
 <<Preliminary Reports>>

Neurolinguistic Evidence for Syntactic and Semantic Processes : A Review of the Literature

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Abstract : Recent investigations of syntactic and semantic aspects of language comprehension in aphasia are reviewed. It is argued that these studies support theoretical assumptions concerning the functional independence of various components of normal language processing. Studies of sentence comprehension support the existence of a syntactic mechanism that is independent of lexically based heuristic strategies for assigning meaning. There is evidence that these independent elements of language are subserved by different portions of the dominant hemisphere of the brain. Studies of aphasic language provide a valuable source of constraints on theories of normal language processing.

Key words : comprehension in aphasia, syntactic breakdown, normal language processing

Introduction

There are two arguments that can be made concerning the importance of aphasia research to the study of normal processes. First, models of normal language functioning should not be inconsistent with the data obtained with aphasic populations. Since current theories of language are so underdetermined by data, it would be foolhardy to ignore a source of constraint on permissible theories of language. The second argument is based on the belief that there is ultimately more than a trivial connection between psychological processes and the brain. It is specifically argued that in the ideal case, brain damage selectively impairs discrete components of language, so processes that are highly interdependent in the normal adult can be more clearly identified. Even in cases involving complex patterns of dissolution, it is possible by a judicious process of comparing various patient types to identify components of processing that are so closely intertwined in the normal adult that they are irretrievable. Ultimately, research motivated on the basis of this claim should generate new

hypotheses about the structure of language processing.

This review focuses on aphasia research that addresses two components that are involved in sentence comprehension : syntactic and semantic processing. At the syntactic level, the concern is with determining whether syntactic processes are independent of semantic processes in sentence comprehension.

Comprehension in Aphasia

Research in aphasia has typically focused on deficits in the productive capacities of brain-damaged patients, that is, on overt speech behavior. Discussion of impairment of the ability to comprehend spoken language has been limited, for the most part, to impressions that a patient's comprehension is relatively impaired or clinically intact. Such global descriptions of the phenomenon of language comprehension obscure the fact that a highly complex interactive system of components and processes underlies the extraction of meaning from a particular configuration of words. It is likely that damage to different parts of the brain will differentially disrupt these

components of comprehension, as the various elements of productive speech are differentially affected.

Several recent investigations have looked more carefully at the process of comprehension in an attempt to disentangle the components involved and to determine whether they can be selectively impaired in comprehension failure (Goodglass & Baker, 1976). One result of these efforts has been the identification of elements of comprehension deficit that are not readily apparent to clinical observation. For example, the class of patients usually said to have relatively intact comprehension (those with anterior damage) is now believed to be deficient in the ability to integrate correctly understood lexical items into certain types of syntactic frames (Caramazza & Zurif, 1976). The impression of intact comprehension in the face of impaired syntax may be produced by the patient's adoption of communicative strategies based on redundant cues to meaning that might occur within the sentence or the surrounding context.

In general, there is reason to expect that the process of comprehension can be analyzed into component elements to pinpoint the site of the breakdown, language comprehension is no more a unitary, all-or-none phenomenon than is the process of language production, and there is no reason to believe that comprehension disruption should be global. Rather, just as in production disturbances, brain damage should cause damage selectively.

Research on Syntactic Breakdown

Caramazza and Zurif (1976) assessed comprehension capacities in aphasics with anterior and posterior lesions of the dominant hemisphere. The task employed in this study was a sentence–picture matching task. Patients were presented orally with a sentence and were asked to choose from two pictures the one that depicted the proposition described by the sentence. There were two major manipulations that

are of interest here : One was the type of sentence used ; the other was the type of information contrast depicted by the picture pair. The important variable in the sentence material was whether the center–embedded sentence was reversible or nonreversible, that is, whether the lexical items contained in the sentence permitted one or more readings if one ignored syntactic constraints. Thus, in the reversible sentence *The lion that the tiger is chasing is fat*, the lexical items alone permit the readings *The tiger is chasing a fat lion*, *The lion is chasing a fat tiger*, *The fat tiger is chasing the lion*, and *The fat lion is chasing the tiger*. However, in the nonreversible sentence *The bicycle that the boy is holding is broken*, selectional restrictions on the lexical items permit only the reading *The boy is holding a broken bicycle*. Four types of picture contrasts were used, three of which could be solved using lexical information alone. The fourth contrast required the patient to recover the correct syntax of the sentence in order to make the correct choice.

