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Agrammatism: Structural Deficits and Antecedent Processing Disruptions*

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This chapter has three sections. The first provides an examination of the general notion that the brain distinguishes among amodal linguistic components. The second section attempts to support a more specific claim: Namely, that from a linguistic perspective, agrammatism can, best be reconstructed in syntactic terms. And the third section focuses upon processing disruptions in agrammatism-that is, upon the antecedents of the inability to represent structural information.

The Neurological Organization of Comprehension and Production Systems

Speaking and listening are incontestably different activities. They also have long been viewed as being separately represented in the brain, the former depending upon putative principles of motor system organization, the latter, upon the organization of auditory perceptual mechanisms. The bulwark for the various forms of this argument has been the seeming dissociation of production and comprehension under conditions of focal brain damage: production being relatively more

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affected by anterior brain damage (implicating motor and premotor areas), comprehension, by damage to auditory association areas. This position, that is, the elaboration of production and comprehension distinctions in terms of & sensory-motor partition, isistiliheld. However, there is also now a competing view, one that takes seriously the possibility that a neurologically adequate functional analysis of language will yield structures and processes along other than modality-specific lines. The hypothesis is that neurologically based representations will be seen to accommodate distinctions among linguistic information structures-phonological, syntactic, semantic-quite apart from the sensory-motor bases of language. Within this framework, the research strategy has been to detail grammatical deformations in the various aphasias, setting aside the commonsense force of the distinction between production and comprehension in favor of a search for correspondences between the two-correspondences reflecting a like arrangement of processing constituents.

As should be apparent from this volume, this "move from the periphery" has been largely sustained by the claim that when left-sided anterior damage affects the production system, it also, though less publicly, affects the comprehension system in a way that seems to involve like structures and the same vocabulary elements. In particular, it has been claimed that patients who tend to omit closed-class items in speech tend also to be unable to interpret sentences in which the critical cues to relational meaning are provided by these closed-class elements (e.g., Zurif, 1980).

If this claim of an overarching disruption is correct, then it follows that there may be an overlap in the normal arrangement of the comprehension and production processing constituents, a common functional arrangement that serves broadly to distinguish, among other things, form from meaning. On this view, the common failure to exploit closed-class items disallows normal syntactic processing and is explicable in terms of disruption to a set of shared procedures involving these items. But, as we argue in the next section, this failure does not foreclose all syntactic ability. Further, and as a reflection of the form-meaning partition, agrammatic aphasic patients are also spared a lexically based semantic capacity (e.g., Berndt & Caramazza, 1980).

This nexus of claims has lately come under some criticism (e.g., Goodglass & Menn, this volume). One complaint turns on the fact that posteriorly brain-damaged Wernicke's aphasic patients also have "syntactic" comprehension problems, despite an output that is palpably different from that of agrammatic (Broca's) aphasics. Given the two different outputs and an ostensibly like problem in comprehension, the

argument is (1) that the site of the lesion determines differences in syntactic limitations only for output, and (2) that so far as comprehension is concerned, syntax is to be regarded simply as a weak link-the most vulnerable to brain damage wherever its site. From this perspective, the limitations on syntactic processing in comprehension and production have little to do with one another.

That may well turn out to be the case. But it is not proved by the data at hand. The claim that Broca's and Wernicke's aphasics are alike in terms of their syntactic limitations rests largely on the demonstration that agrammatic Broca's and paragrammatic Wernicke's aphasics are both less likely to comprehend sentences that are more difficult than those that are less difficult (e.g., Shewan & Canter, 1971)-the metric for difficulty presumably resting on the fact that normals also find some constructions more difficult than others. Such studies, however, have been criticized on methodological grounds and their conclusions heavily blunted (Berndt & Caramazza, 1980). Further, the failure to interpret meaning relations within a sentence can stem from very different causes: from an inability to represent thematic relations to an inability to use closed-class items to assign a phrasal analysis (a necessary processing link in the construction of thematic structure). Even the inability to make use of a particular closed-class item in sentence comprehension can have different computational antecedents (e.g., Friederici, Schonle, & Garrett, 1982): Thus, does the failure to use by to establish the agent of a passive sentence directly implicate a disruption in the formation of thematic structure, or does it indicate an "early" breakdown at the point of integrating the preposition into a phrasal constituent? And, given these alternative possibilities, is the syntactic comprehension failure necessarily to be located at the same processing stage in the two contrasting forms of aphasia?

