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Evidence of disturbances of deep levels of semantic cohesion within personal narratives in schizophrenia

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ABSTRACT

Since initial conceptualizations, schizophrenia has been thought to involve core disturbances in the ability to form complex, integrated ideas. Although this has been studied in terms of formal thought disorder, the level of involvement of altered latent semantic structure is less clear. To explore this question, we compared the personal narratives of adults with schizophrenia ($n = 200$) to those produced by an HIV+ sample ($n = 55$) using selected indices from Coh-Metrix. Coh-Metrix is a software system designed to compute various language usage statistics from transcribed written and spoken language documents. It differs from many other frequency-based systems in that Coh-Metrix measures a wide range of language processes, ranging from basic descriptors (e.g., total words) to indices assessing more sophisticated processes within sentences, between sentences, and across paragraphs (e.g., deep cohesion). Consistent with predictions, the narratives in schizophrenia exhibited less cohesion even after controlling for age and education. Specifically, the schizophrenia group spoke fewer words, demonstrated less connection between ideas and clauses, provided fewer causal/intentional markers, and displayed lower levels of deep cohesion. A classification model using only Coh-Metrix indices found language markers correctly classified participants in nearly three-fourths of cases. These findings suggest a particular pattern of difficulties cohesively connecting thoughts about oneself and the world results in a perceived lack of coherence in schizophrenia. These results are consistent with Bleuler's model of schizophrenia and offer a novel way to understand and measure alterations in thought and speech over time.

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1. Introduction

In his conceptualization of schizophrenia, Bleuler (1911/1950) suggested that people with the disorder shared a core set of features which include disruptions in associative processes. These disruptions compromised a person's ability to form coherent, complex ideas about the self and the world. With a reduced capacity to link related ideas together, Bleuler suggested that previously integrated ideas collapsed into disorganized fragments of experience. These disorganized fragments could no longer form the basis for goal directed activity. He wrote: "It appears as if the pathways of association and inhibition, established by experience, had lost their meaning and significance" (p. 350).

In the century since Bleuler, interest has persisted in disturbances of thought and language. For decades, researchers have investigated formal thought disorder—a set of symptoms reflecting disrupted thought (Kuperberg et al., 2006; Ragin and Oltmanns, 1986) that typically manifest through speech disturbances (Andreasen, 1979; Docherty, 2012; Hoffman et al., 1986). Speech disturbances occur at multiple levels of language, ranging from basic components (e.g., word) to the more complex threads described by Bleuler. They typically include heightened instances of utterances which are incoherent, ideosyncratic, or fail to present ideas in a logical sequence. These disturbances have been observed across the schizophrenia-spectrum, including: schizotypy (Minor and Cohen, 2010; Minor and Cohen, 2012); clinical high risk for psychosis (Bearden et al., 2011; Perkins et al., 2015); early-stage psychosis (Minor et al., 2016); and prolonged schizophrenia (Docherty, 2012; Docherty et al., 2013; de Sousa et al., 2016). In schizophrenia, speech disturbances appear to be trait-like, treatment-resistant, and linked to poor clinical outcomes (Bowie and Harvey, 2008; Docherty, 2012; Holshausen et al., 2014).

Typically, speech disturbances have been assessed using either clinician-rated (e.g., Thought Disorder Index; Johnston and Holzman, 1979) or hand-scoring instruments (e.g., Communication Disturbances Index; Docherty et al., 1996). However, one disadvantage of these approaches

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is they are unable to quickly differentiate speech disturbances at multiple levels of language. Following recent advances, computational assessments have emerged as a scalable alternative with the potential to illustrate the different stages where disturbances in language occur (Bedi et al., 2015; Cohen and Elvevag, 2014; Elvevag et al., 2007; Fineberg et al., 2016; Minor et al., 2015). These methods hold promise for showing how speech is compromised in schizophrenia across words, phrases, sentences, paragraphs, and full conversations. This is important because evidence exists in early and later phases of schizophrenia that people construct representations of themselves and others that tend to be less integrated and complex (Lysaker and Dimaggio, 2014), but it is unclear whether this occurs at basic linguistic levels or reflects higher order disturbances.

