Schizophrenia Bulletin vol. 38 no. 6 pp. 1327–1335, 2012
doi:10.1093/schbul/sbr048
Advance Access publication May 11, 2011

On Identifying the Processes Underlying Schizophrenic Speech Disorder

Nancy M. Docherty*

Department of Psychology, Kent State University, Kent, OH 44242

*To whom correspondence should be addressed; tel: 330-672-7670, fax: 330-672-3786, e-mail: ndochert@kent.edu

Speech of people with schizophrenia is often difficult to follow. There is evidence that neuropsychological deficits associated with schizophrenia explain some of the variance in speech disorder, but its nature and causes overall are not well understood. This study rated speech samples from 60 schizophrenic outpatients for thought disorder, conceptual disorganization, linguistic structural breakdown, and communication failure. A battery of neuropsychological tests potentially relevant to coherent speech production was administered, and associations between these variables and the speech measures were assessed. Consistent with previous research, the measure of functional effect, communication failure, was more highly associated with neuropsychological test performance than were the measures of putative cause: thought disorder, conceptual disorganization, or linguistic structural breakdown. Performance on tests of attention, immediate memory, working memory, organizational sequencing, and conceptual sequencing all were significantly related to the frequency of communication failures in the speech. In hierarchical regression, attention, working memory, and conceptual sequencing each contributed significantly and together explained 29% of the variance. Some other potential contributors to test in future research include auditory attention, internal source memory, emotional disturbances, and social cognitive deficits.

Key words: communication/thought disorder/cognitive impairment/language

Introduction

Thought disorder is a defining characteristic of schizophrenia.[1] Clinically, it manifests as disordered speech, alogia, and/or delusional thinking. Schizophrenia is also characterized by deficits in basic neuropsychological functions such as attention, memory, reasoning, and sequencing ability.[2–5] The relationship between neuropsychological deficits and thought disorder is not entirely clear, but there is a great deal of overlap conceptually. In fact, it is arguable that they are one and the same thing, viewed from different angles. They are defined identically, as disordered cognition, ie, disturbances in thought processes. Although clinical thought disorder is measured in terms of symptoms and neuropsychological deficits are measured in terms of impairments in specific cognitive abilities, both types of measures assess disturbances in thought processes.

Investigations of clinical thought disorder and neuropsychological deficits have nearly always approached them as separate constructs. There is a large literature on cognitive deficits in schizophrenia and another on cognitive symptoms. In support of viewing them separately, the preponderance of findings from studies that have looked at the neuropsychological correlates of schizophrenic symptoms indicates only modest associations with any symptoms, including thought disorder.[4,6–9] On the face of it, these findings might seem to indicate little relationship between neuropsychological deficits and cognitive symptoms. However, one problem with this interpretation is that the range in the variables of interest within a schizophrenic sample is quite restricted. Virtually all the participants in these studies have neuropsychological impairments and cognitive symptoms. Comparing their severities within such a sample is not likely to yield strong associations. The associations would almost certainly be much stronger in a broader sample that included people with and without schizophrenia, with severity of neuropsychological impairments and thought disorder symptoms ranging from none to severe. Such a combined sample would be prohibitively problematic statistically; the point is that the limitations inherent in examining associations between neuropsychological functioning and symptoms in a markedly impaired sample make it unlikely that strong associations will be identifiable even if strong relationships exist. Another difficulty in attempting to relate neuropsychological functioning to symptoms is that symptoms, which are assessed in terms of overt behavior, may manifest similarly across patients yet have different cognitive process origins in different individuals, or manifest

somewhat differently across individuals yet reflect similar cognitive deficits.

The present study focused on disordered speech, one of the symptoms presumably caused by disturbances in thought processes. A number of studies have examined correlations between speech disorder and neuropsychological test performance in areas of attention, working memory, and executive functioning, among others (for review, see ref. Kerns and Berenbaum[6]). In theory, these functions would seem to be very important in coherent speech production, yet with few exceptions, the associations identified have been surprisingly small. In addition to the problems of restricted range and diversity of causes of thought disorder symptoms discussed above, research specifically on the topic of speech disorder has another difficulty related to the approach to classification and quantification of the symptom. Most methods for assessing schizophrenic speech disorder have attempted to target the underlying thought disorder directly, with diverse targets such as associative loosening,[10–12] conceptual disorganization,[13] confabulatory percepts,[14,15] fragmentation,[16,17] and bizarre-idiosyncratic thinking[14,16,18] or combinations of such phenomena.[19,20] Alternatively, schizophrenic disordered speech has been posited to be the product of language-specific structuring deficits,[21,22] and measurement has targeted language structuring processes[23–25] or "schizophasic" deficits.[21,26,27] A third approach has been to assess disordered speech in terms of its functional effects, ie, failures in the communication of meaning.[28] The idea here is that the main purpose of speech is the transmission of meaning from speaker to listener, so measures of disorder in speech are based on the degree to which the conveyance of meaning is impaired. Speech disorder is quantified purely on the basis of pragmatics, on the degree to which its meanings are difficult to ascertain, rather than in terms of underlying thought disorder or linguistic structural impairment. In a previous article,[29] we argued that the communication failure approach to assessing speech disorder is more appropriate than the thought disorder approach for purposes of examining the neuropsychological underpinnings of speech disorder because it targets functional outcome rather than putative cause and then attempts to relate the outcome variable, or symptom, to potential neuropsychological causes.

