Journal of Abnormal Psychology
1994, Vol. 103, No. 2, 241–250


0021-843X/94/$3.00

# The Relationship Between Information Processing and Language Production

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We explored the relationships between information processing and language in order to further the understanding of language disturbances in psychiatric patients. To assess the impact of reduced processing capacity on language, 50 undergraduates completed an interview concurrent with a category monitoring task and a control interview without a concurrent task. Syntactic complexity, verbosity, and pause patterns were all disrupted by a reduction in processing capacity. In addition, individual differences in syntactic complexity and information processing were significantly associated, even after accounting for verbal intelligence. We discuss the relevance of the results for understanding language disturbances in psychopathology and hypothesize that a reduction in processing capacity may underlie the decreased syntactic complexity, decreased verbal output, and increased pause length found in schizophrenia.

Both Bleuler (1911/1950) and Kraepelin (1919/1971) considered disturbances in speech to be core symptoms of schizophrenia. Historically, research on this topic has focused on traditional categories of thought disorder. However, recent work examining schizophrenic speech has used approaches borrowed from the literature on normal speech production. Such research has consistently shown that schizophrenic individuals are more likely than controls to have reduced syntactic complexity (e.g., Fraser, King, Thomas, & Kendell, 1986) and to exhibit incompetent references (e.g., Hotchkiss & Harvey, 1990). Disturbances such as increased semantic errors, syntactic errors, and dysfluencies (e.g., Morice & McNicol, 1986) have also been found among schizophrenic individuals.

The majority of the research on the etiology of language disturbances in schizophrenia has focused on the role of information processing. Schizophrenic individuals exhibit a variety of information-processing deficits, including, but not limited to, (a) selective attention (e.g., Oltmanns & Neale, 1975); (b) short-term memory (e.g., Morice, 1990); (c) signal noise discrimination (e.g., Nuechterlein et al., 1992); and (d) speed of information processing (e.g., Braff, 1989). These deficits are often treated as discrete disturbances that may have independent etiologies. However, it has also been suggested (e.g., Nuechterlein & Dawson, 1984) that these performance deficits all stem from a reduction in the amount of processing capacity available for cognitive operations. Furthermore, this hypothesized reduction in processing capacity has been posited to be the primary information-processing disturbance in schizophrenia (Callaway & Nagdhi, 1982; Nuechterlein & Dawson, 1984).

Researchers have attempted to link information-processing deficits with the language disturbances observed in schizophrenia. In such research, it has been common to divide thought disorder into two global categories: positive and negative (e.g., Docherty, Schnur, & Harvey, 1988). *Positive thought disorder* refers to phenomena such as derailment; *negative thought disorder* refers to phenomena such as poverty of speech. Several studies have shown that deficits in selective attention and working memory are associated with global indexes of positive thought disorder, as well as with incompetent references (e.g., Cornblatt, Lenzenweger, Dworkin, & Erlenmeyer-Kimling, 1985; Harvey & Serper, 1990). Interestingly, such information-processing deficits have not been found to be associated with negative thought disorder. Indirect evidence concerning the information-processing correlates of negative thought disorder can be derived from research on negative symptoms because the two are highly correlated (Andreasen & Olsen, 1982). Deficits in complex information processing (e.g., Cornblatt et al., 1985), signal noise discrimination under heavy processing loads (e.g., Nuechterlein, Edell, Norris, & Dawson, 1986), and slower information processing (e.g., Braff, 1989) are all associated with negative symptoms, but not with positive symptoms. Thus, the relationships between information processing and language in schizophrenia appear to be complex, which led us to ask the following questions: (a) Can a single deficit in information processing, such as the hypothesized reduction in processing capacity, account for the complexity of these relationships? and (b) Do multiple deficits (information processing or otherwise) need to be postulated in order to explain the complexity of these relationships?

We believe that analog research using nonclinical populations can help answer such questions by clarifying the relationships among various facets of language and information processing. If one assumes that the relationships between language and information processing are the same in normal subjects and schizophrenic subjects, then one should be able to use analog studies to test models of schizophrenic language disturbances. In particular, analog studies should be capable of disconfirming

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We thank Alan Mead for his help with computer programming.

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models that postulate sufficient causes for various schizophrenic disturbances. For example, if one hypothesizes that a sufficient cause of incompetent references is a reduction of magnitude X in information-processing capacity, then a failure of such a reduction in processing capacity to induce incompetent references in normal subjects would provide disconfirming evidence for the hypothesis. Research that reveals how information processing and language are associated in a nonpsychiatric population can also be used to generate new hypotheses about the causes of language disturbances in schizophrenia.