To examine whether we could detect disturbances across basic and higher order levels of language, we analyzed cohesion within speech samples of persons with schizophrenia using the Coh-Metrix 3.0, a software system designed to compute cohesion and coherence metrics in transcribed written and spoken language documents (McNamara et al., 2014). Coh-Metrix contains over 100 language indices across 11 categories, ranging from basic descriptors of language (e.g., total spoken words) to complex indices that measure the structure of language within and across sentences (e.g., deep cohesion). Given assertions that difficulties building integrated representations of self and others is a hallmark of schizophrenia, we were interested in indices that measured language at separate levels. Specifically, we tested four types of indices: 1) Basic descriptors, which provided frequency-based counts of speech; 2) Connectives, or words which link ideas and clauses together within a sentence; 3) Situational models, or discourse markers which reflect the structures that allow the meaning of mental states and actions of persons in the text to be grasped within the flow of the narrative; and 4) Deep cohesion, which assess the presence of linguistic structures that allow for a more coherent and deeper understanding of the text (Graesser et al., 2003; McNamara et al., 2014; see Table 1 for more information on specific indices).

In most studies, speech between people with schizophrenia is compared to speech produced by healthy adults. However, persons with schizophrenia experience sociopolitical forms of adversity—including stigma, demoralization, and social alienation—at a greater rate than healthy adults. This adversity likely influences how those with schizophrenia think and talk about their lives in ways that may extend beyond their illness (Ehrlich-Ben Or et al., 2013). Thus, we chose to analyze the speech of adults with HIV+ as our comparison group, as these individuals may be subject to similar adverse experiences and demoralization (Logie and Gadalla, 2009; Varni et al., 2012). In this study, we tested two primary hypotheses. First, we expected the speech of people with schizophrenia to show signs of disturbances across all four types of indices when compared to the HIV+ group. Second, we hypothesized that the Coh-Metrix would show utility for classifying people to the schizophrenia or HIV+ group based solely on the speech produced within their narrative. This study has the potential to demonstrate the specific levels where speech differs in schizophrenia and establish if a novel computerized assessment can categorize people into diagnostic groups based on their speech.

Table 1
Descriptions of Coh-Metrix indices used in this study.

Index	
Descriptive	What index measures
Total words	Total number of words spoken by subject in clinical interview
Unique words	Total number of unique words spoken by subject in clinical interview
Unique-total word ratio	Unique words (i.e., type) divided by total words (i.e., token)
Connectives	
Causal	Connects ideas and clauses using causal words (e.g., because)
Logical	Connects two or more ideas using a logical operator (e.g., and)
Contrastive	Connects ideas using contrastive words (e.g., although)
Temporal	Connects ideas and clauses using temporal words (e.g., first)
Additive	Connects ideas and clauses using additive words (e.g., moreover)
Situational models	
Causal content	Total causal particles (e.g., because) and causal verbs (e.g., impact)
Intentional content	Total intentional particles (e.g., by) and intentional verbs (e.g., contact)
Causal cohesion	Ratio of causal particles to causal verbs
Intentional cohesion	Ratio of intentional particles to intentional verbs
Multidimensional	
Deep cohesion	Presence of causal/logical links to help others develop understanding

Notes. Further information on all Coh-Metrix 3.0. indices available in McNamara et al. (2014).

2. Methods

2.1. Participants

Participants were 200 adults with SCID confirmed diagnoses of schizophrenia or schizoaffective disorder and 55 adults with a diagnosis of HIV+ (see Table 2). Exclusion criteria included inpatient hospitalization or changes in medication being prescribed within the last month, active substance dependence or a chart diagnosis of intellectual disability. Participants were also excluded if they had comorbid diagnoses of schizophrenia and HIV+. All assessments were performed for the schizophrenia group as part of a baseline evaluation for a larger study testing the effects of cognitive behavioral therapy. Assessments for the HIV+ group were performed as part of a protocol examining the effects of social cognitive and metacognitive deficits on wellness and outcome in non-psychiatric medical conditions.

2.2. Instruments

2.2.1. Indiana Psychiatric Illness Interview (IPII; Lysaker et al., 2002)

Speech for this study was collected using the IPII, a semi-structured interview originally designed to measure subjective experience in serious mental illness. Interviews were conducted by trained research assistants and generally lasted 30–60 min. These interviews were audio taped and later transcribed with identifying information removed. The IPII asks participants to tell their life story and how mental illness has affected different facets of their life. It differs from other symptom-based psychiatric interviews in that it does not ask about the presence or absence of specific symptoms. Instead, it focuses on one's experience of mental health challenges. For the HIV+ group, the IPII was modified

Table 2
Demographic and diagnostic data for schizophrenia ($n = 200$) and HIV+ groups ($n = 55$).

