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Automated analysis of written narratives reveals abnormalities in referential cohesion in youth at ultra high risk for psychosis

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ABSTRACT

Schizophrenia and at-risk populations are suggested to exhibit referential cohesion deficits in language production (e.g., producing fewer pronouns or nouns that clearly link to concepts from previous sentences). Much of this work has focused on transcribed speech samples, while no work to our knowledge has examined referential cohesion in written narratives among ultra high risk (UHR) youth using Coh-Metrix, an automated analysis tool. In the present study, written narratives from 84 individuals (UHR = 41, control = 43) were examined. Referential cohesion variables and relationships with symptoms and relevant cognitive variables were also investigated. Findings reveal less word “stem” overlap in narratives produced by UHR youth compared to controls, and correlations with symptom domains and verbal learning. The present study highlights the potential usefulness of automated analysis of written narratives in identifying at-risk youth and these data provide critical information in better understanding the etiology of psychosis. As writing production is commonly elicited in educational contexts, markers of aberrant cohesion in writing represent significant potential for identifying youth who could benefit from further screening, and utilizing software that is easily accessible and free may provide utility in academic and clinical settings.

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1. Introduction

Schizophrenia patients exhibit symptoms of thought disorder in which thoughts may seem illogical or bizarre and are often characterized by language disturbances in speech and writing (Andreasen and Grove, 1986; Andreasen, 1979; Docherty, 2005; Harrow and Quinlan, 1985). Individuals experiencing thought disorder are suggested to produce language that may lack coherence, and these aberrations can impact social-occupational functioning and overall quality of life (Kuperberg and Caplan, 2003). While it is well established that language disturbances are a core symptom (Bleuler, 1950), work examining these disturbances in individuals at ultra high risk (UHR) for psychosis is more limited. Studying UHR populations can provide clinical utility as current research suggests that 15–35% of UHR youth go on to develop a psychotic disorder within two-years (Cannon et al., 2008; Fusar-Poli et al., 2013, 2012). In this context, understanding language disturbances in the UHR period may improve early detection and contribute to our etiological conceptualizations.

Cohesion is an important characteristic of both written and spoken language, reflecting the extent to which a discourse provides grammatical and lexical markers for how concepts are linked across sentences (Halliday and Hasan, 1976). An especially important form is *referential cohesion*, which refers to the overlap of identical or semantically related words and concepts across units in a text, or co-reference. For example, one type of referential cohesion is pronominal anaphora, in which a pronoun is used to refer backwards to a previously mentioned entity. Consider the pair of sentences, “Roy had to go to the grocery store after work. He dreaded going because the store would be crowded.” In this mini-discourse, “He” in the second sentence refers anaphorically to “Roy” in the first sentence, signaling to a listener that these two sentences are related (Halliday and Hasan, 1976; Haviland and Clark, 1974). Another source of referential cohesion in this example comes from the overlap between “the grocery store” and “the store.” This has direct practical clinical relevance for understanding social dysfunction in psychosis; when a discourse lacks cohesion, listeners must work that much harder to extract meaning from the text or speech (Graesser et al., 2004; Haviland and Clark, 1974; McNamara and Graesser, 2014).

Referential cohesion deficits have been consistently reported among schizophrenia patients (Ditman and Kuperberg, 2010; Ditman et al., 2011; Docherty et al., 1996; Hoffman, 1986; Hoffman et al., 1982; Noel-Jorand et al., 1997; Rochester and Martin, 1979). In a landmark

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study conducted by Rochester and Martin (1979), investigators developed a coding system to examine referential cohesion markers and applied this to transcribed speech of individuals with schizophrenia; the investigators found fewer referential markers used in this group compared to controls. Similarly, Docherty et al. (2003) found, in a sample of schizophrenia patients, higher levels of referential cohesion in transcribed speech compared to controls. Other work has observed similar deficits in speech samples from parents and siblings of schizophrenia patients (Docherty et al., 2004, 1996) and individuals with childhood schizophrenia (Caplan, 1994; Caplan et al., 2000).

Recently, researchers have proposed that specific cognitive deficits characteristic of psychosis may also underlie the language disturbances particularly related to verbal learning, working memory, and attention (Ditman and Kuperberg, 2010; Docherty et al., 1996; Stain et al., 2012). One study administered a written story production pictorial task to patients with first episode psychosis and found that story production (assessed by examining words and corrections per minute) was positively associated with verbal learning and fluency (Stain et al., 2012). However, this study did not examine referential cohesion markers. Researchers examining patterns of cohesive deficits in speech samples have also posited that limits in working memory capacity, commonly found in schizophrenia populations (Lee and Park, 2005), may be an important contributor to these individuals' difficulties in establishing appropriate coherence relations (Ditman and Kuperberg, 2010). These working memory impairments may contribute to language disturbances because working memory capacity, which also requires sustained attention, may be overloaded, interfering with the reliable establishment of anaphoric relationships (Ditman and Kuperberg, 2010; Docherty et al., 1996). In a study conducted by Docherty et al. (1996) that examined language and cognition in a schizophrenia sample, referential deficits were associated with both lower working memory and attention scores. While this has been studied in schizophrenia populations, cognition and language dysfunction in UHR youth also make an excellent target.

