Sensitivity to grammatical structure in so-called agrammatic aphasics*

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Abstract

Comprehension failures in agrammatic aphasics, as well as their difficulties in sentence construction, have been attributed to an underlying deficit involving the retrieval of syntactic structure. In this study we show that four agrammatic patients display a remarkable sensitivity to structural information, as indicated by their performance on a grammaticality judgment task. These results indicate significant sparing of syntactic knowledge in agrammatism, and suggest that the sentence comprehension disturbances in these patients do not reflect loss of the capacity to recover syntactic structure. In particular, accounts of the comprehension deficit in agrammatism that implicate a failure to exploit information carried by the closed class (function word) vocabulary are called seriously into question. Alternative explanations of the comprehension problem in agrammatism are explored.

Introduction

The phenomena of aphasia are of psycholinguistic interest primarily insofar as they shed light on normal language processing; in particular, on the questions of whether there are isolable subcomponents of the language

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processing system, whether these subcomponents are describable in terms of levels of representation in linguistic theory, and whether these subcomponents can be associated with specific areas of the brain.

The 'agrammatism' associated with Broca's aphasia is therefore of particular interest, since it has been argued that this disorder represents a selective loss of syntax and thus provides crucial evidence in support of the existence of a syntactic component of the language processor. Agrammatic Broca's aphasics, with lesions in the anterior portion of the dominant hemisphere, are generally restricted in their speech to telegrammatic utterances which rely heavily upon 'open class' lexical content and hardly at all upon structural information provided by word order and 'closed class' grammatical morphemes. Moreover, this impairment in production is frequently accompanied by a similar impairment in comprehension: Broca's aphasics tend to experience considerable difficulty with comprehension tasks when syntax alone furnishes critical aspects of meaning (Caramazza and Zurif, 1976; Heilman and Scholes, 1976; Parisi and Pizzamiglio, 1970; Schwartz et al., 1980). Thus it has been suggested that the agrammatism of Broca's aphasia represents an impairment of one specific component of the language system: that which is concerned with the realization of syntactic structure. (See, for example, Berndt and Caramazza, 1980; Bradley et al., 1980; Caramazza and Berndt, 1978; Goodglass et al., 1979; Kolk, 1978; Saffran et al., 1980; Zurif, 1980).

This view that the comprehension and production problems of agrammatic Broca's aphasics are the result of an inability to construct syntactic representations may be termed the 'syntactic theory' of agrammatism. In this paper, we will present evidence against the syntactic theory. Specifically, we will show that despite their severely agrammatic production and comprehension our agrammatic subjects retain the ability to judge the grammaticality of sentences spoken aloud to them. To the extent that success on our task requires the subject to construct syntactic representations (and we will maintain that there is no reasonable alternative to this supposition), our results provide clear counter-evidence to any version of the syntactic theory yet articulated.

Before presenting our results, however, we turn to a discussion of the evidence for agrammatic comprehension, and the various interpretations thereof; it is on the strength of these interpretations that the plausibility of the syntactic theory rests.\(^1\)

\(^1\) As the category 'Broca's aphasia' is generally applied, it includes patients with expressive language deficits, whose speech is not necessarily agrammatic. Since our interest is in that subset of Broca's aphasics who do show the agrammatic speech pattern, we will refer throughout this paper to agrammatic aphasics rather than to Broca's aphasics.
The comprehension problem in agrammatism

Despite repeated findings in the classical aphasia literature that comprehension of sentences is compromised in at least some Broca's aphasics (see Kolk et al., 1982, [Reference note 2] for a review), the impression that agrammatism is purely an expressive disorder persisted until roughly a decade ago. It has now been clearly demonstrated that these patients are significantly impaired in interpreting sentences like the following, in which word order and grammatical morphemes play a crucial role in establishing the thematic structure of the sentence.

(1) DATIVE (Heilman and Scholes, 1976)
He showed her the baby pictures.

(2) RELATIVE CLAUSE (Caramazza and Zurif, 1976)
The cat that the dog is biting is black.

(3) PASSIVE (Schwartz, Saffran, and Marin, 1980)
The boy is followed by the girl.

The demonstration that these same aphasic patients display adequate comprehension of sentences that are structurally similar to (1)–(3) but whose interpretation is semantically constrained by open class lexical content (Caramazza and Zurif, 1976) suggests the following line of reasoning:

(a) The process of comprehending sentences sometimes, if not always, requires that the syntactic structure of the input sentence be represented in the mind of the listener. Such a representation can be viewed as providing something equivalent to a labelled bracketing of lexical entities, specifying both the temporal and hierarchical characteristics of the input.

(b) There exists a mechanism whose unique function it is to generate such a syntactic representation, i.e., a parser; it is this mechanism that is somehow implicated in agrammatic comprehenders.

(c) The normal operation of the parser is not a necessary requirement for sentence comprehending; that is, it can be bypassed, or its output ignored, in cases where interpretation is lexically or pragmatically constrained.