	Schizophrenia		HIV+	
Demographic	Mean	SD	Mean	SD
Age	47.08	10.48	48.97	11.06
Education	12.58	1.98	13.51	2.21
Male (%)	87.50		89.09	
Race				
African-American (%)	55.55		56.36	
Caucasian (%)	43.00		40.00	
Other (%)	1.50		3.64	
Diagnosis				
Schizophrenia (%)	66.00		N/A	
Schizoaffective Disorder (%)	34.00		N/A	

Notes. N/A: not applicable.

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by inquiring about a non-psychiatric medical illness as opposed to mental illness.

2.2.2. Coh-Metrix 3.0 (McNamara et al., 2014)

The Coh-Metrix system is designed to compute language usage statistics from transcribed written and spoken language samples. It differs from many other frequency-based systems (e.g., Linguistic Inquiry Word Count; Pennebaker et al., 2001; see Buck et al., 2015; Minor et al., 2015) in that, in addition to counting frequencies of certain types of words (like concrete vs. abstract words, or first person vs. second person pronouns), it also tracks underlying relationships between output within sentences, between sentences, and across paragraphs. This includes measures of coherence and cohesion, which assess the extent to which there is meaningful overlap in the words used across some predefined passage of text. Coh-Metrix produces a set of over 100 indices for each corpus, and relies in part on the semantic memory model Latent Semantic Analysis (Landauer and Dumais, 1997) to measure semantic similarity, semantic cohesion, and semantic coherence of words.

Given that analyzing all the Coh-Metrix variables would greatly inflate the risk of spurious findings, we chose to focus on four sets of Coh-Metrix variables (see Table 1). First, we examined three types of basic descriptors: Total words, unique words, and the ratio of unique words to total words. These indices were chosen to show how much content groups generated in response to the IPII, as well as how much lexical diversity was shown by participants (Manschreck et al., 1981). Second, five classes of connectives were assessed: Causal, logical, contrastive, temporal, and additive. Connectives were selected to demonstrate how often participants organized their speech by providing links between words and phrases within a sentence (Cain and Nash, 2011; Sanders and Noordmann, 2000). Third, are four situational model indices: causal content, intentional content, causal cohesion, and intentional cohesion. Causal indices reflect how often participants described actions or events as having a causal mechanism that may or may not be driven by goals or follow a typical story structure; intentional indices reflect how often participants described events or actions taken in pursuit of goals using a typical story structure (Zwaan et al., 1995; Graesser and Hemphill, 1991). Scores for connective and situational model categories reflect instances per 1000 words. Finally, deep cohesion is an index that determines whether the speaker provided necessary links for their audience to gain an understanding of the events and actions described in the text. When deep cohesion is low, this indicates that the audience must work to infer causal relationships; when high, these links are more explicit (McNamara et al., 2014).

2.3. Procedures

Written informed consent was obtained and a clinical psychologist administered the SCID to confirm or rule out schizophrenia. HIV status was determined by chart review. IPIIs were administered by research assistants with a Bachelor's degree or higher in a field related to psychology. Prior to speech analysis, all interviewer speech was removed so that only participant speech was analyzed.

2.3.1. Data analysis

Analyses were planned in four steps. First, the Coh-Metrix system was used to measure the coherence and cohesion of the IPII. Second, we compared groups on demographic variables to determine if there was a need to control for these constructs. Third, we compared the indices of interest between groups, covarying for any relevant demographics. To control for the large numbers of comparisons performed, we used $p < 0.001$ to determine statistical significance. Finally, we conducted a discriminant function analysis to test rates of correct classification.

3. Results

T-tests comparing the age and education between the schizophrenia and HIV+ group revealed significant differences only in education ($F(1,254) = 9.13$; $p < 0.001$. Chi square revealed no significant differences in gender or racial makeup of the groups. All comparisons of Coh-Metrix were therefore conducted controlling for education.

The differences between groups in our Coh-Metrix analyses are shown in Table 3. We conducted a MANCOVA analysis, comparing the selected Coh-Metrix variables between groups controlling for education. This produced an overall significant group effect ($F(11,242) = 4.07$; $p < 0.001$. Individual ANCOVA analyses revealed significant group differences within all four classes of measures (basic descriptors, connectives, situational models, deep cohesion). Regarding basic descriptors, the schizophrenia group produced less speech, more unique words, and had a higher unique to total word ratio. Within connectives, the schizophrenia group had significantly lower causal, logical and contrastive connectives than the HIV+ group. Comparing measures of situation models, the schizophrenia group had significantly higher intentional content and lower causal and intentional cohesion. For deep cohesion, the schizophrenia group produced significantly lower scores on both measures.