Some may question whether research with a nonschizophrenic population can provide any information about schizophrenia. In particular, some may wonder about the wisdom of assuming that the relationships between information processing and language are similar in schizophrenic and nonschizophrenic subjects. However, as Maher (1988) pointed out, "There is a case to be made that psychological processes should be assumed to be normal until their pathological nature has been demonstrated independently" (p. 333). The possibility that disturbances in "normal" processes can lead to "pathological" outcomes has proved to be a valuable strategy in other areas, such as research on aphasia. For example, Martin, Saffran, Dell, and Schwartz (1991) found that a change in the decay rate of an otherwise normally functioning connectionist simulation of language production could produce paraphasic errors almost identical to those found in individuals with deep dysphasia.

In order to improve the ability of analog research to inform the understanding of the relationships between information processing and schizophrenic language disturbances, the facets of information processing that are measured or manipulated in nonschizophrenic subjects should be similar to the facets of information processing that are impaired in schizophrenia. Nuechterlein and Dawson (1984) suggested that a reduction in processing capacity is the primary information-processing disturbance in schizophrenia. A reduction in processing capacity can be induced in normal subjects using a dual-task paradigm. In a dual-task paradigm, participants are asked to perform two tasks simultaneously. If both tasks are capacity demanding, it is assumed that less processing capacity will be available for one or both tasks than under single-task conditions. Numerous studies have shown that a dual-task paradigm can significantly impair performance on one or both tasks in normal subjects, even after data limitations and response mode interference have been ruled out (Wickens, 1984).

It has long been recognized that information processing is not a unitary construct and that there are several different facets of information processing (e.g., Cowan, 1988). It is possible that schizophrenic individuals have several different, discrete information-processing disturbances, some of which are linked to language disturbances. Therefore, it is desirable for analog research to investigate a variety of information-processing facets that are similar to those that may be impaired in schizophrenia. One way to do this in normal subjects is to study individual differences in various facets of information processing. Individuals vary in their "natural" abilities along a variety of information-processing dimensions. Studying the relationships between language and various points on these information-processing continua may provide clues about the links between language and information processing in schizophrenic subjects, whose disturbances may lie at the ends of these continua.

In this study we examined the relationships between information processing and language in a sample of nonpatients, with the goal of exploring several hypotheses about the etiology of schizophrenic speech disturbances. A great deal of research has demonstrated that processing capacity is associated with language comprehension (e.g., Just & Carpenter, 1992). In particular, a reduction in processing capacity, induced through a dual-task paradigm, can induce language comprehension deficits in normal individuals (King & Just, 1991). In addition, individual differences in working memory and language comprehension are related, with low capacity being associated with comprehension deficits (e.g., Engle, Cantor, & Carullo, 1992). We recognize that language comprehension and language production are very different processes that may be related to information processing in different ways. However, several theorists (e.g., Levelt, 1989) have hypothesized that at least some aspects of language production are controlled, capacity-demanding functions. The relatively limited research that has explored the link between processing capacity and language production suggests that processing capacity may be associated with relative clause production (e.g., Power, 1986), phonological complexity (Campbell & Keegan, 1987), lexical access (Daneman & Green, 1986), verbal fluency (Daneman, 1991), reference (Pratt, Boyes, Robins, & Manchester, 1989), and writing rate and errors (Brown, McDonald, Brown, & Carr, 1988). In addition, Bock and Cutting (1992) found that indirectly reducing processing capacity increased syntactic errors. By contrast, one study that directly manipulated processing capacity showed that the manipulation did not alter the frequency of speech disruptions (Ford & Holmes, 1978). However, this study included only 8 subjects and did not have the power to investigate changes in individual types of disruption, such as filled pauses and repetitions. Although preliminary, the majority of the existing research suggests a link between processing capacity and language production. Taken together with the work on language comprehension, we think it is plausible that diminished processing capacity is associated with language production deficits.

One goal of our study was to examine whether particular facets of information processing would be related to the sorts of language production disturbances observed in schizophrenia. In addition, we attempted to collect evidence that would be pertinent to the following two alternative hypotheses: (a) that a single deficit, a reduction in processing capacity, is sufficient to account for all of the language disturbances observed in schizophrenia and (b) that more than one deficit (information processing or otherwise) is needed to account for the variety of language disturbances found in schizophrenia. Finding that inducing a reduction in processing capacity in normal subjects caused all of the language disturbances found in schizophrenia would provide evidence consistent with the first hypothesis. By contrast, finding that inducing a reduction in processing capacity in normal subjects caused some, but not all, of the language disturbances found in schizophrenia would provide evidence consistent with the second hypothesis.

## Method

### *Participants*

Participants were 37 male and 13 female undergraduate students. All participants were native English speakers, and their average age was 18.7 years ($SD = 1.0$).

### *Procedure*

Each participant completed six tasks in the following order: (a) the digit span distraction task (DSDT; Oltmanns & Neale, 1975); (b) a category monitoring task; (c) the Vocabulary subtest of the Wechsler Adult Intelligence Scale–Revised (WAIS–R; Wechsler, 1981); (d) a first interview; (e) the Digit Span subtest of the WAIS–R; and (f) a second interview.