If one goes beyond surface manifestations, it seems not: Agrammatic Broca's aphasics, for example, benefit more than do paragrammatic Wernicke's from the expansion of a complex sentence into a series of simple noun-verb-noun sequences (Goodglass, Blumstein, Gleason, Hyde, Green, & Statlender, 1979); and there are other indications of processing differences between the two groups-differences shown, for example, for the comprehension of discontinuous constituents (Caramazza & Zurif, 1976), for on-line sentence processing (Friederici, 1983), and on some, but not all, metalinguistic tasks (e.g., Pastouriaux, 1982a; von Stockert & Bader, 1976; see also Zurif, 1984). To be sure, the differences are not easily interpretable. But they ought not to be ignored.

A different concern, and one that presents a potentially more serious

challenge to the overarching agrammatism generalization, is that the generalization does not transparently apply to all patients with agrammatic output. Specifically, there are at least two cases presenting with agrammatic speech and what seems to be normal comprehension (see Kolk, van Grunsven, & Keyser, 1982; also Miceli, Mazzucchi, Menn, & Goodglass, 1983). But then, the behavioral features defining the syndromes are simply too crude to insure comparability in patient selection across laboratories-to insure, more specifically, the categorization of patients in terms of principled cognitive distinctions. Surely this is true of the broad categories Broca's and Wernicke's-categories in which the respective grammatical deformations (agrammatism and paragrammatism) figure only as single factors in an overall assessment. It may also be true even of the clinical judgment of agrammatism. The nature of the grammatical abnormality in production (the restriction of syntactic options, the control of closed-class items) is often difficult to chart given the obscuring effects of non-fluency and word-finding difficulties. And it is entirely possible that those agrammatic speakers who do not show agrammatic comprehension produce an output that is subtly but importantly different from those who do have the parallel limitation in speech and comprehension and who are, correspondingly, agrammatic speakers for different reasons (e.g., Tissot, Mounin, & Lhermitte, 1973).

We cannot currently evaluate this last possibility; we raise it in order to indicate the extent to which positions of any sort are grossly underdetermined by actual data, and to indicate also that, for whatever reason, it is possible that only a subset of patients currently described as Broca's aphasic patients, or even as agrammatic patients, are agrammatic in the overarching sense described here. Arguably, however, it is a very large subset.

At any rate, the psychological dimensions used in most current forms of syndrome classification-the division of language into the separate and often idiosyncratically analyzed activities of speaking, listening, and repeating (e.g., Schuell, 1965)-need to be updated. If the study of aphasia is to contribute to our understanding of the organization of language representation in the brain-and importantly in this respect, to our understanding of the equivalences and differences between production and comprehension-the syndromes must be at least approached in terms of our currently best accounts of language structure and processing. In what follows we consider several such approaches.

As mentioned at the start of this chapter, we examine first the notion that agrammatism represents an overarching failure in the ability to specify fully syntactic features in language-that it is a failure that can

be reconstructed in terms of the syntactic level of an adequate grammar. It will become apparent that, in carrying out this reconstruction, we are not seeking to explain agrammatism as a "failure of competence." Rather, our intention here is only to provide some details about the structural properties of agrammatism; in effect, about what constitutes permissible syntactic forms for the agrammatic patient.

We then shift our perspective to examine differences in the real-time processing characteristics underlying the use of lexical information by agrammatic aphasic patients and by patients with no evidence of brain damage. Here we seek the antecedents for the agrammatic patients' inability to recover structural descriptions for sentences. Specifically, although the effects of focal left-sided damage may be accounted for in syntactic terms, we entertain the notion that these effects are, at least partially, the result of disruption to functional systems that are recruited by the linguistic system but which are themselves neither specific to any particular domain (such as that responsible for linguistic performance), nor to any particular input or output channel.