Finally, a discriminant function analysis, using the stepwise methods of entering the independent variables to predict the grouping variable, was conducted in which lower causal, logical and contrastive connectives, measures of deep cohesion and causal and internal cohesion scores were used to predict membership in the schizophrenia and HIV groups. As revealed in Table 4, a significant predictor equation ($X^2 = 44.99$; $p > 0.001$) was produced which correctly classified over 70% of the participants as either having schizophrenia or HIV+.

4. Discussion

In this study, we compared the speech of schizophrenia and HIV+ groups using several different indices from the Coh-Metrix 3.0 and tested whether this method could be implemented to classify people into diagnostic categories. The study is unique in that it compared groups on a wide range of speech indices—from basic descriptors to more complex metrics—and used an interview that naturally elicits a story of the participant's unique experience to collect speech samples. As predicted, the speech in the schizophrenia group showed significant signs of disturbances across all four types of indices (basic descriptors, connectives,

Table 3
Comparisons of language structures within the narratives of adults with schizophrenia ($n = 200$) and HIV ($n = 55$).

Index	Schizophrenia		HIV+		ANCOVA[a]	
Descriptive	Mean	SD	Mean	SD	*F*	*p*
Total words	2788	212	3802	634	3.55	<0.001
Unique words	947	110	757	40	3.57	<0.001
Unique-total word ratio	0.34		0.20		3.50	<0.001
Connectives						
Causal	25.62	6.59	30.46	2.92	22.92	<0.001
Logical	41.86	10.01	47.06	7.10	11.59	0.001
Contrastive	16.25	5.75	19.13	4.45	11.21	0.001
Temporal	19.27	6.67	18.15	6.16	1.21	0.274
Additive	48.29	14.67	50.48	9.18	0.63	0.425
Situational models						
Causal content	51.95	12.18	49.96	9.18	0.38	0.539
Intentional content	27.30	10.51	21.59	7.39	10.16	0.002
Causal cohesion	0.47	0.32	0.70	0.35	17.34	<0.001
Intentional cohesion	0.81	0.48	1.17	0.62	16.81	<0.001
Multidimensional						
Deep cohesion *z*	0.41	0.88	0.81	0.55	13.85	<0.001
Deep cohesion %	63.19	21.00	75.04	15.48	14.92	<0.001

[a] ANCOVA controlling for age and education.

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Table 4
Correct classification rates of membership in the schizophrenia or HIV group based on selected Coh-Metrix scores.

	Predicted groups		
	Schizophrenia	HIV+	n
Actual group			
Schizophrenia	140 (70%)	60 (30%)	200
HIV+	15 (27%)	40 (73%)	55

situational models, deep cohesion). This is in line with previous research that has found greater speech disturbances across the schizophrenia-spectrum (Bearden et al., 2011; Docherty, 2012; Minor and Cohen, 2012; Minor et al., 2016). Whereas most previous studies have employed clinician-rated (de Sousa et al., 2016; Perkins et al., 2015) or hand-scored methods (Bearden et al., 2011; Docherty et al., 2013; Minor et al., 2016) to assess speech disturbance, the current study joins an emerging body of research that implements computerized assessments to assess unique facets of speech in schizophrenia (Bedi et al., 2015; Cohen and Elvevag, 2014; Elvevag et al., 2007; Fineberg et al., 2016; Minor et al., 2015).

Computerized assessments offer the benefit of being able to quickly provide a wide range of speech analyses from spoken or written samples. In this study, it was used to illustrate how those with schizophrenia differ from an HIV+ group in the four different types of indices. Regarding basic descriptors, the schizophrenia group showed less speech output but a higher proportion of unique words. This indicates that they generated less speech in response to an open-ended interview but that their speech tended to stray to various topics—which may signal circumstantiality—more frequently than those with HIV+. For connectives, the schizophrenia group was less likely to link words and phrases within sentences for three of the five measured categories (causal, logical, contrastive). This means their audience was left without important cohesive links to connect ideas within a sentence and had to devote cognitive resources to make these connections (Cain and Nash, 2011; Sanders and Noordmann, 2000). With the situational model, the schizophrenia group exhibited less causal and intentional cohesion, meaning their ratio of particles to content was lower across the full interview in both indices compared to the HIV+ group (McNamara et al., 2014; Zwaan et al., 1995). This holds relevance because low levels of causal and intentional cohesion suggest that those with schizophrenia often lack clarity when discussing both goal and non-goal directed activities to other people. Finally, deep cohesion was significantly lower in schizophrenia compared to the HIV+ group. This suggests that the schizophrenia group was less likely to provide the critical links necessary for their audience to follow their conversation (McNamara et al., 2014). Across indices, a consistent theme was that the schizophrenia group did not give links to help their audience follow their line of thinking; this occurred within sentences, between sentences, and across the full interview.