The distractibility index (the percentage correct in the nondistraction condition minus the percentage correct in the distraction condition) of the DSDT was used to measure selective attention. In the DSDT, participants hear a series of digits read in a female voice (through headphones). On some of the trials, a male voice reads digits in between the digits spoken by the female voice. Participants were asked to write down as many digits as they could remember that were read by the female voice. The Digits Total score of the Digit Span subtest of the WAIS–R was used to measure working memory capacity. The Digits Total score is the sum of Digits Forward and Digits Backwards. In Digits Forward, subjects read a series of digits that increase in length and are asked to recall them in their exact order. In Digits Backwards, the subjects are asked to repeat the digits backward.

The category monitoring task was administered to obtain measures of complex processing ability. This task bears some similarity to the Continuous Performance Test (CPT; Roswold, Mirsky, Sarason, Bransome, & Beck, 1956) in that subjects needed to monitor for a predetermined target. In order to increase the complexity and processing load of this task, we made the following changes: (a) Participants needed to respond after every trial, not just following target trials; (b) whole-word stimuli were used instead of single letters; and (c) a class of target stimuli was used instead of a single target. In the current task, participants saw a series of words appear one at a time in the middle of a computer screen. Participants were told to press, using their preferred hand, one key on the keyboard if the word was an animal (target) and another key if the word was not an animal (nontarget). There was a total of 249 words, of which one fifth were target words. Target and nontarget words were matched for mean frequency (Francis & Kucera, 1982) and mean word length, and were randomly intermixed. Response timing began on presentation of a word and was terminated when the participant responded, or at 3 s if the participant did not respond. A new word appeared on the screen 1 s after the termination of the previous trial. To ensure continued attention to the task, participants were prompted by a message on the screen after every two nonresponses. Two measures of complex processing ability were obtained: errors (false positives and false negatives) and reaction time, calculated using only trials on which participants responded.

The information-processing dimensions examined in this study are all associated with both schizophrenia and schizophrenic vulnerability. Previous research has indicated that both schizophrenic subjects and their relatives perform poorly on the (a) DSDT (e.g., Harvey, Winters, Weintraub, & Neale, 1981; Oltmanns & Neale, 1975); (b) Digit Span subtest of the WAIS–R (e.g., Cornblatt & Erlenmeyer-Kimling, 1985; Morice, 1990); and (c) CPT, particularly when processing loads are high (e.g., Cornblatt & Erlenmeyer-Kimling, 1985; Orzack & Kornetsky, 1966; Wood & Cook, 1979).

The Vocabulary subtest of the WAIS–R was administered to determine whether the relations between language and information processing would reflect anything more than a relationship between verbal intelligence and language. Vocabulary was chosen because it is the subtest that displays the highest correlation with Verbal IQ ($r = .90$; Wechsler, 1981). Two research assistants scored each participant's responses. Interrater reliability, measured using an intraclass correlation with raters treated as random effects and the mean of the raters as the unit of reliability, was .96.

Participants completed both a dual-task interview and a control interview. The dual-task interview was performed concurrently with a category monitoring task. This category monitoring task was identical to the one previously described, but with "body parts" as the target category instead of "animals." The dual-task interview was used to assess the impact of reduced processing capacity on the language variables. Baddeley (1986) argued that working memory involves a central executive with limited capacity that is used for processing incoming information and for storing the products of this processing. Because the category monitoring task involves processing incoming information, we believe it can be reasonably argued that this task taxes working memory capacity. It has also been argued (e.g., Levelt, 1989) that language production requires the storage of the output of various stages in working memory. On the basis of this hypothesis, the category monitoring task and language production should both be competing for the same resources in working memory, producing a reduction in processing capacity available to normal subjects for use in language production. Previous research has indicated that schizophrenic subjects' information-processing difficulties are exacerbated by a dual-task manipulation (Granholm, Asarnow, & Marder, 1991). This finding suggests that a dual-task manipulation such as the one used in our study taps a meaningful aspect of schizophrenic subjects' information-processing disturbances.

The control interview, conducted without a concurrent task, was administered to obtain baseline measures of the language variables. Two parallel 15-question interviews were constructed. Fifteen sets of 2 similar open-ended questions were developed (e.g., "Describe the perfect vacation," "Describe the perfect date"). One question from each of the 15 sets was randomly assigned to each of the interviews. The questions were asked in the same order for each participant, and there was no time limit for the interview. Participants were allowed to say as little or as much as they wanted to in response to each question. However, if a subject did not respond to a question within 5 s or stopped in the middle of a response for 5 s, they were prompted to continue speaking. The version used for the control interview versus the dual-task interview was alternated across participants. The order of the interviews was counterbalanced across participants. The analyses were collapsed across interview order and version because they exerted no meaningful effects on the dependent variables. Research assistants, unaware of condition (control or dual task), transcribed all of the interviews. A second research assistant and one of us, also unaware of condition, checked each transcript for accuracy.