Grammatical Characterizations of Agrammatic Aphasia

As already noted, the intention in this section is to determine what additional conditions or constraints ought to be imposed on an otherwise normal linguistic model to account for agrammatism. That is, we seek here structural constraints that are consistent with the observed limitations and with processing characterizations of these limitations.

Three such accounts have been offered (Caplan, this volume; Grodzinsky, 1984; Kean, 1977, 1980). We dwell on that offered by Grodzinsky (1984) and use the others only for contrastive purposes.

Grodzinsky's account is primarily motivated by observations of the effects of brain damage in Hebrew speakers-observations that seem to be strikingly different from those of English-speaking aphasic patients. In order to elaborate upon the differences, we need first to enter some facts concerning the structure of Semitic languages.

In Semitic languages a formal distinction between derivational and inflectional morphology is not possible. Moreover, there is a vast number of word forms related to each other only through identical consonants; that is, there is no linear string of elements that they share. (For a detailed discussion of Semitic morphology, see McCarthy, 1979, 1980 and Halle & Vergnaud, 1980). The vowels that are inserted between these consonants are, in turn, a part of the morphology. Thus, a

fully inflected lexical item may have the form: prefix-CVCVC-suffix. Obviously, then, in order for a lexical item to have phonological shape it must be inflected, as these discontinuous strings of consonants are phonologically illegal; that is, they cannot be pronounced.

Given these facts, how would one expect agrammatism consequent to brain damage to be manifested in a Semitic language? Viewing it as "omission" or "absence" of grammatical formatives clearly does not work: Since phonological shape presupposes inflection, the inability to inflect would result in a failure even to emit the major lexical categories: nouns, verbs, and adjectives. Not surprisingly, this is not observed.

Rather, observations of two Hebrew-speaking agrammatic aphasics have revealed that inflections are retained in their spontaneous speech, but that they do not very often fit the sentential context: The word forms produced are very often incorrectly inflected for grammatical dimensions (e.g., tense in verbs). Equally important, however, these forms are always morphologically well formed.

Consider the following aberrant sentences, produced by one of the two patients:

(1) *tiylu 'anaxnu ba'ali ve'ani*
'took-a-walk (III person plural, past) we husband and I'

(2) *salos milim ... lo ... slosa milim ve'arba'a ne'elam*
'three (F) words (F) ... no ... three (M) words (F) and four (M) disappear (M, sing.)'

The first question that comes to mind, given these output configurations, is whether or not the patient can even be considered an agrammatic aphasic. We think she can because of the diagnostic criteria invoked in selecting the patients analyzed here: namely, as positive signs, general nonfluency and relative omission of prepositions; and as a negative point, the absence of neologisms and semantic paraphasias in speech output. Further, the patients studied have lesions generally associated with agrammatic speech in English-that is, in the area supplied by the superior distribution of the left middle cerebal artery.

Granting this diagnosis and the generality of the agrammatic syndrome across languages, how can we account for the spontaneous speech patterns in Hebrew?

In approaching this issue, it seems, first of all, reasonable to suggest that the performance deficit can itself be straightforwardly characterized, not as a loss of the closed-class item vocabulary per se, but rather as a loss of the ability to select properly among inflected forms. On this view, the aphasic patient retains all the morphological rules (thereby never producing a morphologically blocked form, such as, say,

**mook* in English as the past tense form of make). But what is not available to the patient is a means of selecting the properly inflected form. As a consequence, he is forced into a guessing situation concerning what form to use.

