4 Lexical Processing and Sentence Comprehension in Aphasia

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We show in this chapter that selective aphasic deficits dissociate distinct language processing systems. To this end, we focus on disruptions of lexical access that appear to implicate initial stages of sentence comprehension.

The analyses we present turn on comparisons between agrammatic (Broca's) aphasic patients and paragrammatic (Wernicke's) aphasic patients. By the former we mean roughly, that type of aphasia in which complex syntactic structures and closed-class elements tend to be omitted in production and abnormally processed for comprehension purposes (Berndt & Caramazza, 1980; Zurif & Blumstein, 1978). Wernicke's aphasic patients, by contrast, present with an output that features misuse of grammatical devices-prepositions notably-and not telegraphic omission (Goodglass & Kaplan, 1972). Patients within this latter group also have sentence comprehension problems (Goodglass & Kaplan, 1972)-on some accounts, problems of the same sorts as those shown by the agrammatic patients (e.g., Goodglass & Menn, 1985; Shewan & Cantor, 1971). However, arguments for similarity in this respect rest on demonstrations that both groups fail to comprehend complex sentences. Without arguing the matter in detail, it is entirely possible that an apparently similar failure can have different antecedents (e.g., Friederici, 1983; Pastouriaux, 1984). Our group analyses are designed to explore this possibility.

A general feature of the analyses described here is that, unlike much work in neuropsychology, we do not translate freely between linguistic and processing theories. We do not distinguish, say, between a syntactic processing module and a phonological processing module simply in virtue of formal linguistic terminology. Rather, although we accept that processing modules are initially defined by linguistic information types, we seek evidence for their existence in terms of fixed and mandatory operating characteristics-that is, in terms of a functional architecture elaborated in real-time terms (Fodor, 1983; Pylyshyn, 1983). We return to this point in the context of the two experiments reported here.

GRAMMATICAL CLASS EFFECTS IN SENTENCE PROCESSING

The first of these studies turns on our efforts to characterize a sentence parsing device based on closed-class vocabulary elements and relatedly, to reconstruct features of agrammatic comprehension on the basis of a disruption to this device.

The initial line of observations supporting this set of possibilities stemmed from a number of lexical decision tasks-tasks in which subjects must decide if a letter string does or does not form a word in their language. Normal subjects were observed to respond in systematically different ways to open-class and closed-class items. Their reaction times for open-class words but not for closed-class words were found to be frequency sensitive. Also, they showed sensitivity to potential word formation processes for open-class items but not for closed-class items, this latter being manifested as an interference effect-an elevation in judgment time-for nonword judgments when the nonwords contained content word stems. So, for example, they took longer to classify *casterty* as a nonword than they did *nacherty*, *cast* but not *nach* being an open-class item. This interference effect did not occur, however, for nonwords in which the first syllable was a closed-class item: *sucherty* took no longer to be classified as a nonword than did *nacherty*. In effect, the closed class seemed to be contacted in some fashion that eliminates interference from a partial analysis as the input is being processed (Bradley, 1978).

Importantly, however, agrammatic patients did not show this insulation effect for the closed class. Nor did they show frequency insensitivity for closed-class recognition in the first mentioned task. In short, on both tasks, agrammatic patients treated closed-class items as they did open-class items (Bradley, 1978; Bradley, Garrett, & Zurif, 1980).

These observations were interpreted by Bradley et al. (1980) as evidence for a differential impairment of two normally distinct forms of word retrieval. By hypothesis, the closed-class access system was taken normally to provide essential input to a parser (i.e., to a device that assigns a syntactic analysis to the input), and the agrammatic patients' apparent inability to exploit this system was thus argued to provide a plausible account of their syntactic problems in comprehension. This argument was strengthened, moreover, by evidence that the failure to distinguish the two word classes on these tests was not a consequence of brain damage in general, but was tied to patients whose syntactic limitations demonstrably implicated elements of the closed class. Several mild Wernicke's (or possibly gnomic) patients were tested with the same materials and they showed the normal dissociation patterns (Bradley et al., 1980).