2 Others have argued that the plausibility of the syntactic theory hinges on the demonstration of a strict co-occurrence of agrammatic production with agrammatic comprehension, and that such a demonstration has not been forthcoming (Goodglass and Menn, in press). In particular, it would appear that agrammatic production is neither a sufficient condition for agrammatic comprehension (Kolk et al., 1982 [see Reference note 2]; Miceli et al., 1983) nor is it a necessary one (Caramazza and Zurif, 1976; Heilman and Scholes, 1976). For a further discussion of this point, and its relevance for theories of agrammatism, see Schwartz et al. (forthcoming).
Thus the question for many contemporary aphasia researchers, who tend to accept this line of reasoning implicitly if not explicitly, concerns the nature of the parsing deficit in agrammatism.

On one proposed account, agrammatism represents a breakdown in the algorithmic routines that characterize the operation of the parser (Berndt and Caramazza, 1980; Caramazza and Zurif, 1976). This presumably means that the rules which assign a syntactic representation to the input string no longer apply, and comprehension is determined solely on the combination of rules of open class lexical interpretation and a set of heuristics for assigning semantic roles.

Others have attempted to characterize the disorder as one having to do specifically with the function word vocabulary. One such 'functor theory' of agrammatism is put forth by Kean, who argues that the Broca's aphasic "tends to reduce the structure of a sentence to the minimal string of elements which can be lexically construed as phonological words in his language" (Kean, 1977, p. 25). This simplification is taken to be the source of both the production and the comprehension impairments: having reduced each word to the minimal form in which it may occur independently as a phonological word, the Broca's aphasic fails to attend to suffixes and other elements which do not occur independently as phonological words.3

Any version of the functor theory which attributes agrammatic comprehension to a simple failure to attend to this class of items is faced with two serious objections. First, it has been established that agrammatic Broca's aphasics are generally sensitive to the meanings of many function words (Goodglass et al., 1970; Schwartz et al., 1978 [see Reference note 4], 1980; but see Goodenough et al., 1977, for findings to the contrary). Schwartz et al., 1980, observed, for example, that their agrammatic subjects rarely confused prepositions such as on and in in comprehension tasks involving sentences of the form NP is on NP; they tended rather to reverse the roles of the two NPs, suggesting that the problem lies not in a failure to attend to the preposition (a function word) but rather in an inability to assign the correct argument structure to the sentence.

3The claim that Broca's aphasics simplify the structure of the sentence in this way is not identical to the claim that the elements which these patients tend to drop are all and only the clitics; the former claim, but not the latter, is compatible with the generally observed omissions of non boundary affixes such as ity (e.g., in morbidity). There is no level of linguistic representation at which all items which can be lexically construed as phonological words are distinct from all those which cannot; at R-structure, for example, the distinction is between actual phonological words and clitics. (See Kean, 1977, 1979a).

For further discussion of the phonological characterization of the function word vocabulary, see Lapointe, in press.
A second objection is that while such a theory is adequate to explain the failures of agrammatic aphasics on tasks involving functor-dependent constructions such as passives, their impaired performance on other constructions is more difficult to explain. The finding of Schwartz et al. (1980) that some agrammatic aphasics experience difficulty with comprehension tasks involving simple active declarative sentences (e.g., *The horse kicks the cow*) suggests that a simple failure to attend to functors cannot account for the full range of agrammatic comprehension deficits; even without its functors, a simple active declarative sentence should be as interpretable as a telegram (*horse kick cow*).

The first objection, that agrammatics are sensitive in many cases to the meanings of functors, presents a problem only for that version of the functor theory which represents agrammatic aphasics as lacking knowledge of functors or as ignoring them outright. Recent work by Bradley and her colleagues (Bradley, 1978; Bradley et al., 1980) suggests a somewhat different version of the functor theory. Bradley argued on the basis of lexical decision tasks that normals have special access routines for closed class items different from the routines used to access open class items, i.e., members of the major lexical categories. In contrast, Broca’s aphasics appear to access all lexical items in the same way and thus are hypothesized to lack the special access routines for functors. Building upon Garrett’s (1975, 1976, 1980) findings with respect to the computational distinctness of the closed class vocabulary in normal language production, Bradley et al., 1980, hypothesize that functors play a crucial role at an early stage of language comprehension by facilitating the identification of constituent structure. On the assumption that normals’ special access routines for functors facilitate parsing, the authors propose that agrammatic aphasics do not simply ignore functors, but rather are unable to utilize them at the stage of processing where these elements can provide crucial clues to sentence structures.