In bringing this to bear upon languages that have linear stems like English, it may reasonably be claimed that the patients adopt a default strategy. That is, on the assumption that they are unable to select the correct inflection, they can be supposed to opt for its 0 form (given that 0 is always an option in English-the infinitive for verbs, and the singular for nouns, but see footnote 1 concerning languages that have linear stems but not always 0 forms). This default option, however, is rarely available to the Hebrew-speaking patient, as phonological shape presupposes inflection. So, if the inflectional paradigm of an item consists of two elements, salos ('three'-Feminine) and glosa ('three'-Masculine), an agrammatic patient is as likely to produce one as the other, fashioning, as a result, phrases that are syntactically aberrant.[1] This phenomenon is exemplified in terms of a lack of grammatical agreement between a noun and an adjective as follows:

(3) *slosa milim*
'three (M) words (F)'

It ought to be apparent that to this point our claims have been elaborated largely in vague processing terms (such as "default strategy"). However, as we seek to show below, so far as grammatical distinctions are concerned, these claims implicate only the syntactic level. At least this appears to be so under two empirically well-motivated linguistic assertions: The first is that the phonological component operates on representations comprised of labeled bracketings that designate syntactic structure and that are specified for all grammatical dimensions (tense, gender, etc.) (e.g., Chomsky, 1981); the second is that morphological rules in Hebrew figure as part of the phonological component (McCarthy, 1980).

Within the context of these assertions, agrammatism can be linguistically reconstructed in terms of the operation of an intact phonological component on an underspecified syntactic representation.

[1] One should also mention, in this context, the case of agrammatism in Italian, as it stands midway between English and Hebrew. Verbs in Italian have a linear stem, but unlike English, this stem is a non-word. That is, it is phonologically but not morphologically legal. Accordingly, it is not surprising to note that aphasics tend to use *inflected* forms (usually the infinitive), such that they do not "omit" grammatical formatives in every instance, but rather use some when they are necessary for morphological reasons.

Briefly put, the proposal is that in agrammatism, the level of S-structure representation comprises a complete set of phrase markers, but that these phrase markers are not fully specified with respect to grammatical features. The "syntactic tree" is complete, but some terminal nodes are missing-in particular, the nodes that are not lexically specified at S-structure representation. As a consequence, the phonological component will not be provided with sufficient information to form unique phonological shapes of the sort that fit together to form grammatical sentences. If, say, the node immediately dominated by INFL, which may have the grammatical features (+/-tense,+/-AGR),[2] is missing, then any optional tense, person, gender, or number that is exploited morphologically may appear on the surface. Further, since on this model morphological rules must operate, only legal, that is, well-formed, words will appear. But these words may be embedded in syntactically aberrant sentences.

A proposal of complete syntactic structure that is not specified for the grammatical formatives is compatible with the data for agrammatism in both English and Hebrew. The intactness of the phonological component ensures the well-formedness of lexical units, whereas the incomplete syntactic representation permits certain ill-formed sentences to pass as grammatical.

One apparent problem with this characterization has to do with prepositions. That is, Hebrew-speaking agrammatic aphasics omit these elements no less than do English-speaking patients. This problem is not insurmountable, however. We may simply assume that whatever the range of selection is for a preposition, it also includes a H value, or we may take the accusative to be the 0 case, as suggested by David Caplan. On this assumption the Hebrew as well as the English-speaking agrammatic patient has available a default procedure for prepositions. In short, the Hebrew agrammatic patient treats prepositions and inflectional morphology differently, omitting the former, guessing at the latter. To take an example, consider the sentence:

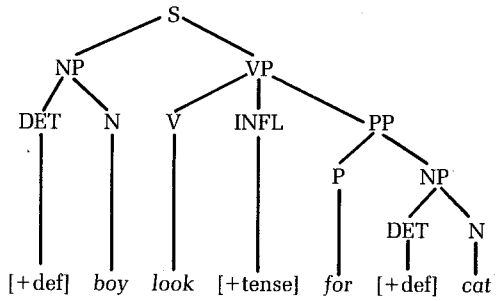
(4) *The boy looked for the cat*

and its S-structure representation:

[2] When we say that a constituent C is immediately dominated by some node a, we mean that in the syntactic "tree", α is a category "over" C = [$_\alpha$... C ...], and there is no β such that [$_\alpha$... [$_\beta$ ... C ...] ...].