Some aspects of these original observations have not been uniformly replicated. In particular, the general claim that closed-class access is not frequency sensitive is questionable (Gordon & Caramazza, 1982; Segui, Mehler, Frauenfelder, & Morton, 1982). For English language materials, it seems likely that item selection, word length, and range of frequency sampled are important factors in determining the experimental outcome (e.g., Egido & Garrett, 1981). Yet, although the status of claims for frequency based differences between open- and closed-class words in lexical decision tasks is thoroughly mixed, we have been impelled to a certain stubbornness in pursuing part of an account of agrammatic comprehension in terms of a disruption to the normal mode of contacting closed-class representations.

Our continued interest in this possibility has turned on a number of factors. There are, first of all, the observations that, whatever the nature of the antecedent disruption(s), agrammatic patients are unable to make normal use of closed-class items for comprehension (e.g., Berndt & Caramazza, 1980). And so far as normal processing is concerned, there remain a number of replicable and individually persuasive observations-apart from frequency effects-indicating that the features governing open-class access are different from those governing access of the closed class. This difference appears to implicate early, automatic (i.e., unconscious) mechanisms of word recognition. We have already cited the interference effect for nonword judgments in this respect (Bradley, 1978; Bradley et al., 1980). There are, in addition, a number of visual hemifield effects implicating open-closed class access differences-that is, observations that the two classes are treated differently in the right visual field but not the left (Bradley & Garrett, 1983; Shapiro & Jensen, 1986). And there is a general class of effects that indicate a difference between the two classes in their availability for conscious report (Garcia-Alba & Sanchez-Casas, 1983; Haber & Schindler, 1981; Healy, 1976; Mundie, 1980). It is this last set of effects-the so-called invisibility effects-that we have most recently used as a means of analyzing normal and aphasic performance and on which we report here. (See also Rosenberg, Zurif, Bownell, Garrett, & Bradley, 1985.)

The particular task that we used was a letter cancellation task. When neurologically intact subjects are faced with the requirement to cross out target letters in a text, they are more apt to notice and cancel the letters when they appear in open-class words than when in closed-class words. These experimental findings are informally confirmed by one's normal impression of proofreading experience in which inversions and repetitions of closed-class items seem more likely to be overlooked than similar errors involving open-class elements. In some sense, then, properties of closed-class items less readily intrude themsely s into conscious attention-they tend toward invisibility. And clearly one plausible assumption is that this pattern arises because of differences in the way that the products of the open- and closed-class access routes relate to processes of sentence analysis and interpretation, and hence to processes of conscious report.

There are, of course, other possible assumptions. One such is that the normal pattern of detection failures is not a function of vocabulary type, but, rather, is influenced by frequency differences that are confounded with the vocabulary type contrast. Closed-class items are, after all, generally more frequent than open-class items, and it is possible that the higher the frequency of a letter sequence, the more likely the target letter embedded in that sequence is to be missed in a letter cancellation task (e.g., Drenowski & Healy, 1977; Healy, 1976).

Other questions relating to our assumption that the invisibility effect is intimately related to the operation of the closed-class route also compelled our consideration: First, even assuming that the detection difference could be accountable in terms of the open-closed class distinction, would this difference be altered by instruction? Specifically, could the extra closed-class errors be eliminated by alerting subjects to potential error in that class, as would be the case if the data reflected nothing other than some situation-specific scanning strategy? Or, as we were supposing, would the pattern prove to be intractable-the result, that is, of an unconscious and impenetrable processing mechanism, and in particular, the result of an automatic closed-class parsing device? Second, would the normal letter detection pattern emerge only for sentence material, that is, only in a situation in which the closed-class mechanism carries out its normal parsing function, or would the normal pattern also-and less explicably, from our perspective-be observed for nonsense or scrambled "prose"? Finally, what might be expected of aphasic patients' performance? Would those who speak and understand agrammatically-those who by our hypothesis no longer have access to a closed-class parsing route-notice and cross out target letters equally for the two vocabulary classes? That is, would they treat open- and close-class items similarly? And if so, would this effect be rooted specifically in agrammatism, or would it be observed as a consequence of brain damage in general? Clearly, Wernicke's patients also have sentence processing limitations, but to return to the question posed earlier, are these limitations of the same sort vis-a-vis unconscious lexical access processes as those in agrammatism?