In preliminary support of this hypothesis, performance on tests of low-load sustained attention and simple sequencing were found to correlate significantly more highly with a measure of communication failures in speech than with measures of formal thought disorder.[29] The present study was an attempt to test the same hypothesis in a more comprehensive way, using a more extensive battery of speech measures, including measures of formal thought disorder, conceptual disorganization, linguistic structural impairment, and communication failure, and a more extensive neuropsychological test battery, including tests of auditory and visual attention, immediate auditory memory, working memory, simple sequencing, organizational sequencing, and conceptual sequencing. Associations of the neuropsychological test scores with the different kinds of speech disorder ratings were compared. The unique and combined contributions of impairments in these neuropsychological functions to the variance in speech disorder also were assessed.

Methods

Participants

Participants were 60 adult outpatients who met *Diagnostic and Statistical Manual of Mental Disorders*, *Fourth Edition* (DSM-IV) criteria for schizophrenia or schizoaffective disorder.[1] The sample consisted of the first cohort of participants in a larger, ongoing project.[30] All participants were receiving treatment at 1 of 2 local community mental health centers. Patients were referred to the study by case managers or self-referred in response to signs posted in the clinic waiting rooms. Individuals who met DSM-IV criteria for current (past year) substance abuse or dependence were excluded from the study, as were those with histories suggestive of possible complicating organic conditions. Individuals whose primary language was not English also were excluded. The resulting sample was 55% male, 67% African-American, 30% Caucasian, and 3% other race/ethnicity. Ages ranged from 25 to 51 years, with a mean age of 42. Patient educational level ranged from 8 to 16 years, mean (SD) = 11.6 (1.8) years. Parent educational level (highest parent of each patient) ranged from 3 to 18 years, mean (SD) = 12.0 (3.2) years. Patient duration of illness ranged from 8 to 42 years, mean = 23 years. Participants were receiving atypical antipsychotic medications (82%), conventional antipsychotics (18%), or no antipsychotics (8%). Ten percent were receiving both kinds of antipsychotics. Mood stabilizers also were prescribed for 22%, antidepressants for 51%, antianxiety medications for 22%, and anticholinergics for 12%.

Procedure

Measures for the present study were administered in 2 sessions. The first session included informed consent, diagnostic interview, symptom ratings, and collection of the speech sample. Neuropsychological tests were administered in the second session, in a fixed order, 1 week later. Patients were paid for their participation.

Measures

Clinical Assessment. The Schedule for Affective Disorders and Schizophrenia diagnostic interview,[31] adapted slightly for use with DSM-IV criteria, was administered to all participants. Diagnoses were determined by a clinical psychologist with extensive research diagnostic experience,

using information from this interview and clinic records. Symptom ratings were done using the Positive and Negative Syndrome Scale (PANSS).[32] The interviews and symptom ratings were done by graduate assistants trained in the measures. Interrater reliability on the PANSS was assessed using independent coratings of audio-recorded interviews of a subsample of patients. Intraclass correlation (ICC) for total PANSS ratings and for the conceptual disorganization item were high, ICC = .96 and.92, respectively.

Speech Samples. Participants were asked to describe themselves, their interests, and their daily activities for 10 minutes. Interviewers prompted them with comments or questions as needed to keep them talking, to keep them on the prescribed topics as much as possible, and to steer them away from any emotionally laden topics. The speech samples were audio recorded and later transcribed for rating.

Formal Thought Disorder. The speech samples were assessed from the formal thought disorder perspective using selected scales from Andreasen's Thought, Language, and Communication Scales (TLC).[10] The full TLC consists of a large number of scales, many of which have substantial overlap (eg, derailment, loss of goal, and nonsequitur) or occur very infrequently (eg, clanging; word approximations). The scales rated in the present study included Poverty of Speech, Poverty of Content of Speech, Pressure of Speech, Derailment, Tangentiality, and Incoherence. TLC ratings were done directly from the audio recordings rather than from the transcripts. Two TLC scores were used in the analyses: a TLC total score, computed as the sum of ratings of all the above variables, and a TLC disorganization score, computed as the sum of the scales most reflective of disorganization: derailment, tangentiality, and incoherence. The disorganization score was included because it represents a somewhat more narrowly defined formal thought disorder, and one that could possibly be more reflective of cognitive impairment than the more broadly defined total score. The ratings were done by 2 individuals trained in the method. Interrater reliability on a subset of 12 speech samples was acceptable, ICC = .88 for TLC total and ICC = .86 for TLC disorganization.

Conceptual Disorganization. Thought disorder was also assessed using the "conceptual disorganization" item of the PANSS. This item is a global measure of disorganization of thought as reflected in speech, rated on a 7-point scale from "absent" to "very severe."