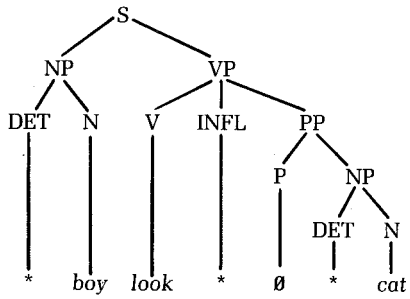
INFL is an abstract inflection marker, which can get values for tense and agreement (AGR).

(5)



By the account sketched above, (6) will be the representation available to the agrammatic patient at S-structure:

(6)



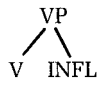
Note that on this account, each " * " may be freely selected from the range of possible values defined for the category that dominates it (e.g., 0, *a, the* for DET).

Some comparisons with Kean's (1977) and Caplan's (this volume) analyses are now in order. Kean seeks to form a partition between the informally grouped open-class items (N,A,V) on the one hand, and the closed-class items, on the other, within a formal linguistic model. The need for such a partition derives from descriptions of agrammatism that stress omission of the closed-class elements. The problem is that nouns, verbs, and adjectives do not constitute a natural class within the theory of syntax, hence one must seek a linguistic characterization that can partition the two groups. Kean finds the mechanism of word-boundary assignment at the phonological level as capable of doing so and consequently claims that the formal characterization of agrammatism is phonological. In English the result is the distinction between the stressed elements-N,A,V, and the unstressed ones-monosyllabic prepositions, determiners, inflections, and so forth, which indeed tend to be omitted in agrammatism.

There are several problems with this characterization, however. First, the formal system that it assumes is incapable of handling nonconcatenative morphologies (like the Semitic one, see McCarthy, 1980); thus the account cannot be universal unless it is modified substantially. Second, even if modified, it would have problems with the data presented here: The modified account (which presumably would now invoke lexical well-formedness criteria in addition to boundaries) would not be capable of predicting patterns of misselection, since it would say nothing about agreement or tense, which are not features at the phonological level.

Consider now Caplan's account: He views agrammatism as an impairment that is formally best characterized at the syntactic level. Specifically, he claims that only major lexical category labeling is available to the patient, and no syntactic structure-in particular, no phrasal nodes (NP, VP, etc.). By contrast, the account presented in this chapter argues for the necessity of such nodes in the syntactic representation available to the agrammatic. The Hebrew data show that although the patient makes errors in inflection he nonetheless inflects in a well-formed fashion. Hence a representation minimally consisting of the following schema is necessary:

(7)



In sum, on the evidence available, it seems reasonable to reconstruct agrammatism in syntactic terms, such that, though the overall syntactic structure is retained, certain terminal nodes are missing. Yet, having entered this claim, we hasten to add how unclear is its fit in a performance model of agrammatism. Indeed the most we can claim for the account offered here (apart from its linguistic justifiability) is that it provides a characterization solely of the effects of the processing losses. That is, it suggests that so far as the grammatical deformation is concerned, these computational disruptions (whatever their range and nature) impact only upon the syntactic level.

Lexical Processing and Agrammatic Aphasia

As noted, we are concerned here with how certain specific processing differences in lexical retrieval between agrammatic and normal listeners may underlie the dysfunctions found in the agrammatic pa-

tient's linguistic performance. We consider the possibility that the source of some of these dysfunctions may lie in domain-general cognitive functions that are recruited by the linguistic processor but are not unique to the language domain and that, in addition, are not differentiated by a production-comprehension distinction. In order to pursue this argument, we must first provide some background to the issue.

In the late 1970s to early 1980s much of the experimental examination of claims about functional modularity in the human language processing system has focused on the lexicon. While there are a number of historical and practical explanations for this focus, the overarching reason appears to be that both performance and competence theories of language have either explicitly or implicitly assigned a relatively independent role to lexical information. Thus, the lexicon has been viewed as a logical place in which to search for experimental evidence in support or refutation of the view that mental function consists of modular, autonomous subsystems. This issue has developed into an active debate as to whether the language processing system consists of a modulár set of relatively autonomous subsystems or of a maximally interactive set of processing routines. The autonomous, modular position holds that at an initial level the processing of one piece of linguistic 'information' takes place independently of knowledge derived from other sources or levels of analysis; under the interactive model, any type of linguistic or cognitive information can affect the processing of another piece of information at any time (see Marslen-Wilson, 1980; Swinney, 1982 for elaboration of these positions).