The Appendix contains examples of the language variables investigated in this study. These examples were taken from both the literature on schizophrenic speech and from this study (if participants displayed the phenomena).

*Traditional thought disorder ratings.* Two research assistants scored all of the categories from the Scale for the Assessment of Thought, Language, and Communication (TLC; Andreasen, 1986), using the revised definitions described by Berenbaum, Oltmanns, and Gottesman (1985). Interrater reliability was measured using intraclass correlations with the raters treated as random effects and the mean of the raters as the unit of reliability. The participants did not display most of the phenomena rated by the TLC. Because of the low frequencies, only poverty of speech showed adequate reliability (.85). We are confident that the low frequencies of most phenomena rated by the TLC truly reflects the absence of these phenomena and not the inability to detect their presence. In our previous research with psychiatric samples, we have been able to train undergraduates to reliably rate these phenomena when they are present (e.g., Berenbaum & Barch, 1993; Berenbaum et al., 1985).

*Syntactic complexity, verbosity, and syntactic errors.* An advanced linguistics graduate student made the following ratings for each transcript: (a) number of independent clauses; (b) number of dependent clauses; and (c) number of syntactic errors. Syntactic errors were defined as anything that resulted in an ungrammatical spoken English sentence and were counted even if the participant corrected the error. Because of the enormous amount of data generated by the interviews, linguistic ratings were completed only on the first 8 questions in each transcript. To ensure that the ratings from the first 8 questions were representative of all 15 questions, the linguist completed the ratings for all 15 questions on a subset of 14 transcripts. The correlations between the ratings for the first 8 questions and the ratings for all 15 questions ranged from .90 to .97 ($M$ = .94).

Another advanced graduate student in psycholinguistics, also unaware of the interview condition, completed the same ratings for a subset of 28 transcripts. Interrater reliability, measured using an intraclass correlation with the raters treated as random effects and the individual rater as the unit of reliability, was .99 for number of independent clauses, .97 for number of dependent clauses, and .87 for number of syntactic errors.

Verbosity was measured by counting the number of words per interview. Poverty of speech, as measured by the TLC, was also considered a measure of verbosity. Number of words and poverty of speech were associated in both interviews ($r$s = −.37 and −.54, respectively), suggesting that they were measuring a similar construct.

Syntactic complexity was measured in two ways: the average number of dependent clauses per T-unit and the average number of words per T-unit. A T-unit is a single independent clause with all of its modifying subordinate clauses (Hunt, 1965). These measures are believed to represent syntactic complexity because they reflect global acquisition sequences. As children mature, they begin to introduce dependent clauses into their speech, and their average T-unit length increases (Hatch, 1983). The two measures of syntactic complexity were highly correlated in both interviews ($r$s = .69 and .76, respectively), suggesting that they were measuring the same construct.

A syntactic error score was calculated by dividing the number of syntactic errors by the number of words. This correction for verbosity was used because opportunities for errors are determined by the quantity of speech.

*Dysfluencies.* Two research assistants and one of us, all unaware of the interview condition, rated repeated words, false starts, and corrections. Repeated words were coded if the participant repeated a single word. A false start was coded if (a) the participant said one or more words of a sentence, did not finish, and then produced a different sentence (e.g., "I like—it's a good book) or (b) the participant said two or more words of a sentence, stopped, repeated some or all of the original words, and then finished the sentence (e.g., "I feel good when I—when I create things"). A correction was coded if the participant completed a whole sentence but then went back and corrected it (e.g., "It was a good school—it is a good school"). Parenthetical clauses were ignored when making these ratings. Interrater reliability, measured with an intraclass correlation treating raters as random effects and the mean of raters as the unit of reliability, was .99. Dysfluency scores were calculated by dividing the sum of repeated words, false starts, and corrections by the number of words. This correction for verbosity was used to account for the number of opportunities for dysfluencies.

*Filled pauses.* The number of filled pauses (e.g., "um," "ah") in each interview was coded as a measure of the difficulty of language generation (Rochester, 1973). To correct for verbosity, we divided the number of filled pauses by the number of words.

Table 1
*Correlations Among the Information-Processing Measures*

| Measure | 2 | 3 | 4 |
|---|---|---|---|
| 1. Distractibility index | −.11 | −.06 | −.10 |
| 2. Digits total score | — | −.16 | −.14 |
| 3. Category monitoring errors | | — | −.10 |
| 4. Category monitoring reaction time | | | — |

*Incompetent references.* A research assistant, unaware of the interview condition, rated unclear or ambiguous references according to the criteria outlined by Halliday and Hasan (1976). An unclear reference was defined as a demonstrative or personal reference with an unrecoverable referent. An ambiguous reference was defined as a demonstrative or personal reference with two or more possible referents. One of us, also unaware of the interview condition, rated a subset of 39 transcripts for incompetent references. Interrater reliability, measured with an intraclass correlation treating raters as random effects and the individual rater as the unit of reliability, was .86. To account for verbosity, we divided the number of incompetent references by the number of words.