To gain information on these questions we used the letter detection task, but with the following features incorporated: We prepared three normal prose passages typed in capital letters; the target in two of them was the letter *T*, in the third *A*. In two of these passages-one with an *A* target and one with a *T* target-we included sets of three target-bearing words such that the members of each set resembled each other phonologically and also bore a particular relation to each other in terms of frequency. These triplets were each comprised one closed-class item (e.g., *BUT),* one high frequency open class item (e.g., *PUT),* and one low frequency open-class item (e.g. *BAT*). In each such triplet, the closed-class item was approximately 10 times more frequent that the high frequency open-class item, which, in turn, was approximaely 10 times more frequent than the low frequency open-class item. In addition to the three prose passages, we prepared a scrambled word version of one of the passages, in which the words within each sentence were randomly ordered.

We tested neurologically intact patients, agrammatic aphasic patients, and Wernicke's aphasic patients with this material. To minimize task-specific strategies, the patients were instructed to read each passage at normal speed and they were timed with a stopwatch to encourage them not to read more slowly than they do normally. Further, they were asked multiple choice questions in the middle and at the end of each of the passages to ensure that they were reading for meaning and not just scanning the letters. Finally, and as forecast, in order to determine how resistant the open-closed class difference is to attentional demands, we instructed a subset of the neurologically intact subjects to pay special attention to small words like *by* or *such*, as these are often neglected on the task.

The data we obtained are rather straightforward. First, the neurologically intact subjects: We confirmed previous reports that they are less able to detect target letters in closed-class items than in open-class items. In addition, we observed no effect of frequency per se on the error pattern. That is, when we considered performance for targets embedded in the triplets stepped in frequency, we found a significantly higher proportion of detection errors in the closed-class items than in the high and low frequency open-class items, but no significant difference between the high and low frequency items within the open class. We also found the normal open-closed class target detection difference to be significant in the prose condition but not in the scrambled condition, indicating that the invisibility of closed-class items is in some way dependent on sentence parsing and interpretation. And we noted no significant performance differences between subjects who were specifically instructed to attend to the closed class and those who were not forewarned, suggesting that the greater number of closed-class errors observed on this task reflects the operation of a normally automatic and impenetrable processing mechanism. Of course, a clear candidate for such a mechanism is the closed-class word retrieval system that we have described-the system that is, by hypothesis, in the service of a parser.

With respect to the aphasic patients, we found that for standard prose, the Wernicke's patients, like the neurologically intact patients, were less able to detect target letters in closed-class items than in open-class items, whereas the agrammatic aphasic patients detected targets with an almost equal facility in the two vocabulary classes. These data are also compatible with our functional analysis. Thus, the agrammatics' relatively equal number of errors on open- and closed-class targets may reasonably be viewed as reflecting a disruption of the structurally relevant closed-class access and analysis route. and as the Wernicke's data make clear, this processing problem is selectively tied to the overt features of agrammatism and not to the consequences of brain damage in general.[1]

It should be noted, however, that the Wernicke's patients did not perform entirely normally on these tasks either. The pertinent data in this respect are those obtained in the scrambled word condition: As already remarked, the normals showed much less of an open-closed class difference in this condition than they did with normal prose; by contrast, the Wernicke's patients showed very little shift from the pattern observed for them on the prose condition. Their closed-class access and parsing mechanism may, therefore, be hypothesized to be less than normally tied to the exigencies of interpretive systems. The effects of damage to the tissue implicated in Wernicke's aphasia may spare the ability to construct phrasal constituents (via the closed class route, at least), but" these constructions cannot then be mapped normally onto semantically interpretable levels. Alternatively, one may suppose that for normals the mapping is effected and rejected on interpretive grounds, but that this feedback influence is lost for Wernicke's patients.