There was a clear effect of contrast type for the agrammatic (anterior) aphasics, who responded correctly about 90% of the time on the lexical contrasts but only about 70% of the time on the syntactic contrasts. The paragrammatic patients showed no reliable pattern but were significantly poorer in overall performance than the agrammatic patients. Furthermore, the performance of agrammatic and paragrammatic patients showed a clear and consistent difference based on whether the sentence was reversible or nonreversible. The agrammatic patients performed at the 90% level of accuracy on nonreversible sentences, but their performance dropped to chance with reversible sentences. The paragrammatic patients' performance was unaffected by this manipulation. These results clearly show that the agrammatic aphasic's ability to comprehend sentences is seriously compromised. What is more important, the locus of disruption appears to be at the level of syntactic process-

ing.

This limitation of anterior aphasics' ability to process syntactic information has emerged in several other recent studies of comprehension (Marin, Saffran, & Schwartz, 1976 ; Scholes, 1978) and in studies of linguistic intuitions on the structure of sentences (Zurif, Caramazza, & Myerson, 1972 ; Zurif, Green, Caramazza, & Goodenough, 1976).

This last set of studies indicates that the anterior aphasic's intuitions about his language are as agrammatic as his output. Zurif et al. (1972) required patients to judge which words of a sentence "went best together." The patients were presented with triads of words from the sentence (which was always in their view) and were asked to point to the two words that were most closely related. These judgments of proximity were analyzed using a hierarchical clustering procedure (Johnson, 1967) to obtain for each sentence a treelike hierarchical structure. The implicit hierarchical organization that emerged for the normal control group corresponded to the familiar parsing tree of the surface structure of a sentence. The structures that emerged for the anterior aphasics, on the other hand, were quite distorted. The aphasics

grouped together only the content words and for the most part ignored or inappropriately placed the function words. Thus, it appears that the anterior aphasic's agrammatism extends to his intuitions about language. (Fig.1)

Memory and Syntactic Processing

The foregoing treatment of comprehension performance has proceeded as if the only mechanisms involved were language-specific ones. It is obvious, however, that there are non-linguistic cognitive operations that come into play in processing a sentence for comprehension. Lexical meaning involve retrieval mechanisms that access prestructured conceptual entities, but sentence meaning additionally involve the operation of a syntax, a system of rules that works over time to determine the logical relations that hold among the lexical items in a sentence. The operations of a syntactic system necessarily implicate the functioning of a working memory that temporarily stores parts of a sentence while the remainder of the sentence is being encoded.