## Results

We first examined the correlations among the various measures of information processing. As can be seen in Table 1, none of the information-processing measures were significantly correlated, a result that is consistent with the view that information processing is not a unitary construct. Table 2 contains the descriptive statistics for the measures of complex information processing and for the language variables. Dependent sample $t$ tests indicated that, compared with baseline, subjects made more errors, $t(49) = -8.19, p < .001$, and took longer to respond, $t(49) = -12.05, p < .001$, on the category monitoring task with the concurrent interview. This result provides evidence that our dual-task paradigm was capable of reducing processing capacity and inducing significant performance deficits.

Next, we explored the impact of reduced processing capacity on the language variables. We began by examining whether reduced processing capacity would elicit any of the categories of thought disorder. The only category of thought disorder displayed by participants with enough frequency to be rated reliably was poverty of speech. A dependent sample $t$ test indicated that the dual-task interview elicited significantly more poverty of speech than did the control interview, $t(49) = -2.58, p < .05$. These results indicate that a simple reduction in processing capacity reduces verbosity but that it does not elicit any other subtype of thought disorder.

We then examined the impact of reduced processing capacity on syntactic complexity and verbosity (as measured by the number of words). A dependent sample Hotelling's $T^2$, comparing dependent clauses per T-unit, words per T-unit, and total number of words from the two interview conditions, was significant, $T^2(3, 47) = 21.62, p < .005$. Ninety-five percent Bon-

Table 2
*Means and Standard Deviations for Complex Information Processing and Language Variables in Each Condition*

| | Interview | | | |
|---|---|---|---|---|
| | Control | | Dual task | |
| Variable | *M* | *SD* | *M* | *SD* |
| Complex information processing | | | | |
| Number of errors | 8.58 | 6.07 | 21.32 | 9.95 |
| Reaction time (in milliseconds) | 60.29 | 8.40 | 97.19 | 24.86 |
| Thought disorder | | | | |
| Poverty of speech | 0.09 | 0.26 | 0.21 | 0.43 |
| Syntactic complexity and verbosity | | | | |
| Number of dependent clauses per T-unit | 0.40 | 0.20 | 0.34 | 0.16 |
| Number of words per T-unit | 9.1 | 2.4 | 8.1 | 2.1 |
| Number of words per interview | 545.4 | 353.5 | 446.7 | 286.0 |
| Difficulty of language generation, Syntactic errors, reference, and fluency | | | | |
| Number of filled pauses per word | 0.047 | 0.028 | 0.060 | 0.026 |
| Number of syntactic errors per word | 0.001 | 0.003 | 0.001 | 0.005 |
| Number of incompetent references per word | 0.002 | 0.002 | 0.001 | 0.003 |
| Number of dysfluencies per word | 0.021 | 0.013 | 0.021 | 0.012 |

ferroni confidence intervals indicated that scores for all three of these variables were significantly different in the two interviews. As shown in Table 2, scores for each of the three variables were reduced in the dual-task condition, demonstrating that reduced processing capacity impairs both the quantity and syntactic complexity of speech.

We then tested whether reduced processing capacity would affect filled pauses, syntactic errors, reference, and fluency. A dependent sample Hotelling's $T^2$, comparing filled pauses, syntactic errors, incompetent references, and dysfluencies in the two interviews, was significant, $T^2(4, 46) = 24.8, p < .005$. However, 95% Bonferroni confidence intervals indicated that only filled pauses were more common in the dual-task interview than in the control interview. It is possible that the other variables did not appear to be influenced by reduced processing capacity because they had low means that were often smaller than their standard deviations. However, a categorical analysis of the dichotomously coded data (present and absent) for syntactic errors, incompetent references, and dysfluencies also did not reveal any effect of reduced processing capacity. It is also possible that our null findings for these variables were attributable to the manipulation not being effective for all participants. Therefore, we repeated the previously described analyses using only those subjects who scored below the mean on percentage of nonresponses ($M = 3.2$, $SD = 7.0$). The results were identical to those described earlier, suggesting that manipulation failure does not explain the lack of an association between reduced processing capacity and syntactic errors, reference, and fluency.

The results of the previous analyses indicate that reduced processing capacity affected syntactic complexity, verbosity, and filled pauses. To determine whether these three facets of language were related to each other, we examined the correlations among them. As can be seen in Table 3, the variables were all highly correlated. Each linguistic measure from the control interview was highly correlated with the same measure from the dual-task interview. As expected, lower syntactic complexity was related to lower verbosity. In addition, both lower syntactic complexity and verbosity were related to a greater number of filled pauses.

