavior can be explained by the variance in attitudes (Schutz and Six, 1996), thus objective

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measurement of behavior and cognitive processes is essential. One objective method for understanding these relationships is psychophysiological assessment.

Electroencephalography (EEG) and event-related potentials (ERPs) allow the detection of early neurological processes involved in stimulus processing. A well-studied ERP signal is the auditory N400 (McCallum et al., 1984; Friederici et al., 1993). This phenomenon, observed by a negative deflection of the EEG waveform, beginning as early as 50 ms after word onset in continuous speech (Holcomb and Neville, 1991), reaching peak amplitude around 400 ms post-stimulus onset, and lasting until approximately 700 ms post-stimulus onset (MacGregor et al., 2009), represents recognition of a semantic incongruity within the sentential context (Kutas and Hillyard, 1980a,b, 1981; Friederici et al., 1993). The N400 is thought to reflect an attempt to integrate novel linguistic information, given the expectation of the listener about upcoming words (Friederici et al., 1993) and has recently been studied with respect to natural sentence processing (Holcomb and Neville, 1991; Hagoort and Brown, 2000).

Although word-by-word presentation allows for a clear separation of the ERPs, this method does not account for cues that are present in continuous speech (Sanders and Neville, 2003). Continuous speech processing results in a less defined N400 component due to the carryover effects of previous words in the sentence (Holcomb and Neville, 1991; Sanders and Neville, 2003), however the effect is still observable and, since it is a response to more natural conversational structure, is more ecologically valid.

The N400 effect is also sensitive to pragmatic violations of world knowledge or expectation. Hagoort et al. (2004) demonstrated that violations of world knowledge result in the same amplitude of N400 effect as semantic violations within a sentential context. Similarly, placing an unexpected sentence such as "the cat picked up the chainsaw" into the context of a cartoon reduces the amplitude of the N400 because unrealistic actions like these are expected within the context of the cartoon (Nieuwland and Van Berkum, 2006; Filik and Leuthold, 2008).

The present study examined the N400 effect to hearing schizophrenia-related communication abnormalities as a function of the listener's awareness of diagnosis. We predicted a larger N400 amplitude in response to communication abnormalities without awareness of schizophrenia, compared to when the listener is told that the speaker has schizophrenia. We also hypothesized that the N400 amplitude would be greater for the more severe form of communication abnormality, neologisms, compared to word approximations, given that the degree of contextual irrelevance produces greater N400 (Yamada and Neville, 2007).

2. Methods

2.1. Participants

Twenty participants (10 males, 10 females) were randomized to the control (not told of a diagnosis; n = 10) or told diagnosis (n = 10) conditions. Participants were undergraduate students at Queen's University and were compensated with course credit. All participants were between the ages of 18 and 20, native English speakers, and right handed. All reported to have never been diagnosed with a mental illness nor to have had any direct personal contact with anyone who has schizophrenia.

2.2. Materials and procedure

The EEG task follows a typical N400 paradigm (Friederici et al., 1993) with word approximations and neologisms used as sentence final-word targets. Prior to hearing the conversation segments, participants were randomized to either being told that the responder had schizophrenia or not being told about a diagnosis. Individuals who were told the responder had schizophrenia were given the following message.

The second individual (the one responding to the question) has schizophrenia. Schizophrenia is a disorder characterized by psychotic symptoms including hearing voices and seeing things that are not there. In addition, individuals with schizophrenia may display catatonic or paranoid behaviors and may communicate in abnormal ways.

The stimuli simulate a conversation between two people: a person asking a question and a person responding to that question (1a, 1b). Both speakers were actors who were compensated for their time. Thirty unique responses, to four unique questions, were paired with four unique sentence-final words per response for a total of one hundred twenty unique sentences. Sentence final words fell into one of four categories: typical, word approximation, neologism, and filler. The word approximation and neologism endings represent communication abnormalities that occur in individuals with schizophrenia (Andreasen, 1986) and were incongruent with the rest of the sentence. The typical endings were a sentence final word that was congruent with the rest of the sentence, and the filler endings consisted of more than one word that changed the meaning of the sentence ending (1b). All sentences were subjected to a pseudo-cloze probability pre-test by 8 volunteers to ensure that typical endings were in fact congruent. Filler endings were used to mask which sentence-final word was the study target.

(1a) Q: Are you still interested in going out for dinner later?
R: Would you be ok with staying in, instead? I'm trying hard to save *money/animals/spindeloon*.

(1b) R: Would you be ok with staying in, instead? I'm not in the mood to go out tonight.

All neologisms, and corresponding typical words, were derived from a previous report that documented and defined these words from a subject with schizophrenia (LeVine and Conrad, 1979). Word approximations were created by the experimenters to be incongruent with the preceding context; incongruence was confirmed during the pseudo-cloze probability pre-test. All sentences were recorded from actors who were instructed to speak in a neutral tone. Sentence beginnings and sentence final words were parsed together using the phonetic analysis software PRAAT (Boersma, 2001), such that all sentences had the same acoustic beginning and only differed in the sentence final word. All sentences were adjusted using PRAAT to an intensity level of 70 dB.

All conversation segments were auditorily presented to participants through Etymotic Research ER-30 Tubephone Insert Earphones, which attenuate background noise by 30 dB in the frequency region of 125–8000 Hz. Ambient noise in the laboratory was controlled and no visual or auditory interruptions occurred during procedures for any of the participants.

After hearing each segment of conversation, participants were asked the following question: "On the following scale (1 = Definitely Not, 2 = Very Unlikely, 3 = Unlikely, 4 = Neutral, 5 = Likely, 6 = Very Likely, 7 = Definitely) please rate how likely you would be to continue talking to an individual who spoke like this".

2.3. EEG recording and analysis

The EEG was recorded using a HydroCel 64-channel, Geodesic Sensor Net at a sampling rate of 250 samples/s. Impedances for each electrode were kept below 30 kΩ upon commencement of the study and were not allowed to rise above 100 kΩ throughout the study. EEG data was processed offline by applying a high pass filter at 0.1 Hz and a low pass filter at 30 Hz. Data were segmented into 1000 ms segments starting 100 ms prior to the sentence final word and ending 900 ms after sentence final word onset. Any segments containing artifacts or eye blinks were excluded from further