Linguistic Structural Disturbance. Linguistic structural disturbance was assessed using a method based on the work of Hoffman et al[24] that examines the hierarchical relationships among the statements in narrative speech. The method parses the speech into separate statements, roughly defined by independent clauses, and determines whether each statement follows from the preceding ones or whether there are disruptions in the hierarchical structure of the clausal sequences. The types of disruptions described by Hoffman et al include (1) complete breaks, in which a statement is (inappropriately) unrelated to previous statements, (2) nonpresuppositional associations, in which a statement is related to the previous speech, but only in a tangential and nonsubordinate way (eg, by association with a word in the previous statement), (3) negations, in which a statement directly contradicts a previous statement, (4) upward branching, in which a subordinate statement (inappropriately) precedes a superordinate one, and (5) nontransitive dependencies, in which a statement is related to previous statements, but not subordinate to them, and thus changes the direction of the narrative before the previous topic has reached closure. Following the method of Hoffman et al, each complete break was counted as 4 points, negations and nonpresuppositional associations as 3 points, and upward branching and nontransitive dependencies as 2 points. This method was applied to continuous narrative statements (ie, with no interruptions by a conversational partner). In the present study, the first set of 10–18 continuous statements in the speech sample was used, ending the segment with as complete a thought as possible within this span. In order to control for differences among participants in the number of statements assessed, the total score was divided by number of statements. These ratings were done by the first author, after obtaining acceptable interrater reliability with a second rater, ICC = .90.

Communication Disturbances. Communication disturbances were rated using the Communication Disturbances Index (CDI).[33] This is a measure of references in speech that is based entirely on failures in the transmission of meaning. The CDI defines references very broadly. The measure identifies all words or phrases with unclear meaning in a speech sample, classifies each instance as 1 of 6 different types of referential communication failure, and computes the frequencies with which they occur in the speech sample. The 6 types include (1) vague references, which are words or phrases that are unclear due to a lack of specificity, (2) confused references, which are unclear because they could refer to one of several possible referents, (3) missing information references, which are references for which the referent has not been provided and is not known to the listener, (4) ambiguous word meanings, unclear because the word or phrase has more than one possible definitional meaning, and the correct choice is not clear from the context, (5) wrong word usage, in which the meaning is unclear because of a seemingly incorrect word choice, and (6) structural unclarities, which are statements in which the meaning is unclear because of a breakdown in grammar. Use of poor

grammar, vague words, and so on, are only counted if they impair the conveyance of meaning from speaker to listener. Instances are counted, and the sum is divided by number of hundred words (# words/100) in the speech sample, to control for differences among subjects in amount of speech generated. These ratings were done using both the transcripts and the recordings. The rater attained good reliability with a second rater on a separate set of speech samples prior to completing the ratings for the present study, ICC = .94.

Neuropsychological Tests. Sustained attention was assessed using 2 continuous performance tasks (CPTs). The first (CPT-A) was a simple test of auditory sustained attention that consists of an 8-minute audiotaped quasi-random series of letters presented at 1-second intervals.[34] The subject is instructed to respond to a target letter every time it occurs. Errors of commission were very rare. Scores were computed as number of omissions. The second was the CPT-Identical Pairs test (CPT-IP),[35] which assesses visual sustained attention and also has a working memory component. Conditions 2, 3, and 4 were administered, with target stimuli of 2, 3, and 4 digits. Sensitivity scores, which take into account both hit rate and false alarm rate, were calculated for each condition. Working memory was assessed using the digit span test, including digits forward and backward.[36] Digits forward is a test of immediate auditory memory, and digits backward is a measure of manipulation of information in immediate auditory memory. A computerized version of the Wisconsin Card Sorting Test (WCST)[37,38] also was used as a measure of working memory. This measure is less heavily weighted toward the auditory modality than the digit span and requires somewhat longer-term processing. It also assesses more controlled (as opposed to automatic) processes than does the digit span. The WCST score used in the analyses was total number of errors. Simple sequencing ability was tested using the Trails A test, and organizational sequencing by the Trails B test.[39] Trails A presents the subject with a page with lettered circles scattered on it. The test requires the subject to draw a line from A to B to C in a "follow the dots" manner. Trails B requires the participant to draw a series of lines connecting 26 letters and numbers in alternating sequence. The reciprocals of time to correct completion were used as the scores on these tests. For those few who did not complete Trails B within 360 seconds, the test was discontinued and a maximum time of 360 seconds was used as the score. Conceptual sequencing involves the ordering of subordinate concepts in the service of superordinate concepts. The conceptualization subtest of the Shipley Institute of Living Scale[40] was administered as the test of conceptual sequencing ability. This test consists of 20 sequences of numbers, letters, or words. The participant is required to add to each given sequence by generating new sequential items. Each sequence is based on a different concept, with graduated levels of difficulty. Some facsimile sequences are (1) 9 8 7 6 5 _ _; (2) thin in clover over trout out blunder _ _ _ _ _; and (3) down up under over out. Scores are the number of items correct. This test has been used in some contexts as a measure of concept formation, or abstraction, but it also requires the ability to generate and organize simple concepts into sequences in the _ _. service of larger concepts, a capacity that is potentially particularly important for the generation of coherent speech.