Having found that a reduction in information-processing capacity affected verbosity, syntactic complexity, and the use of filled pauses, we examined whether individual differences in information processing would be associated with individual differences in these three linguistic indexes. We addressed this question by conducting multiple regression analyses, examining whether the information-processing measures (i.e., distractibility index, digits total, category monitoring task errors, and category monitoring task reaction time) could predict the linguistic measures from the dual-task interview. Our reason for using the measures from the dual-task interview instead of the control interview (or a difference score) was similar to the reason for doing an electrocardiogram stress test. An electrocardiogram stress test, in which the heart is taxed more than normal, can be used to identify subtle heart problems that are not noticeable under ordinary circumstances. Similarly, we hypothesized that a dual-task paradigm would make it possible to uncover relationships between individual differences in information processing and language that would not be noticeable under ordinary circumstances in a nonpsychiatric sample. We conducted a separate multiple regression, using the information-processing variables as predictors, for each of the five linguistic measures (i.e., dependent clauses per T-unit, words per T-unit, words per interview, poverty of speech, and filled pauses). The four information-processing variables were forced to enter the regression equations simultaneously. Individual differences in information processing were capable of predicting individual differences in the number of dependent clauses per T-unit ($R = .51, p < .01$) and the number of words per T-unit ($R = .50, p <$

Table 3
*Correlations Among Complexity, Verbosity, and Language Generation Difficulty Measures*

| Measure | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1. Dependent clauses per T-unit | .49*** | .69*** | .54*** | −.19 | −.31* |
| 2. Words per T-unit | .76*** | .54*** | .70*** | −.37** | −.40** |
| 3. Words per interview | .62*** | .69*** | .77*** | −.37** | −.49*** |
| 4. Poverty of speech | −.52*** | −.69*** | −.54*** | .65*** | .46*** |
| 5. Filled pauses per word | −.42** | −.41** | −.53*** | .29* | .75*** |

*Note.* Correlations above the diagonal are for the control interview, correlations below the diagonal are for the dual-task interview, and correlations on the diagonal are between the same variables from the two different interviews.
* $p < .05$. ** $p < .01$. *** $p < .001$.

.05).[1] As shown in Table 4, the beta weights indicated that the distractibility index and errors on the category monitoring task were the best predictors for both measures of syntactic complexity. Individual differences in information processing did not significantly predict words per interview ($R = .27, p > .1$), poverty of speech ($R = .31, p > .1$), or filled pauses ($R = .35, p > .1$). It is worth noting, however, that errors on the category monitoring task were consistently associated with words per interview, poverty of speech, and filled pauses ($\bar{r} = .23$) and that the distractibility index was associated with poverty of speech ($r = .19$), although we are reluctant to overinterpret these zero-order correlations because the multiple regressions were not statistically significant.

It is possible that information-processing deficits and lower syntactic complexity were associated because they both reflect lower verbal intelligence. To test this hypothesis, we examined whether individual differences in information processing would still be associated with syntactic complexity after accounting for the relationship between verbal intelligence and syntactic complexity. We conducted two hierarchical multiple regressions, using both the WAIS–R Vocabulary scores and the information-processing measures to predict each of the two syntactic complexity measures. The WAIS–R Vocabulary scores were forced to enter the equations in the first step, and the information-processing measures were entered as a block in the second step. The Vocabulary scores significantly predicted both the number of dependent clauses per T-unit ($R = .30, p < .05$) and the number of words per T-unit ($R = .37, p < .05$). However, even after entering the Vocabulary scores, the information-processing variables were still significant predictors of both dependent clauses per T-unit ($R^2$ change $= .20, p < .05$) and words per T-unit ($R^2$ change $= .17, p < .05$). Therefore, lower verbal intelligence cannot account for the association between individual differences in information processing and syntactic complexity.

Table 4
*Standardized Beta Weights for the Information-Processing Variables Predicting Complexity in the Dual-Task Interview*

| Information-processing variables | Language variable: Dependent clauses per T-unit | Language variable: Words per T-unit |
|---|---|---|
| Distractibility index | −.25* | −.29* |
| Digits Total score | .22 | .14 |
| Errors on the category monitoring task | −.36** | −.34** |
| Reaction time on the category monitoring task | −.07 | −.15 |

* $p < .05$. ** $p < .01$.