Because language (like other cognitive functions) is a dynamic process, much of the critical evidence in resolution of this modularity-interactivity debate has hinged on the delicate examination of language during language processing, examination that is known as real-time or on-line analysis. Such analysis has commonly been used to study changes in the nature of lexical processing induced by the influence of various types of contextual information, with the goal of determining whether the presence of such contexts ever changes subsequent lexical processing. Swinney and his colleagues (Onifer & Swinney, 1981; Prather & Swinney, 1977; Swinney, 1979), for example, have used a technique called Cross-Modal Lexical Priming to examine the effects of a wide range of 'higher-order' contexts (including discourse information, syntactic information, and lexical-semantic information) upon the access and integration of lexical material during language comprehension.

Lexical priming is a well-established effect in which the processing of a word under certain task conditions is facilitated if a semantically

related word has been previously processed. One such task condition involves requiring a lexical decision to be made about a string of letters while the subject is simultaneously listening to a sentence. Thus, a subject might hear The doctor decided to cure agrammatism through bloodletting, and if shortly after hearing the word doctor in the sentence, that person is required to decide whether the visually presented string of letters *NURSE* forms a word or not, that decision will be faster than if the letter string had followed some other, unrelated, word in the sentence. This cross-modal lexical priming technique allows the experimenter to determine whether or not a certain word meaning in a sentence has been activated. A finding of facilitation (priming) for a lexical decision about a letter string that is related to some critical word in the sentence constitutes evidence that the meaning for that word had been activated, because unless the meaning of the word in the sentence was accessed there could have been no priming effect. In all, the cross-modal lexical priming task has been found to be a sensitive, non-intrusive, and flexible measure of the access and processing of lexical information during fluent language comprehension.

As suggested, this technique has been used to examine questions about the autonomy-interactivity of the processing of lexical information during language comprehension. Much of this work has involved the investigation of the effects of a strongly biasing prior context upon the retrieval of the various meanings of a polysemous word. If, for example, a person hears the sentence The man saw several spiders, roaches, and other *bugs* in the corner of his room, and if that same person is required to make lexical decisions about strings of letters such as *ANT* or *SPY* (which were visually presented immediately after the ambiguous word bugs was heard in the sentence), there are several obvious predictions that might be made. If, as predicted by the "maximally interactive" model presented earlier, contextual information interacts with the access and processing of subsequent lexical information, then only lexical decisions to the word *ANT* should be primed. That is, if the context causes only the contextually relevant interpretation of the homograph-homophone bugs to be accessed, there can be no basis for finding a priming effect to a string of letters related to the other, contextually inappropriate meaning of that word (*SPY*). Conversely, if lexical access is an autonomous, independent module in the language processing system, then one would predict that context should not affect the access of information for a word, and that one should find priming for letter strings related to all interpretations of the ambiguity, whether they are contextually relevant or not. (It is of course

necessary that at some later time contextual information be taken into account; however, the question of how that takes place is independent of the issue of the autonomy-interactivity of the lexical access process).

The results of a number of studies of this type have been quite clear-cut: Priming has been found for all interpretations of the ambiguous word when tested for immediately following its occurrence. That is, regardless of the type of contextual information, it appears that lexical access is an autonomous, form-driven process that involves the exhaustive retrieval of information related to the word. It is worth noting that the exhaustive character of lexical access is a quality often attributed to 'automatic' cognitive processes: Retrieval and search processes that are routinized and overlearned (as is clearly the case with language in normal adult listeners) have been shown to be rapid and exhaustive in nature.