These last possibilities for Wernicke's raise the question: How can a device that provides input to a parser persist in its operation when faced with unparsable (scrambled prose) passages? The answer we think turns on the notion of impenetrability (Fodor, 1983; Pylyshyn, 1983): One facet of a form-driven or bottom-up device-of the sort that we characterized in our discussion of the closed-class route-is that it accesses lexical information, but does not evaluate the context in which the item appears (nor, relatedly,

[1]Two earlier studies by Ross (1983) and by Locke and Deck (1982) using the standard letter detection paradigm have been recorded in the literature. Our results differ from those of Ross, who reported the normal detection pattern for anteriorly lesioned patients; but our data are in agreement with those reported by Locke and Deck for a similar group. In both these other studies, however, the manner of patient classification makes the results difficult to interpret in relation to agrammatism. Both studies distinguish patients on the basis of lesion site-broadly, anterior versus posterior; and neither indicated the degree to which the behavioral features of agrammatism were present. It seems likely, then, that patient selection differences underlie the variations in the outcome of these studies.

In this respect, we cannot ignore the pitfalls of group research spelled out by Bade,:ker and Caramazza (1985). They question agrammatism as a coherent psychological entity and claim, on this and other bases, that the only proper manner by which to reach an understanding of the mechanisms of language processing is to analyze exhaustively single aphasic cases. In our view, it seems somewhat premature to assume what theoretical processing distinctions ought to be applied in the evaluation of a coherent theoretical entity. Rather, our best hope of forming cognitively coherent categories-of bootstrapping our knowledge of agrammatism-is to form groups on the basis of specific behavioral features of presumed theoretical relevance. Still, as made abundantly clear by Badecker & Caramazza (1985), we can no longer afford to treat interlaboratory or even intragroup variability as a random effect of no theoretical significance.

the semantic force of the item). On this view, contextual constraints apply after the information has been accessed. Accordingly, initial access based on word forms may be spared in Wernicke's aphasia, but because patients presenting with this syndrome have an interpretation problem, they are unable to apply context-or more properly in the present instance, lack of context-to block local phrasal assignment efforts.

But to return to the closed-class access device, itself: The data to this point sustain a mechanistic account in terms of the operating characteristics of a specific word access system-characteristics that show the system to be distinguished normally from that underlying open-class access; and that show it to be unalterable, and cognitively impenetrable (as underlined by the Wernicke's patients performance). And on such an account, the agrammatic patients' failure to contact closed-class word representations is not seen as some failure of stored representations, but rather as a processing failure-as a failure, presumably, to make these elements available at the right time in the processing sequence.

EXHAUSTIVE LEXICAL ACCESS IN SENTENCE PROCESSING

In this section we continue to explore the impenetrability of lexical access. We do so now, however, in a more direct and encompassing fashion, bringing forth evidence that provides a somewhat different perspective on the agrammatics' failure to make normal use of a closed-class access and parsing device.

The study that we undertook-detailed elsewhere (Swinney, Zurif, & Nicol, 1989) and only summarized here-turned on the use of words with two or more meanings. These items provide a straightforward means of examining the effects of context on lexical access: Simply, sentence context can be rigged to make one or the other meaning of an ambiguous item relevant, and if lexical access were not contextually impenetrable, only the contextually relevant sense of that item should be accessed. If, however, access is impenetrable, then all meanings might be expected to be momentarily active. Clearly, this last claim is a time-dependent one. Context must eventually exert an effect-we do not normally experience entertaining contextually irrelevant meanings of such words. Accordingly, any investigation of impenetrability must depend on measures of lexical access as they unfold during the act of comprehension.