Findings from this study also showed how selecting a small subset of indices from a computerized measure can result in correctly classifying subjects into diagnostic categories in over 70% of cases. This holds potential clinical implications. Although computerized speech measures are an emerging methodology, they hold important advantages over interview ratings (e.g., increased objectivity, identification of specific segments of disturbance within speech samples) and hand-scoring methods that use trained raters (e.g., efficiency, fewer resources in terms of training personnel and conducting ratings). If validated, computerized measures could be useful as a supplemental tool to screen for or differentiate between diagnostic classifications. Future studies should compare ratings from the Coh-Metrix to other commonly used speech disturbance measures to determine convergence.

While the correlational nature of the study prevents us from making authoritative assertions about causality, results suggest many possibilities for investigation in future research. For one, results closely parallel early observations by Bleuler (1911/1950) and Jung (1906) and suggest that at basic levels, persons with schizophrenia tend to struggle to connect ideas, and also to form more complex ideas within the flow of discourse. In other words, disturbances appear at the level of integration of information. Indeed, there appears to be material within narratives which could come to describe the person as an agent in the world but it is not cohesively connected to other material. Theoretically, this may suggest that disturbances in sense of self and related metacognitive processes in schizophrenia may be in part conceptualized as difficulties connecting disparate aspects of self- experience. Specifically, the metacognitive and dialogical disturbances broadly observed to occur in this condition (Lysaker and Lysaker, 2010; Lysaker and Dimaggio, 2014) along with alterations in sense of agency (Dimaggio et al., 2009) and personal identity (Andresen et al., 2003; Lysaker and Lysaker, 2010) may stem in part from alteration in the back linguistic structures which enable ideas to be connected to one another within the flow of conscious thought and interpersonal communication.

Of note, there are limitations. The sample was composed of participants who were mostly men in their late 40s. All participants were actively involved in treatment. It may well be that different forms of disturbances of deep levels of semantic cohesion exist among younger persons, women with schizophrenia vs. persons with HIV, or persons who reject treatment. We also examined one speech sample and hence it is unclear to what extent the disturbances noted here are stable over time. The construct of adversity is broad and it is unknown whether the HIV+ and schizophrenia groups experienced levels of adversity which were truly comparable. Certainly, there are other groups who experience considerable adversity and we know little about whether they experience disturbances in deep levels of semantic cohesion that compares to those diagnosed with schizophrenia. The HIV+ group and the schizophrenia group may also have differed on other characteristics which were not assessed here. More research is also needed to determine whether disturbance in coherence and cohesion plays a role in functional impairment and is related to outcome. Finally the IPII interview cues persons to discuss their life history and personal narrative and it is unknown whether interviews which are more factually or present oriented would elicit similar sets of abilities of difficulties.

With replication there may be several important implications and avenues for future research. If Coh-Metrix scores reflect disordered thought at the level of basic coherence and cohesion it may be that it could be used to track changes over time and prove an important marker of change. Results may also have implications for understanding the mechanisms of change. It could be for instance that metacognitively oriented treatment that assist persons to form integrated ideas of themselves and others (Hamm et al., 2013; Lysaker and Klion, 2017) are operating at the level of helping persons compensate for, or perhaps correct for these basic alterations in semantic cohesion. Finally, many questions remain for future research including whether these disturbances are present before or after the onset of illness and whether they resolve as persons move towards wellness.

Conflict of interest

There are no conflicts of interest or disclosures.

Contributors

Michael Jones, Tim Rubin, Paul Lysaker and Jon Willits designed the study. Kyle Minor and Jon Willits managed the literature searches. Authors Paul Lysaker and Jon Willits did the statistical analysis. Author P.H. Lysaker wrote the first draft of the manuscript. Authors Michael Jones, Tim Rubin, Kyle Minor and Jon Willits commented on the first manuscript and contributed to the writing of the subsequent manuscript versions. All authors contributed in the finalization of the manuscript and have approved the final version.

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