To the extent that memory mechanisms are im-

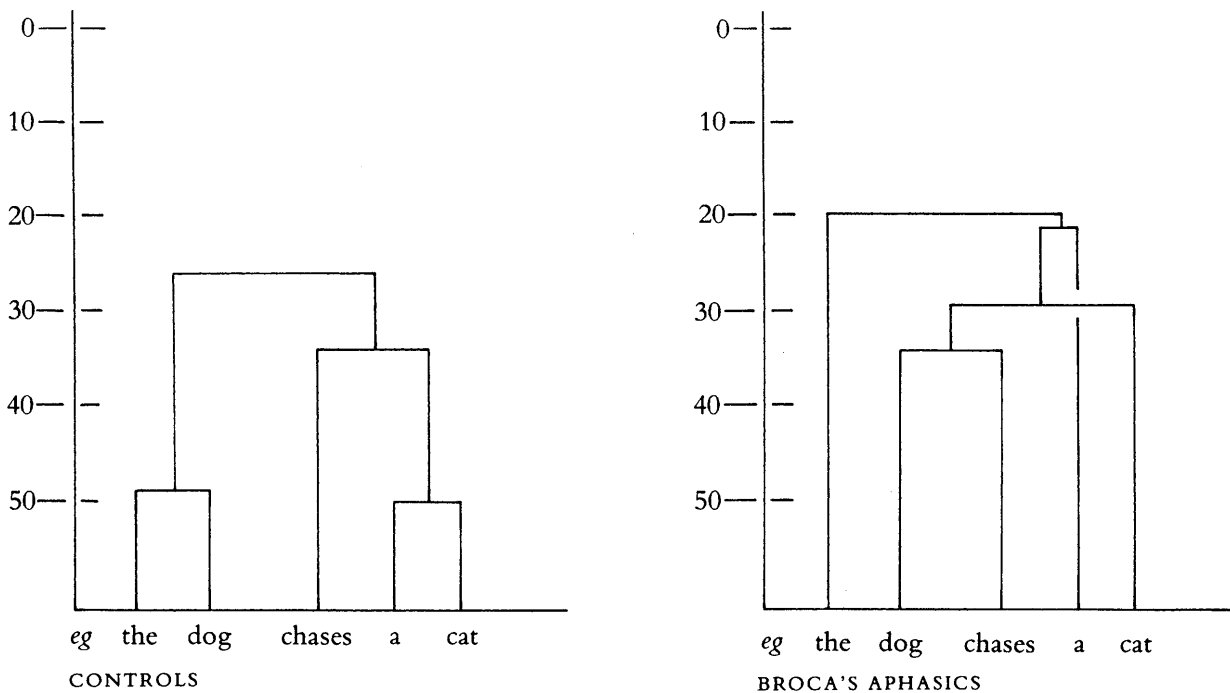


Fig. 1 : Scaling structures for, 'the dog chases a cat'. (From Zurif et al. (1972))

paired in patients with damage to the dominant hemisphere, comprehension performance will be disrupted (Cermak & Moreines, 1976 ; Lesser, 1976 ; Saffran & Marin, 1975). Consequently, it is critical that a specific memory deficit be ruled out as a basis for the abnormal comprehension performance in the anterior aphasic in order to maintain the position that structures of the anterior part of the dominant hemisphere subserves syntactic operations.

In this section, a number of recent studies were reviewed that clearly point to the functional and neurological independence of syntactic and semantic processing in sentence comprehension. Data obtained from studies of sentence processing in aphasia are important for a number of reasons. First, they establish a clear brain/function relation in which the anterior portion of the dominant hemisphere subserves syntactic processes. Second, they demonstrate that in sentence comprehension, syntactic processes are independent of processes such as strategies based on lexical comprehension. Third, they demonstrate the psychological reality of linguistic processes by showing that although these processes interact with other cognitive operations (e.g., memory), they can be selectively affected by brain damage. Even though these conclusions are of a rather general nature at this time, they form the basis on which more detailed experimental studies can be conducted.

Some Comments

This review has led to the conclusion that a clear formation of the functional organization of the dominant hemisphere can lead to important insights into the structure of normal language processes ; that is, even though there is logically no reason why the study of language breakdown cannot proceed independently of concerns about brain structures, it is an empirical fact that there is a strong correlation between brain structures and linguistic processes. This

is a substantive neurolinguistic conclusion that is of heuristic value for psycholinguistics in that it provides strong constraints on the generation of hypotheses about language processes. Thus, knowing that damage to a particular area of the brain affects a specific language component can lead to the formulation of testable hypotheses about the structure of that component and the interaction of that component with other cognitive processes. For example, on the basis of prior observations that damage to the anterior part of the dominant hemisphere affects syntactic processes, hypotheses could be tested concerning the operation of syntactic mechanisms in sentence comprehension. Caramazza and Zurif (1976) were able to demonstrate that anterior aphasics achieve a relatively high level of sentence comprehension through the application of lexical and heuristic processes. This result leads support to the hypothesis that heuristic procedures can independently assign a semantic interpretation to a sentence. What is interesting is that this latter hypothesis is one of several competing hypotheses that, according to Fodor, Bever, and Garrett (1974), cannot be differentiated on the basis of data obtained in studies with normal subjects.

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