Such measures are termed *on-line* or *real-time* measures. They are not rooted in an assessment of the finished product, that is, in an assessment of ultimate success or failure of sentence comprehension. The letter detection measure, on these grounds, is one such. For the ambiguous word study to be reported, we made use of a different technique termed *cross modal lexi-*

cat priming (CMLP) (Swinney, Onifer, Prather, & Hirshkowitz, 1979). This technique depends on the effects *of* lexical priming, which is the facilitation in the processing of one word due to having heard just previously another related word. As an example of CMLP, consider the experimental situation in which a subject listens to, "The doctor decided to see his patients only on Monday," and, while listening, is required to make a lexical decision-that is, a word/nonword judgment-for a visually presented letter string. The priming effect is embodied in the finding that if the letter string is presented immediately on hearing *doctor,* lexical decisions are faster for words related to *doctor (e.g., nurse)* than for unrelated, control words. Such priming indicates that the meaning of the word in the sentence-doctor-has been activated or, somehow, contacted.

As forecast, the variation on this technique that is of interest here turns on the inclusion of ambiguous words in sentences. Specifically, in this situation priming is assessed for both meanings of the word in sentence contexts that are relevant to only one or the other of its meanings. So, for example, in the sentence, *The man saw several spiders, roaches, and other bugs in the corner of his room,* priming is assessed for both meanings of the word bugs-the contextually relevant insect sense and the contextually irrelevant espionage sense. In the first instance, the lexical decision time for the letter string *ANT* is charted; in the second instance, that for the string SPY is examined; and in each instance, the reaction time is compared to the lexical decision time for a letter string forming a word that is matched in frequency to the target (*SPY* or *ANT*) but unrelated to any sense of *bugs*.

Repeatedly, two phenomena are observed with neurologically intact subjects. The first is that when the letter string is flashed on the screen at a point immediately after the subject has heard the word *bugs* in the aurally presented sentence, there is priming for both of its interpretations, regardless of contextual information and regardless, also, of the a priori likelihood of the interpretations of the ambiguity. (In the example given, the insect sense of *bugs* is more usual than the spy sense.) The second phenomenon is that if the lexical decision probe is delayed-if the letter string does not appear until about one and a half seconds after the word *bugs* is heard-only the contextually relevant interpretation of the ambiguity shows a priming effect (again, independently of the a priori frequency of the interpretation) (Onifer & Swinney, 1981; Swinney, 1983).

These observations suggest that lexical access during normal sentence comprehension is an autonomous-contextually impenetrable-form driven process; that it involves the exhaustive retrieval of interpretations for a lexical candidate; and that contextual information has its effect on lexical processing only after access (Swinney, 1983). Presumably, the point of this design feature-of the temporary activation of all senses of a word-is not to be wasteful, but to provide efficiency in a situation that demands rapid processing-to provide, more particularly, a fully elaborated lexical data base for independent, (but, of course, unconscious) decision processes. The point is to avoid commitment to a wrong word sense that will require backtracking.

It was in the context of these findings and attendant speculation that we again examined our mechanistic, account of agrammatism. The questions we posed were: Is the failure of agrammatic patients to access normally closed-class items a failure restricted to that domain? Or is the problem more pervasive, affecting properties of open-class access as well as closed-class access? Are they deficient, that is, in all language activities that demand rapid processing-not only in the rapid (possibly, simultaneous) access of closed-class items for the purpose of phrasal assignment, but also in the exhaustive access of ambiguous open-class items? And, again, if a disruption to such initial processing stages is found to occur, is it restricted to agrammatism or does it accompany aphasia in general?

Acting on these questions, we prepared sentences for aural presentation containing lexical ambiguities of the aforementioned type (indeed, including the example given); and we used the CMLP paradigm wherein the visually presented target items demanding a lexical decision appeared immediately after the ambiguous word in the sentence. We tested neurologically intact patients, agrammatic, and Wernicke's aphasic patients. And to buttress our instructions that they were not just to wait for the letter string, but to try also to understand each sentence, each subject was asked at several points during the experimental session to "say in your own words what you have just heard."