Analysis

The analysis was done in 3 parts. First, correlations were computed between the different measures of speech disturbance. Next, correlations were computed between neuropsychological test scores and the measures of speech disturbance, to test the hypothesis that the communication measure would be the most highly associated with neuropsychological performance. Finally, a hierarchical regression was computed, testing the incremental and combined contributions of the neuropsychological measures to the speech disorder.

Results

Patients with schizophrenia did not differ significantly from those with schizoaffective disorder on any of the speech measures, so the 2 groups were examined as one. Distributions of TLC total, TLC disorganization, and PANSS conceptual disorganization ratings met assumptions of normality. Linguistic structure ratings and CDI ratings were skewed in the positive direction and therefore were log-transformed for the analyses. Distributions of the neuropsychological test scores met normal assumptions, with the exception of the CPT-A, on which nearly half the participants made no errors. Scores on that test were dichotomized. There were no significant effects of race/ethnicity, gender, age, or parents' educational level on any of the speech measures.

Correlations Between Measures of Speech Disturbance

Means and SDs for the measures of speech disorder are presented in table 1 and correlations between them in table 2. Associations were all in the positive direction, but generally modest in size, and in some cases not significant statistically. Significant correlations were found between the CDI, the PANSS conceptual disorganization scale, and the linguistic structural measure. Neither TLC rating corresponded to any significant degree to PANSS ratings of conceptual disorganization, linguistic structural impairment, or CDI communication disturbance in this sample.

Correlations of Speech Measures With Neuropsychological Test Scores

Correlations were computed between the measures of speech disorder and neuropsychological test scores (see table 3). TLC total and TLC disorganization ratings

Table 1. Means and SDs of Measures of Disorder in the Speech of 60 Patients With Schizophrenia or Schizoaffective Disorder

Measure	Mean	SD
TLC total	3.18	1.48
TLC disorganization	2.39	1.06
PANSS conceptual disorganization	2.19	1.13
Linguistic structural impairment	0.31	0.35
CDI total	1.96	1.06
CPT-A omissions	1.70	2.95
CPT-IP, 2 digits, d'	2.29	1.05
CPT-IP, 3 digits, d'	1.66	0.90
CPT-IP, 4 digits, d'	0.88	0.62
Digit Span, forward	7.04	2.17
Digit Span, backward	4.88	1.98
Digit Span total	11.97	3.65
WCST total errors	31.80	11.27
Trails A, time (s)	20.11	9.66
Trails B, time (s)	137.76	70.82
Shipley II	14.29	8.22

Note: TLC, Thought, language, and Communication Scales[10]; PANSS, Positive and Negative Symptom Scales[32]; CDI, Communication Disturbances Index.[28]; CPT-A, Continuous Performance Test—Auditory; CPT-IP, Continuous Performance Test—Identical Pairs; WCST, Wisconsin Card Sorting Test.

were not significantly related to performance on any of the tests. PANSS conceptual disorganization was related to performance on one test of working memory, digit span backward, but not to the tests of attention, sequencing, or conceptual sequencing. The linguistic structural measure was related to one test of attention, the most difficult condition of the CPT-IP, but not to any of the other tests. CDI ratings, on the other hand, were significantly related to performance on measures in several areas: attention (CPT-IP, all conditions), working memory (digit span forward and backward), organizational sequencing (Trails B), and conceptual sequencing (Shipley II). CDI ratings were not related significantly to performance on the CPT-A, Trails A, or WCST.

Mean correlations were computed between each speech measure and the summary measures of attention (CPT-IP total), working memory (digit span total), organizational sequencing (Trails B), and conceptual sequencing (Shipley II). Mean correlation of these cognitive variables with the CDI was $r = -.42$; with PANSS conceptual disorganization $r = -.16$; with linguistic structure $r = -.03$; with TLC total $r = -.06$; and with TLC disorganization, $r = -.07$. Hotelling's t-test for correlated correlations was used to compare the CDI correlations with those of the other measures. For CDI vs PANSS conceptual disorganization, t (57) = 2.16, $P < .05$; for CDI vs linguistic structure, t (57) = 2.32, $P < .05$; for CDI vs TLC total, t (57) = 2.28, $P < .05$; and for TLC disorganization, t (57) = 2.28, $P < .05$.

Table 2. Correlations Between Measures of Speech Disturbance, $n = 60$

	1	2	3	4	5
1. TLC total	1.00				
2. TLC disorganization	0.81**	1.00			
3. PANSS conceptual disorganization	0.04	0.03	1.00		
4. Linguistic structural impairment	0.11	0.18	0.29*	1.00	
5. CDI total	0.14	0.18	0.44**	0.32*	1.00

Note: TLC, Thought, language, and Communication Scales[10]; PANSS, Positive and Negative Symptom Scales[32]; CDI, Communication Disturbances Index[28].
*$P < .05$; **$P < .01$.