## Discussion

In this study we found that an experimental manipulation that led to reduced processing capacity resulted in decreased verbosity and syntactic complexity, as well as difficulties in language generation (filled pauses). We also found that individual differences in selective attention and complex information processing were related to individual differences in language production, particularly syntactic complexity. Thus, the results of this study indicate that certain facets of information processing are associated with at least some of the language disturbances found in schizophrenia. We feel that two aspects of these results are particularly noteworthy: (a) The information-processing manipulation led to some of the language disturbances seen in schizophrenia, but not others, and (b) individual differences in

[1] In hierarchical multiple regressions that entered the matching linguistic measure from the control interview before entering the information-processing measures as a block, individual differences in information processing remained associated with individual differences in dependent clauses per T-unit ($R^2$ change = .19, $p < .01$) and words per T-unit ($R^2$ change = .10, $p = .07$).

information processing and language were associated in a nonpsychiatric population, even after controlling for verbal intelligence.

What can these results reveal about the relationship between information processing and language production in schizophrenia? A reduction in processing capacity was not sufficient to cause several of the language disturbances found in schizophrenia. Thus, our results are inconsistent with the hypothesis that a single deficit, a reduction in processing capacity (at least of the magnitude induced in this study), is sufficient to account for all of the language disturbances observed in schizophrenia. By contrast, our results are consistent with the alternative hypothesis that in order to explain the variety of language disturbances found in schizophrenia, one must posit either a more severe reduction in processing capacity or more than a single deficit (information processing or otherwise). In particular, several aspects of our results are consistent with the hypothesis that more than a single deficit is necessary to explain language disturbances in schizophrenia. Not all facets of language appeared to be equally associated with each other. Syntactic complexity, verbosity, and language generation difficulty (filled pauses) were all highly intercorrelated, but they did not display a clear link to the other language variables. Furthermore, not all aspects of language were equally associated with all facets of information processing. A similar pattern of results has been found in research on schizophrenia. Poverty of speech, syntactic complexity, and pause length are associated with each other, but not with positive thought disorder (Morice & Ingram, 1983; Resnick & Oltmanns, 1984); positive thought disorder and incompetent references are associated with each other, but not with negative thought disorder (Harvey & Serper, 1990). As discussed earlier, research on schizophrenia also shows that not all language disturbances are associated with the same information-processing deficits. Taken together, our results and the research on schizophrenia suggest that schizophrenic language disturbances may form at least two dimensions, each of which may be linked to different etiological factors.

We think that the results of our study generate some testable hypotheses about the possible causes of disturbances in both of the language dimensions described earlier. In this study, the dimension consisting of verbosity, syntactic complexity, and pausing was affected by reduced processing capacity. We hypothesize that among schizophrenic individuals, disturbances in this language dimension are influenced by chronic reductions in processing capacity. Two lines of evidence stemming from the literature on schizophrenia are consistent with this hypothesis. First, there is evidence that reduced verbosity and syntactic complexity, as well as reduced processing capacity, are all relatively stable in schizophrenia (e.g., Docherty et al., 1988; King, Fraser, Thomas, & Kendell, 1990; Nuechterlein et al., 1992). Second, research has demonstrated an association between global indexes of negative symptoms and information-processing deficits thought to be attributable to reduced processing capacity (Nuechterlein et al., 1986).

We found that individual differences in certain language and information-processing dimensions were associated. We believe these results also provide evidence consistent with the hypothesis that a traitlike deficit in processing capacity underlies schizophrenic subjects' poverty of speech, reduced syntactic complexity, and increased pause length. Specifically, these results suggest that there are continua of language and information-processing capabilities that are linked. We found that those nonpsychiatric individuals with the poorest selective attention and complex information processing had the least syntactically complex speech and also tended to produce less speech and more filled pauses. This result is consistent with the hypothesis that the more severe disturbances in both information processing and language continua found in schizophrenia are also linked. This hypothesis is supported by research showing that schizophrenic subjects' relatives, whose information-processing capacities fall between those of schizophrenic and control subjects (e.g., Cornblatt & Erlenmeyer-Kimling, 1985), also display reduced verbal productivity (Harvey, Weintraub, & Neale, 1982).

Although participants in this study displayed reduced syntactic complexity and verbosity when deficits in processing capacity were induced, they did not display positive thought disorder or increased syntactic errors, incompetent references, or dysfluencies. Although admittedly speculative, we hypothesize that the subjects in our study did not exhibit these language disturbances because they compensated for a reduction in processing capacity by decreasing the quantity and syntactic complexity of their speech. As suggested by Morice (1986), some schizophrenic individuals may not be reducing syntactic complexity as a way of compensating for constraints on language generation. One hypothesis is that schizophrenic individuals who continue to produce complex speech may exhibit positive thought disorder and increased errors and dysfluencies. Preliminary support for this hypothesis comes from a study by Morice and McNicol (1986), who found a trend for increased syntactic complexity to be associated with more frequent dysfluencies among schizophrenic subjects. A related hypothesis is that the use of compensatory strategies such as reducing syntactic complexity and verbosity depends on the ability to allocate information-processing resources. Some schizophrenic individuals may have a deficit in the ability to allocate information-processing resources that impairs their ability to use such compensatory strategies and hence contributes to positive thought disorder and increased errors and dysfluencies.