What is of relevance here is the contrast between this exhaustive, automatic access process found for normal listeners and that access process found for agrammatic aphasics. In a study by Swinney, Zurif, Rosenberg, and Nicol (1984) the experimental conditions involving biasing contexts and ambiguities described just above were presented to agrammatic patients. (It should be noted that all of the experimental ambiguities in these studies contained one interpretation that was far more likely than the others, ceteris paribus.) In contrast to the findings for neurologically intact listeners, priming for agrammatic patients was found only for the most a priori likely interpretation of the ambiquity when that interpretation fit the contextual constraints of the sentence. Such a result suggests that instead of the exhaustive, automatized lexical access process possessed by normal adult listeners-a process that allows for the rapid retrieval and analysis of lexical information necessary for the comprehension of rapid speech-agrammatic patients employ a slower, serial, self-terminating access process in retrieving information from lexical memory. In such a process, the lexicon is searched (from most frequent to least frequent) until an interpretation is found for the word. Provided that this entry does not conflict with contextual cues, no further access of information for the word takes place. Such self-terminating searches are a not uncommon finding in the study of human cognitive processing. They largely appear to occur in conditions where automaticity has either never developed in a retrieval process or where it has broken down. For example, it appears that self-terminating retrieval searches exist for the processing of lexical ambiguities by normal subjects when they are presented in isolated decision

tasks or in non-fluent or non-speech language contexts (see e.g., Forster, 1976), conditions in which it is obvious that the subjects have little practice. In short, it appears that normal listeners utilize automatized routines during comprehension of fluent speech, routines that are rapid and that exhaustively retrieve information for a particular lexical form, thus presenting the comprehension device with a rich array of information to combine and evaluate in developing a structural description (or semantic interpretation) for an utterance. Agrammatic aphasics appear to have suffered a specific breakdown in this retrieval routine, such that although retrieval proceeds, it takes place in a slower and less elaborative fashion, thus providing a very different information base to the comprehension system of the agrammatic listener. This has a number of implications for the language performance of the agrammatic. Perhaps the most obvious of these is that a disruption in a well-established retrieval pattern-in terms of either the rate or scope of information retrieval-is quite likely to result in the presentation of an impoverished information base to the comprehension device. Even if the comprehension device is otherwise operating as in normal patients, it may simply not be provided with information at an appropriate rate to be easily integrated into ongoing structural or semantic analyses. Further, the processing system may not be obtaining the normal array of information that goes into such processing decisions. Given the large amount of ambiguity at all levels of language processing (phonological, lexical, structural, and discourse), it seems likely that our normal comprehension routines have developed to evaluate large amounts of conflicting information rapidly. A breakdown in even a small portion of the system, such as lexical access, is quite likely to cause both errors and serious changes in processing, which, in turn, may well be the basis for some aspects of the disrupted performance in agrammatic aphasic patients.

While this argument has been framed in terms of the comprehension system (and obviously, the current data only speak to this condition), it is entirely likely that the line we have been pursuing holds equally well for the production system. Specifically, the processing separation of lexical form and meaning constraints implicated in the exhaustive lexical access procedures noted here for comprehension seems to have a counterpart in normal production (Garrett, 1982b). Accordingly, one might expect that, just as this processing separation does not hold for agrammatic comprehension, so too it does not hold for agrammatic production.

At any rate, the disruption to the lexical access routine detailed for

comprehension bears both upon the modularity issue and upon the functional equivalence of theoretical linguistic information sources to the performance architecture of the language processing system. In this context we briefly consider an interesting, if premature, notion: the possibility that the disruption to exhaustive lexical access found in agrammatic aphasic is not a disruption specific to the linguistic domain. At first glance, this may seem an unpalatable suggestion for any model committed to the notion that the agrammatic disorder is linguistic in nature, or more generally, to the view that language constitutes a neurologically independent entity. But it need not be so construed. It is not at all disruptive to either of these claims to suggest that there exist domain-general cognitive routines that are recruited by independent cognitive systems. Most certainly, it is important to be able to know whether or not there are such overarching routines, in order that we can better understand the precise relation between putative domains of mental performance.