Together, these studies provide evidence of deficits in referential cohesion in individuals with schizophrenia, yet limited work has been done among UHR youth. Existing studies have examined transcribed speech in UHR youth and identified cohesive deficits, including in the area of referential cohesion, and found that these abnormal features of speech were predictive of conversion to psychosis (Bearden et al., 2011; Bedi et al., 2015). However, less attention has been given to features of referential cohesion in the production of written language, or how potential difficulties in appropriately marking coherence relations might be related to patterns of cognitive differences. Using the Coh-Metrix tool, we examined whether indices of referential cohesion in the narratives produced by UHR youth were associated with symptomology and cognitive measures of verbal learning, working memory, and attention. Based on previous work (Bearden et al., 2011; Bedi et al., 2015; Ditman and Kuperberg, 2010), we predicted that the narratives of UHR youth would exhibit significant abnormalities in all referential cohesion features (i.e. difficulties with using pronouns and nouns cohesively) on a local (adjacent sentences) and global (all sentences) level when compared with healthy controls. Further, consistent with prior investigations observing relationships between referential cohesion and clinical features (Caplan, 1994; Elvevåg et al., 2007; Moro et al., 2015) and cognition (Docherty and Gordinier, 1999; Docherty et al., 1996; Stain et al., 2012) in individuals with psychosis, we predicted that these impairments will be related to elevated positive, negative, and disorganized symptoms and decreased performance on verbal learning, working memory, and attention.

2. Materials and methods

2.1. Participants

A total of 84 adolescents and young adults (UHR = 41, control = 43), aged 13–24 (UHR mean = 19.33, SD = 1.44; Control mean =

18.76, SD = 2.63) were recruited through the Adolescent Development and Preventive Treatment (ADAPT) program using email, newspaper, media announcements, Craigslist, and flyers. The exclusion criteria for all participants included history of significant head injury or other physical disorders affecting brain functioning, mental retardation (defined by an IQ of <70), or history of a substance dependence disorder in the prior 6 months. Additionally, UHR exclusion criteria included an Axis I psychotic disorder diagnosis. Control exclusion criteria included any diagnosis of an Axis I disorder or a first-degree relative with psychosis. UHR inclusion criteria included the presence of an Attenuated Positive Symptom (APS) or Genetic Risk and Deterioration (GRD) with a decline in functioning (Miller et al., 1999).

2.2. Clinical interviews

The Structured Interview for Prodromal Syndromes (SIPS; Miller et al., 1999) was used to detect UHR syndromes and assess symptomatology. The Structured Clinical Interview for the DSM-IV (SCID, research version; First et al., 1995), was used to rule out Axis I psychotic disorders and substance dependence. Role functioning was also examined using the Global Functioning Scale: Role (GFS-R) (Niendam et al., 2006). On the GFS-R, a score of 10 indicates “Superior Role Functioning” (e.g., independently maintains superior functioning in demanding roles), whereas a low score of 1 reflects “Extreme Role Dysfunction” (e.g., on disability, non-independent status).

2.3. Cognitive assessment

The Word Reading subtest of the fourth edition of the Wide Range Achievement Test (WRAT) was used as a measure of general intelligence (Wilkinson and Robertson, 2006). Participants were also given the Hopkins Verbal Learning Test – Revised (HVLN-R) (Brandt, 1991), which measures verbal learning, the Letter Number Sequencing (LNS) test, which assesses verbal working memory (Wechsler, 1997), and the Continuous Performance Test, identical pairs version (CPT-IP) (Cornblatt and Lenzenweger, 1989), a computerized measure of sustained attention. For all tests, the number of correct responses was recorded and raw scores converted to standardized t-scores, correcting for both age and gender.

2.4. Written narratives

To obtain the written language samples, participants were administered a narrative description task using the Boston Cookie Theft Image (Goodglass and Kaplan, 1983). In this task, participants were instructed to write a brief story about an image depicting a woman washing dishes while two children take cookies from a jar. Participants were given up to 10 min to produce their narratives. After data collection was complete, the handwritten narratives were entered verbatim into computer files by a naive research assistant, which were then submitted to Coh-Metrix 3.0, a web-based computational language analysis tool (<http://cohmetrix.com/>) (McNamara and Graesser, 2014).

Although the Coh-Metrix tool provides numerous measures covering a range of text and discourse characteristics, here we focused on three indices related specifically to referential cohesion, measured both locally and globally. To compute these indices, Coh-Metrix first applies a part-of-speech tagger and syntactic parser to the text input, as well as dictionary look-up functions to identify the root and morphological forms (e.g., plurals, past tense) of words. From these linguistic properties, the tool can then identify particular types of relational connections, or “overlap,” across different segments of the text (Graesser et al., 2004; McNamara and Graesser, 2014). Specifically, Coh-Metrix computes three forms of referential overlap. First, *stem overlap* refers to the proportion of sentences in the text with nouns that match any words (regardless of part of speech) in an adjacent sentence or

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