The neurologically intact patients showed priming for both senses of each ambiguous word. Their data, in short, uphold earlier indications that lexical access momentarily involves the exhaustive retrieval of interpretations of a lexical item and that such retrieval is not influenced by contextual information. More generally, these normal data sustain the notion of a language comprehension system organized in terms of encapsulated (autonomous) processesor modules, and they sustain its corollary, that contextual constraint is not introduced wherever potentially useful, but only after the access processes have done their work. That is, context is introduced as a means of selecting among competing representations provided by an independent processing device.

The fluent Wernicke's aphasic patients also showed priming for both senses of ambiguities. Again, as in the letter detection task, we found no compelling evidence of a disruption at initial stages in which form-based word retrieval processes are active. Rather, and now with some cumulative force, we are led to the conclusion that the Wernicke's limitation is to be located elsewhere, somehow involving either the formation of semantically interpretable structures based on data provided by the encapsulated lexical access system or the capacity to draw inferences from such structures.

The agrammatic patients, by contrast, did show a disruption at the stage of exhaustively accessing word meanings. Specifically, they showed priming only for the most frequent sense of the ambiguous word-regardless of context. Although this pattern is clearly aberrent, it cannot be construed as the consequence of an undifferentiated failure of automatic processing, at least not in the context of sentence interpretation.[2]

The data suggest, therefore, that lexical access in agrammatism remains context free-that is, is still informationally encapsulated (Swinney et al., 1989). One possible account of this is that the module can no longer sustain parallel access. This assumes that the normal access of ambiguous word meanings is correctly characterized as the consequence of a parallel engagement of representations. That is a plausible construal, but it is not the only possibility. We must consider also a second scenario: (a) that exhaustive access takes the form of an ordered activation or a serial search through the range of meaning candidates within the set defined by an ambiguous word; (b) that the order of this search or activation is controlled by frequency of meaning occurrence (e.g., Forster, 1979; Simpson, 1984); and (c) that when the number of candidates in the set is very limited, the activation or search is normally carried out at a rate too fast for us to measure with our existing techniques. On this view, the lexical module in agrammatism operates with a slower than normal rise time, and only the most frequent meaning representation is engaged within the time frame imposed by the on-line experimental paradigm. Pursuing this notion, the facilitation for all senses of an ambiguous word should eventually be shown, but at a point in the sentence that is noticeably later than that which is shown normally. We are currently investigating this possibility.

We cannot resolve this parallel-serial issue here. But whether the lexical access limitation in agrammatism is to be characterized as a failure to engage word meaning representation in parallel or as a slower than normal frequency controlled search or activation, the effect of the disruptions is the same: The sentence comprehension device is provided with an impoverished lexical data base for subsequent processing.

Earlier we forecast that these data would provide a different perspective on the closed-class processing problem. We now return to this forecast, emphasizing, first, what we do not mean by it. We do not think that the CMLP data in any way argue against the respective processing roles of the

[2]Although we failed to find a normal priming pattern, we demonstrated some priming, namely priming for the most frequent senses of a word. Mtlberg and Blumstein (1981), by contrast, demonstrated no evidence of priming in agrammatic Broca's aphasia. Importantly, they employed am isolated word processing paradigm, where we assessed priming in the context of sentence processing. Whether it is this difference-that of examining normal language processing or of examining processing on a lexical task with which subjects have little familiarity-or some other difference that underlies their different observations is a problem currently under investigation.

open and closed vocabulary classes, or even against the use of this distinction to account in part for the agrammatics' parsing disruption. Rather, we refer to only the possibility that the agrammatic patients' closed-class accessing problem might be an instance-the most sensitive reflection-of their failure to access exhaustively any restricted lexical domain-an instance possibly attributable to an inability to sustain normally rapid processing.