Neuropsychological Contributors to Communication Failures in Speech

The summary measures of attention, working memory, organizational sequencing, and conceptual sequencing all were correlated with CDI ratings. However, these cognitive functions are not completely distinct from each other. Correlations of the test scores with each other are presented in table 4. To assess their incremental and combined contributions to the frequency of communication failures in speech, these 4 test scores were entered hierarchically into a regression equation on CDI ratings. The neuropsychological variables were entered in order of increasing complexity. The most basic function, sustained attention, was entered first because all the other functions rely on it to some extent. Working memory was entered second, to see whether it contributed to communication failures beyond the effects of attention. Organizational sequencing, which relies on working memory as well as attention, was entered third, and the most complex function, conceptual sequencing, was entered fourth. Results of the regression, with R square change at each step, are presented in table 5. Each step made a significant contribution, with the exception of organizational sequencing in the third step. Attention, working memory, and conceptual sequencing each contributed significant variance, sequentially. The overall equation was significant, R (4, 55) = 0.54, $R^2 = 0.29$, $P < .01$. The test scores, taken together, explained 29% of the variance in total CDI ratings.

Discussion

This study applied several different measures of schizophrenic speech disorder to the speech of stable outpatients with schizophrenia or schizoaffective disorder. The

Table 3. Correlations of Neuropsychological Test Scores With Speech Disorder Ratings, $n = 60$

Neuropsychological Measure	TLC Total	TLC Pos	PANSS Disorg	Linguistic Structure	CDI Total
Attention					
CPT-A omissions	0.20	−0.02	0.15	−0.03	0.02
CPT-IP 2 condition, d'	0.04	0.01	−0.18	−0.06	−0.39**
CPT-IP 3 condition, d'	−0.06	−0.11	−0.02	−0.09	−0.35**
CPT-IP 4 condition, d'	−0.04	−0.02	0.00	−0.30*	−0.32*
CPT-IP total, d'	−0.02	−0.04	−0.09	−0.15	−0.40**
Working memory					
Digit span, forward	0.05	−0.07	−0.22	−0.05	−0.36**
Digit span, backward	−0.18	−0.07	−0.28*	−0.18	−0.39**
Digit span, total	−0.06	−0.08	−0.28*	−0.09	−0.42**
WCST total errors	0.03	0.02	0.04	−0.12	−0.07
Organizational sequencing					
Trails A, time (s)	−0.04	−0.09	−0.11	−0.17	−0.19
Trails B, time (s)	−0.05	−0.06	−0.18	0.00	−0.31*
Conceptual sequencing					
Shipley, part II	−0.12	−0.01	−0.10	0.12	−0.52**

Note: Abbreviations are explained in the first footnote to table 1.

Table 4. Correlations Between the Summary Neuropsychological Test Scores, $n = 60$

	1	2	3	4
1. Attention (CPT-IP total)	1.00			
2. Working memory (digit span total)	0.48**	1.00		
3. Organizational sequencing (Trails B)	−0.36**	−0.44**	1.00	
4. Conceptual sequencing (Shipley II)	0.54**	0.72**	−0.48*	1.00

Note: CPT-IP, Continuous Performance Test—Identical Pairs.
*$P < .05$; **$P < .01$.

measures of cognitive disorganization, linguistic structural impairment, and communication failure were significantly correlated with each other, but not with TLC ratings of formal thought disorder. The modest sizes of the associations among the speech measures, most of which were applied to the same or overlapping speech samples, indicate that the way in which speech disturbance is defined has a substantial impact on its measurement. Neuropsychological test performance was more highly related to CDI ratings than to disorganization, linguistic structure, or formal thought disorder ratings. These results provide further evidence that the cognitive process underpinnings of schizophrenic speech disturbance are more readily identifiable when the speech disorder measure targets functional impairment, ie, failure in the communication of meaning, than when it attempts to target directly the putative cause, ie, thought disorder, disorganization, or linguistic structuring impairment. Significant and sizeable associations were found between the cognitive measures and CDI ratings, which is notable especially in light of the restricted ranges inherent in a sample such as this.

The TLC ratings in the present study were not related to the other measures of speech or to neuropsychological test performance. Because the TLC contains many scales that have significant overlap with each other, and some that occur very infrequently, we used only selected scales in this study, as described in the "Methods" section. It is possible that the full TLC would have been more highly related to the other variables. However, the scales were selected with the intention of optimizing associations with disorganization and negative processes. In previous studies, the same TLC scales used here have corresponded to CDI and disorganization ratings at low to moderate levels,[29,41] but neither these TLC scales nor TLC ratings using all the scales have been very highly related to neuropsychological variables in most studies.[6] The absence of any associations between the TLC scales and the other speech measures in the present study is likely to have been due to the nature of the sample, which consisted of relatively stable outpatients. The TLC is a more "clinical" measure than the others, in the sense that it reflects frank pathology, and is not very sensitive to subtle, subclinical gradations of disturbance such as have been found in the speech of nonschizophrenic relatives of patients and nonpsychiatric individuals.[41] In contrast, the CDI is quite sensitive to low-level instances of communication failure as well as to higher, pathological levels. TLC ratings have been found to be less stable over time in patients than CDI ratings and more highly related to current clinical state.[42] Both CDI ratings and neuropsychological test scores have been relatively stable in patients over time and across changes in clinical state, compared with the TLC.[42,43]