The results of our study generate some testable hypotheses about the causes of the various language disturbances found in schizophrenia. It is possible that among schizophrenic individuals, a different factor, such as social disengagement (Mayer, Alpert, Stastny, Perlick, & Empfield; 1985), is responsible for the language disturbances (e.g., reduced verbosity) that were caused by reducing the processing capacity of the subjects in our study. However, our results are consistent with the hypothesis that reduced processing capacity may be one factor, but not necessarily the only one, that can influence verbosity, syntactic complexity, and pausing. Therefore, the possibility that a chronic, traitlike reduction in processing capacity underlies disturbances in these phenomena in schizophrenia merits further exploration. One way of testing this hypothesis, and particularly its specificity to schizophrenia, would be to explore the relationship between reduced information-processing capacity and linguistic output in other diagnostic groups. For example, depressives also display poverty of speech (Andreasen, 1979). Depressives' poverty of speech could be linked to a similar, although more state-like, information-processing deficit. In addition, further research is needed to investigate the etiology of other disturbances in schizophrenic speech, such as positive thought disorder and increased errors and dysfluencies. In particular, the hypothesis that difficulties in the allocation of information-processing resources contribute to these language disturbances is worthy of further exploration.

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*(Appendix follows on next page)*

## Appendix

### Examples of Language Phenomena

| Language phenomena | Examples from the schizophrenia literature | Examples from the current study |
|---|---|---|
| Loss of goal | Question (Q): "Do you watch or play any sports?" Answer (A): "Uh, no not really, I don't. I used to like to play in volleyball. I used to like to play volleyball with my kids, with my daughter and, and my, uh, grandchildren, and uh, my two sons that were. . . . We liked to go out to eat. We do like going out to eat all three of us, all four of us together with the grandkids. So all of us go eat, go out to eat."[a] | |
| Derailment | (Q): "What do you think about the weather?" (A): "Well, I think it's pretty nice. I thought maybe I had some babies that weren't grandkids."[a] | |
| Tangential response | (Q): "Do you ever go dancing now?" (A): "When I was young I won prizes for dancing."[b] | |
| Incoherence | "I don't think they care for me because two million camels . . . 10 million taxis. . . . Father Christmas on the rebound."[b] | |
| Neologisms | "I got so angry I picked up a dish and threw it at the *geshinker*."[c] | |
| Poverty of speech | (Q): "Were you working before you came in the hospital?" (A): "No." (Q): "What kind of jobs have you had in the past?" (A): "Oh, some janitor jobs, painting."[c] | (Q): "When you are praised, how do you react?" (A): "Smile." (Q): "How do you get along with your family?" (A): "Very well." |
| Incompetent references | "A commuter and a skier are on a ski lift and *he* looks completely unconcerned."[d] | (Q): "Describe the perfect vacation." (A): "Um . . . I would like to either go to Bermuda or Jamaica. *It*'s my favorite place." |
| Syntactic complexity | "John went home."[e] (one independent clause; three words per T-unit) "John, who was tired, went home."[e] (one independent clause, one dependent clause; six words per T-unit) | (A): "I get angry." (one independent clause, three words per T-unit) (Q): "If you could buy any house in the world, what would it be like?" (A): "It would be medium-sized, probably about the same size as what I live in at home now, which is just enough bedrooms for like the three kids and the parents." (one independent clause, two dependent clauses; 31 words per T-unit) |
| Syntactic error | "He __ not attending a large university"[e] | "My favorite movie was *Lethal Weapon*. *It* just *have* a lot of action and comedy at the same time." |
| Dysfluencies | "We have a room where I went to that we, where we enjoy ourselves, and we, where I was enjoying myself."[a] | (Q): "How do you get along with your family?" (A): "It's like, I don't know, I feel kinda bad but its probably, it's like, more like its, we got, we live together but sometimes, you know, it doesn't mean we actually have to get along." |
| Filled pauses | "I'm fifty eight years old and, uh, I, uh, live at uh, a nursing home, and, uh, I like to live there."[a] | (Q): "What do you think about the situation in Iraq?" (A): "Umm, oh, shoot, uh, Iraq is, well it I . . . I believe that, umm, President Bush is, umm, an effective leader." |

[a] Taken from Berenbaum and Barch (1993). [b] Taken from Berenbaum and Oltmanns (1983). [c] Taken from the Scale for the Assessment of Thought, Language and Communication (Andreasen, 1986). [d] Taken from Rochester, Martin, and Thurston (1977). [e] Taken from Thomas, King, Fraser, and Kendell (1990).

Received June 8, 1992
Revision received August 20, 1993
Accepted August 25, 1993 ■