This possibility is at present no more than intriguing. The several meanings of an ambiguous word constitute a very different sense of domain than that defined by the array of closed-class vocabulary items. The former is elaborated in terms of whatever it is that underlies meaning relations; the latter constitutes a domain in virtue of a common function, namely, that of parsing (see also, Grodzinsky, 1984, and Kean, 1982). But, granting that this difference need not correspond to a processing module distinction, it seems reasonable to suppose that information in both domains-that comprised of meaning representations in the one instance and of lexical forms with the same function in the other instance-is accessed in the same obligatorily exhaustive fashion: Clearly, the tasks of determining what counts as more forceful evidence for this notion and then gaining the relevant data remain before us. For the present, however, it does not seem unreasonable to suppose that the inability to engage multiple representations at a normal rate has implications for more than the processing of ambiguous items.

The possibility that we have raised can be extended to bear on another substantive-indeed, fundamental-question concerning the characterization of brain-language relations: Is the agrammatic patients' failure to engage exhaustively meaning representations indicative of an even wider based disruption of information access-of a disruption that extends even beyond language? Thus, although the disruption that we examined here clearly impacts on language comprehension, it is much less clear that the processing disruption, itself, is to be viewed as a diagnostic of a language-specific problem. It might well be the case that the agrammatics' inability to access lexical items in the normally exhaustive manner is but one reflection of a failure to show exhaustive computation in any domain. Relevant here are preliminary unpublished data gathered by Swinney and Prather that suggest that exhaustive access is also normally a feature of processing in the nonverbal, visual domain-that neurologically intact subjects automatically (and momentarily) elaborate all interpretations of an ambiguous visual form (e.g., a necker cube) even though they only become aware of a single interpretation (organization) at any one time. Whether such elaboration is shown also by agrammatic patients is an issue that we are currently addressing, for only by examining this phenomenon in language and other realms will we be able to distinguish domain-specific from domain-general problems in aphasia.

CONCLUSION

At the outset of this chapter we distinguished between the approach taken here and the more usual information processing analyses of language disorders. both share the usual assumptions: that the language faculty can be decomposed into a set of processing components or modules, some of which are disrupted by brain damage; that the spared components do not, themselves, perform differently when one or more of the other components are not functioning normally; and that the pathological performance will provide a basis for discerning which components or modules are disrupted (Caramazza, 1984). The difference between the two approaches turns on the manner by which each isolates the modules of the system. Information processing approaches to language disorder characterizations typically produce modules in line with relatively uncontroversial distinctions among information types specified in linguistic theory. So, generally, there are phonological, syntactic, lexical, and semantic components-each, often, with its own buffer. To these constituents additional components and access routes are provided as needed whether to explain modality differences in performance (auditory vs. visual input systems) or to account for linguistically related symptoms, such as the relative sparing of concrete as opposed to abstract nouns or of open-class items as opposed to closed-class items (e.g., Coltheart, Patterson, & Marshall, 1980, chapters and references therein).

By contrast, the approach exemplified by the two studies described in this chapter is not one of isolating modules as a direct reflection of partitions in linguistic theory, nor one of isolating modules (together with their functional lesions) solely as a means of redescribing the patterns of sparing and loss in aphasia. Rather, the evidence for modules in the present analyses emerges as the consequence of charting mandatory operating characteristics of the comprehension system. Thus, whatever the status of closed-class access, our demonstration of the impenetrability (autonomy) of lexical access in general is grounded in the finding that such access is momentarily uninfluenced by context. And, to the extent that we have shown that the agrammatic deficit is statable in terms of a disruption internal to this device and not to its absence-the module is not destroyed, it just works abnormally-we have provided a more suitable framework for evaluating variability and imprecision in aphasic performance. By contrast, functionally excising one or another box in an information flow diagram disallows any explanation for the often encountered pattern of suboptimal performance that is, nonetheless, above chance.

By not confusing modules with the linguistic objects they are intended to implement, and by, instead, measuring and ensuring the degree of encapsulation of any particular device in terms of on-line operating characteristics, we lessen the distance between the science of cognitive psychology and neuroscience-the distance between descriptions of the functional architecture of language and descriptions of its (presumably hardwired) neurological resources.

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