Lower scores on tests of sustained attention, working memory, sequencing, and conceptual sequencing were associated with higher frequencies of communication failures in speech. It is always possible that such correlations are due to differences among patients in general level of cognitive functioning, rather than to specific effects. A common approach to this generalized deficit problem is to factor out a measure of general intelligence, and test whether the associations are still significant. We took a different approach, based on the idea that global cognitive impairment is probably the result of impairment in one or

Table 5. Hierarchical Regression of Neuropsychological Test Scores on Communication Disturbances Index Ratings, $n = 60$

Variables/steps	R	R^2	R^2 Change	FChange	P
1. Attention (CPT-IP total d')	0.41	0.16	0.16	11.16	.001
2. Working memory (digit span total)	0.48	0.23	0.07	4.78	.03
3. Organizational sequencing (Trails B)	0.49	0.24	0.01	0.68	.42
4. Conceptual sequencing (Shipley II)	0.54	0.29	0.06	4.58	.04

Note: Abbreviation is explained in the first footnote to table 4.

more lower level cognitive functions that affect performance on virtually all higher level tasks, rather than some kind of diffuse G-factor. This approach assumed that neuropsychological variables (and the CDI too, in this case) correlated with each other because they all rely to some extent on certain basic low-level cognitive abilities. One of the most basic is sustained attention. Impairment in this function makes it impossible to do well on almost any neurocognitive test. At the next level, but still basic, immediate memory relies on attention but may be impaired even if attention is intact. Immediate memory impairment affects the ability to perform well on many higher level neurocognitive tasks. In the present study, the lower level processes were regressed out one at a time, hierarchically, to test whether the higher level processes (eg, conceptual sequencing) were related to speech disorder only because both relied on lower level processes such as attention, or whether impairments in the higher level process also contributed to speech disorder even after removal of their shared variance with lower level processes. The regression procedure used in the present study was viewed as a better method of identifying specific effects than the method of factoring out measures of general intelligence, which are really just nonhierarchical composites of measures of attention, working memory, sequencing, and other related functions.

In the realm of attention, CDI ratings were associated with the visual measure but not the auditory one. This was somewhat surprising because auditory attention might be expected to be more relevant to speech performance. However, the auditory measure used in this study was relatively easy, and as a result scores on the test had to be dichotomized, which may well have reduced its efficacy as a correlational variable. The question of whether a more challenging test of auditory attention would be more highly related to speech disorder is a topic for future research.

Digit span scores were related to CDI ratings, supporting the idea that working memory impairment is part of what underlies CDI communication failures. However, scores on the WCST, which also reflect working memory ability, were unrelated to CDI ratings or any of the other speech disorder measures. WCST scores had a good range and distribution, so the cognitive capacities it assesses appear to be less relevant to coherent speech production than those assessed by the digit span test. The working memory required by the WCST is less immediate than that required by the digit span test. The WCST also is primarily visual, whereas the digit span is auditory. Finally, because the WCST is relatively complex, performance reflects other capacities besides working memory, including concept formation and maintenance and the ability to switch sets. These other capacities may have affected WCST scores enough to diminish its measurement of differences among participants specifically in working memory capacity.

Simple sequencing, assessed by the Trails A test, was not significantly related to CDI ratings, but the more complex sequencing assessed by Trails B was. Trails B has a heavier working memory component than Trails A, and this may explain the difference. Trails B correlated significantly with digit span, a measure of working memory, and no longer exerted a significant influence on CDI ratings after the effects of the CPT-IP and digit span were removed via regression. Conceptual sequencing was substantially related to CDI ratings. This is consistent with our previous findings.[29] Furthermore, it continued to contribute significantly even after removal of the effects of the CPT-IP, digit span, and Trails B tests. Generation of coherent speech requires the sequencing of small concepts (words) for the purpose of conveying larger concepts (thoughts). The test of conceptual sequencing, which requires the generation of sequential concepts in the service of a larger concept, appears to capture to a significant extent cognitive impairments that compromise communicative ability in people with schizophrenia.

Conclusions and Future Directions

Performance on the neuropsychological tests was not very highly related to speech disorder measured from thought disorder, disorganization, or linguistic structuring perspectives but explained a significant proportion of the variance in speech disorder measured from the perspective of communication failure. This supports the idea that communication failures in the speech of schizophrenic patients may not reflect psychotic ideation so much as they reflect combinations of schizophrenia-related neuropsychological impairments. That being said, the majority of the variance in schizophrenic speech disorder is still unexplained. In the interests of developing interventions to ameliorate speech disorder, it would be very helpful to have a fuller understanding of its causes. As discussed in the "Introduction," there are limits to the current method of examining correlates of speech disorder, primarily due to the restriction of range inherent in samples consisting only of people with schizophrenia. However, future studies of

neuropsychological correlates of schizophrenic communication failures still may be able to reveal additional cognitive contributors related to auditory attention, or to other specific facets of cognitive functioning such as internal source memory, semantic memory, and cognitive control.[44–46] Psychophysiological and neuroimaging studies also have had some success in delineating the brain structures and activity involved in speech symptoms (eg, Kuperberg et al[47,48]). These lines of research show considerable promise for identifying and localizing the brain processes involved. In addition, beyond cognitive process impairments, schizophrenic speech may be affected by emotional symptoms. Speech samples on emotionally negative topics have been found to exhibit more disorder than those on pleasant or neutral topics in patients as a group, and this effect is more pronounced in some patients than others.[49,50] Possibly the anxiety and other emotional symptoms that are present in some people with schizophrenia contribute to the disorder in their speech beyond the effects of neuropsychological impairments, or else interact with neuropsychological impairments to affect speech.[50] Finally, speech disorder may have social cognitive contributors. Investigators have observed that the schizophrenic speaker often does not seem able to take the perspective of the listener well enough to understand the information necessary for clear communication of meaning.[14,16,18] Future research on the origins of schizophrenic disordered speech should examine the effects of other potential neuropsychological contributors beyond those studied here, the brain areas and processes involved, and emotional and social cognitive contributors as well.