It has been suggested that a reasonable first-blush metric for determining candidacy for the domain generality of a process is to establish that this process exists in at least two independent mental spheres (in this case, language and at least one other) and that it is computationally identifiable (Swinney & Smith, 1982). It has been noted, above, that exhaustive retrieval from memory is a common feature of normal cognitive processing. Not only does it hold for language (lexical retrieval) but it also has been shown to hold for a number of nonlinguistic studies involving memory for lists of isolated numbers or words (see, e.g., Shiffrin & Schneider, 1979; Sternberg, 1966). Here we have detailed the breakdown of these exhaustive retrieval routines in agrammatic patients specifically in relation to sentence processing. Intriguingly, however, a similar breakdown has been demonstrated for aphasic patients on the aforementioned nonlinguistic studies of memory for item lists: Specifically, Swinney and Taylor (1971) have demonstrated that aphasics search short-term memory in a serial, self-terminating fashion, just as they do for word meanings in sentences, whereas normal controls search exhaustively in both instances. It appears, then, that there is some initial basis for believing that one of the results of brain damage underlying agrammatism might be a breakdown in a generalized routine that allows for the implementation of automatized, rapid exhaustive searches of memory.

Given the current data, however, this is little more than a vague hypothesis. After all, performance on word lists is, broadly considered, a verbal activity-even if far removed from sentence processing. Ac-

cordingly, in order to determine more convincingly whether the disruption of lexical search is the result of damage to a domain-general routine, or to a domain-specific routine, we need to assess performance on tasks that are clearly not mediated in any way by the linguistic system. Prather, Nicol, Zurif, and Swinney have begun such work, utilizing ambiguous figures (e.g., the Necker cube) for which the critical differential interpretations of the figure (i.e., which face of the cube, for example, is seen as being in front) has no easy or utilizable verbal label. In preliminary studies, Prather has found that perceptual analysis of ambiguous figures normally displays the same (exhaustive) elaborative property as does the analysis of linguistic information. What remains is to determine empirically how agrammatic aphasic patients perform with these figures. If, like neurologically intact subjects, agrammatics immediately access all of the interpretations of an ambiguous figure, then the disruption of an automatized exhaustive search of memory will be shown to be restricted to the verbal domain. More generally, such automaticities will be shown to be parameters of their respective domains, not the reflections of an overarching, or domain-general, process. If, however, agrammatic aphasic patients carry out nonnormal self-terminating searches even in the nonverbal visual sphere, evidence will have been garnered to support the notion that the cortical tissue implicated in agrammatic aphasia is needed also to sustain domain-general processes.

Again, however, it must be emphasized that such a finding would in no way blunt the linguistic characterization entered in the previous section of this chapter. Rather, we feel that the inquiry elaborated upon here provides us with a better distinction between the information that the linguistic system requires in order to do its normal calculations and the types of linguistic operations that are performed on this data base. Thus, even if our suggestion of breakdown in a domain-general processing device is found to hold, it is also true that a linguistic characterization of the disorder is relevant and important; it seems apparent from the linguistic characterization offered here, that even should the processing disruption prove to be domain general, it nonetheless has a differential effect on the different levels of the linguistic system, affecting most obviously the syntactic level.

How the disruption we have characterized relates to other disruptions of syntactically supported language processes, namely those involving access to closed-class vocabulary items (Bradley et al., 1980), remains a priority for future research. What does seem clear at this stage, however, is that we will develop productive models of language

organization in the brain only by combining principled linguistic descriptions and careful on-line examinations.[3]

[3] The notion of automaticity and lexical access in aphasia has been elaborated along a somewhat different line. In particular, Blumstein, Milberg, and Shrier (1982; see also Milberg & Blumstein, 1981) have shown a dissociation between the ability to judge meaning similarities among words and performance on a lexical decision task, the former indexing conscious access of semantic information in memory, the latter, automatic activation. It is interesting that on the basis of these and other observations, Blumstein (1982) has lately proposed that agrammatic comprehension might possibly turn out to be best characterized as a loss of automaticity that adversely affects the representation of information on all linguistic levels. While we clearly agree with Blumstein on the need to explore this possibility, we seem to diverge concerning the approach, at least insofar as our ongoing work explicitly seeks contrasts that bear upon the domain-general versus domain-specific issue.