Funding

National Institute of Mental Health (R01-MH58783).

Acknowledgments

This study was carried out at Community Support Services in Akron, Ohio. The author thanks the administration, staff, and patients for their assistance and participation. The authors have declared that there are no conflicts of interest in relation to the subject of this study.

References

1. American Psychiatric Association. *Diagnostic and Statistical Manual of Mental Disorders. 4th ed, revised Washington, DC:*American Psychiatric Association Press; 2000.
2. Heinrichs RW, Zakzanis KK. Neurocognitive deficit in schizophrenia: a quantitative review of the evidence. *Neuropsychology*. 1998;12:426–445.
3. Nelson EB, Sax KW, Strakowski SM. Attentional performance in patients with psychotic and nonpsychotic major depression and schizophrenia. *Am J Psychiatry*. 1998;155:137–139.
4. O'Leary DS, Flaum M, Kesler ML, Flashman LA, Arndt S, Andreasen NC. Cognitive correlates of the negative, disorganized, and psychotic symptom dimensions of schizophrenia. *J Neuropsychiatry Clin Neurosci*. 2000;12:4–15.
5. Wolwer W, Gaebel W. Impaired trail-making test-B performance in patients with acute schizophrenia is related to inefficient sequencing of planning and acting. *J Psychiatr Res*. 2002;36:407–416.
6. Kerns JG, Berenbaum H. Cognitive impairments associated with formal thought disorder in people with schizophrenia. *J Abnorm Psychol*. 2002;111:211–224.
7. Nuechterlein KH, Edell WS, Norris M, Dawson ME. Attentional vulnerability indicators, thought disorder, and negative symptoms. *Schizophr Bull*. 1986;12:408–426.
8. Goldberg TE, Aloia MS, Gourovitch ML, Missar D, Pickar D, Weinberger DR. Cognitive substrates of thought disorder, I: the semantic system. *Am J Psychiatry*. 1998;155: 1671–1676.
9. Palmer BW, Dawes SE, Heaton RK. What do we know about neuropsychological aspects of schizophrenia? *Neuropsychol Rev*. 2009;19:365–384.
10. Andreasen NC. Thought, language, and communication disorders: I. clinical assessment, definition of terms, and evaluation of their reliability. *Arch Gen Psychiatry*. 1979;36:1315–1321.
11. Manschreck TC, Maher BA, Milavetz JJ, Ames D, Weisstein CC, Schneyer ML. Semantic priming in thought disordered schizophrenic patients. *Schizophr Res*. 1988;1:61–66.
12. Spitzer M, Braun U, Hermle L, Maier S. Associative semantic network dysfunction in thought-disordered schizophrenic patients: direct evidence from indirect semantic priming. *Biol Psychiatry*. 1993;34:864–877.
13. Overall JE, Gorham DR. The brief psychiatric rating scale. *Psychol Rep*. 1962;10:799–812.
14. Johnston MH, Holzman PS. *Assessing Schizophrenic Thinking.* San Francisco, CA: Jossey-Bass; 1979.
15. Rapaport D, Gill MM, Schafer R. Diagnostic Psychological Testing. New York, NY: International Universities Press; 1968.
16. Wynne LC, Singer MT. Thought disorder and family relations of schizophrenics: I. A research strategy. *Arch Gen Psychiatry*. 1963;9:191–198.
17. Wynne LC, Singer MT. Thought disorder and family relations of schizophrenics: II. A classification of forms of thinking. *Arch Gen Psychiatry*. 1963;9:199–206.
18. Harrow M, Quinlan DM. *Disordered Thinking and Schizophrenic Psychopathology.* New York, NY: Gardner Press; 1985.
19. Andreasen NC. *Scale for the Assessment of Positive Symptoms.* Iowa City, IA: University of Iowa Press; 1983.
20. Liddle PF, Ngan ETC, Caissie SL, et al. Thought and language index: an instrument for assessing thought and language in schizophrenia. *Br J Psychiatry*. 2002;181: 326–330.
21. Chaika E. A linguist looks at schizophrenic language. *Brain Lang*. 1974;1:257–276.
22. Crow TJ. Is schizophrenia the price that homo sapiens pays for language? *Schizophr Res*. 1997;28:127–141.
23. Morice RD, Ingram JC. Language analysis in schizophrenia: diagnostic implications. *Aust N Z J Psychiatry*. 1982;16: 11–21.
24. Hoffman RE, Stopek S, Andreasen NC. A comparative study of manic vs schizophrenic speech disorganization. *Arch Gen Psychiatry*. 1986;43:831–838.

25. Sledge WH, Hoffman RE, Hawkins K, Docherty NM, Quinland DM, Rakfeldt J. Linguistic deviance in schizophrenia, preliminary report. *In:* France J, Kramer S, eds. *Communication and Mental Illness: Theoretical and Practical Approaches.* New York, NY: Jessica Kingsley; 2001:371–392.
26. Lecours AR. Schizophasia: the glossomanic and glossolalic subtypes. *In:* Sims A, ed. *Speech and Language Disorders in Psychiatry.* London, UK: Gaskell; 1995:81–95.
27. Thomas P, Leudar I, Napier E, Kierney G, Ellis E. Syntactic complexity and negative symptoms in first onset schizophrenia. *Cognit Neuropsychiatry*. 1996;1:191–200.
28. Docherty NM, DeRosa M, Andreasen NC. Communication disturbances in schizophrenia and mania. *Arch Gen Psychiatry*. 1996;53:358–364.
29. Docherty NM. Cognitive impairments and disordered speech in schizophrenia: thought disorder, disorganization, and communication failure perspectives. *J Abnorm Psychol*. 2005;114:269–278.
30. Docherty NM. *Cognitive Bases of Schizophrenic Language Symptoms.* 2007. NIMH Research Grant # R01–MH058783.
31. Spitzer RL, Endicott J. *Schedule for Affective Disorders and Schizophrenia—Lifetime Version.* New York: New York Psychiatric Institute; 1977.
32. Kay SR, Flszbein A, Opfer LA. The positive and negative syndrome scale (PANSS) for schizophrenia. *Schizophr Bull*. 1987;13:261–276.
33. Docherty NM, Rhinewine JP, Labhart RP, Gordinier SW. Communication disturbances and family psychiatric history in parents of schizophrenic patients. *J Nerv Ment Dis*. 1998; 186:761–768.
34. Lezak MD. *Neuropsychological Assessment.* 3rd ed. New York, NY: Oxford University Press; 1995.
35. Cornblatt BA, Risch NJ, Faris G, Friedman D, Erlenmeyer-Kimling L. The continuous performance test, identical pairs version (CPT-IP): I. new findings about sustained attention in normal families. *Psychiatry Res*. 1988;26:223–238.
36. Wechsler D. *WAIS-R Manual; Wechsler Adult Intelligence Scale—Revised.* New York, NY: Psychological Corp.; 1981.
37. Kongs S, Thompson L, Iverson G, Heaton R. *Wisconsin Card Sorting Test-64 Card Computerized Version.* [computer software]. Odessa, FL: Psychological Assessment Resources; 2000a.
38. Kongs S, Thompson L, Iverson G, Heaton R. *Wisconsin Card Sorting Test—64 Card Version. Professional Manual.* Odessa FL: Psychological Assessment Resources; 2000b.
39. Reitan RM, Davison LA. *Clinical Neuropsychology: Current Status and Applications.* Oxford, England: V. H. Winston & Sons; 1974.
40. Zachary RA. *Shipley Institute of Living Scale: Revised Manual.* Los Angeles, CA: Western Psychological Services; 1986.
41. Docherty NM, Miller TN, Lewis MA. Communication disturbances in the natural speech of schizophrenic patients and non-schizophrenic parents of patients. *Acta Psychiatr Scand*. 1997;95:500–507.
42. Docherty NM, Cohen AS, Nienow TM, Dinzeo TJ, Dangelmaier RE. Stability of formal thought disorder and referential communication disturbances in schizophrenia. *J Abnorm Psychol*. 2003;112:469–475.
43. Liu SK, Chiu C, Chang C, Hwang T, Hwu H, Chen WJ. Deficits in sustained attention in schizophrenia and affective disorders: stable versus state-dependent markers. *Am J Psychiatry*. 2002;159:975–982.
44. Harvey PD. Reality monitoring in mania and schizophrenia: the association of thought disorder and performance. *J Nerv Ment Dis*. 1985;173:67–73.
45. Nienow TM, Docherty NM. Internal source monitoring and communication disturbance in patients with schizophrenia. *Psychol Med*. 2005;35:1717–1726.
46. Kerns JG. Verbal communication impairments and cognitive control components in people with schizophrenia. *J Abnorm Psychol*. 2007;116:279–289.
47. Kuperberg GR, Kreher DA, Ditman T. What can event-related potentials tell us about language, and perhaps even thought, in schizophrenia? *Int J Psychophysiol*. 2010;75:66–76.
48. Kuperberg GR, West WC, Lakshmanan BM, Goff D. Functional magnetic resonance imaging reveals neuroanatomical dissociations during semantic integration in schizophrenia. *Biol Psychiatry*. 2008;64:407–418.
49. Docherty NM, Hall MJ, Gordinier SW. Affective reactivity of speech in schizophrenia patients and their nonschizophrenic relatives. *J Abnorm Psychol*. 1998;107:461–467.
50. Burbridge JA, Barch DM. Emotional valence and reference disturbance in schizophrenia. *J Abnorm Psychol*. 2002;111: 186–191.