This version of the functor theory thus escapes the first objection noted above, the observation that agrammatic aphasics frequently appear to be

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4 Even this variant is not without problems, however. If the crucial difference between agrammatic aphasics and normals is the failure of agrammatics to differentially access functors at an early stage of language processing, resulting in the inability to construct initial representations of syntactic structure, then we are led to the improbable claim that the absence of overt functors, as in, for example, the sentence *Mary hit George*, should result in agrammatic comprehension by normal listeners. Similarly, we might expect, if functors are so absolutely essential to the parsing of even simple active sentences, that normals and agrammatic aphasics would perform similarly, and poorly, on comprehension tasks involving ‘Tarzan talk’ sentences like *Man follow dog*. It is our experimentally unverified conviction that they would not.

5 Followup studies by other investigators have posed serious challenges to Bradley’s interpretation of her findings with normals (Gordon and Caramazza, 1982a; Segui et al., 1983) and with agrammatics (Gordon and Caramazza, 1982b) [see Reference note 1]).
sensitive to the meanings of closed class items. It also provides at least the possibility of an explanation for the second objection, the word order difficulties noted by Schwartz et al.; even in simple active declarative sentences which could presumably be understood on the basis of open class word order alone, it could be argued that the inability to exploit closed class items prevents the agrammatic aphasic from constructing an initial representation of syntactic structure. Thus Zurif and Blumstein speculate that

an inability to make use of grammatical morphemes as syntactic place holders limits the ability to assign content words to their grammatical function in a sentence (for example, subject noun or object noun). Indeed, it may well be that a minimum requirement of a syntactic processor is to assign form-class designations to open-class elements as a function of sequencing constraints on closed-class elements, and it seems that it is just this operation that Broca’s aphasics are unable to perform (Zurif and Blumstein, 1978, p. 234).

Bradley, Zurif, and their colleagues have provided an enlightening and persuasive account of agrammatic comprehension, tying together psycho-linguistic work on both normals and aphasics and incorporating the beginnings of an explicit theory of sentence processing. It is a parsimonious account as well, hypothesizing a simple disruption (loss of special access routines for functors) that has widespread consequences due to the interaction of this impaired component with the otherwise unimpaired language processing system. In particular, it is not inconsistent with this account that the syntactic analyzer itself, or the knowledge structures which govern its operation, be spared in Broca’s aphasia. All that is required is that the normal operation of the parser be precluded by the absence or paucity of the categorized closed-class input that is crucial to its operation. Thus one can rightly argue, as Kesn (1977; 1979a, b) has done, that a functor deficit does not necessarily imply a syntactic deficit.

What do these variants of the syntactic theory have in common? The basic claim of the theory, whether it attributes the comprehension impairment in agrammatism to a general breakdown in syntactic parsing routines or to a more specific problem with the functor vocabulary, is that agrammatic aphasics fail on comprehension tasks because they do not form adequate representations of syntactic structure. However, it is important to observe that the data from picture-pointing tests of sentence comprehension do not provide unassailable evidence for such a claim. This is because errors could very well reflect a failure to map syntactic structures which are indeed well-formed onto fully-specified semantic objects, or to successfully compare the products of sentence and picture decoding. This point has not been lost on aphasia researchers; converging evidence for the syntactic theory of agrammatism has been sought in a wide variety of paradigms. Many of these,
because they utilize a written format (e.g., Andreewsky and Serton, 1975; von Stockert and Bader, 1976; Zurif et al., 1972), have little direct bearing upon the question whether, and to what degree, Broca's aphasics are capable of constructing syntactic representations of spoken sentences.

The most direct way to address this question, we believe, is to ask patients to judge the grammaticality of auditorily presented sentences. The few recent studies that have used this paradigm to investigate syntactic knowledge in Broca's aphasics (Gardner et al., 1975; Goodglass et al., 1970; Luria, 1975) have tended to produce results consistent with the syntactic theory, although in no case is the demonstration conclusive. In fact, these studies are problematic in several respects. First, they have tended to sample quite narrowly from the range of possible syntactic violations, concentrating disproportionately upon number agreement and similar morphological phenomena. Second, in the design of these studies, grammaticality judgments are mixed with judgments of truth or plausibility, thus raising the possibility that errors reflect attentional or response biases, rather than the integrity of the parsing operations. Finally, these studies have employed testing procedures that place a heavy burden upon short term memory.

To investigate these issues further, we have developed a new grammaticality judgment task which samples systematically from across a broad range of sentence structures. This task has been administered to four agrammatic Broca's aphasics, all of whom fail on conventional picture-pointing tasks of sentence comprehension. Our goal has been to discover whether such patients are, as predicted by the syntactic theory of agrammatism, insensitive to the constraints that determine syntactic well-formedness.

Method

Subjects

The subjects in this study are four adult females, victims of organic brain damage suffered a minimum of one year earlier. All four are aphasics of the Broca type (Goodglass and Kaplan, 1972), and all are agrammatic in both production and comprehension. The small sample size is attributable to the rarity of this syndrome in its pure form. These four are the only agrammatic subjects we have tested with this procedure thus far. Further details of their medical history and language characteristics are available in Table 1.

6 Requiring patients to assess the grammaticality of oral and written sentences seems to have been a standard feature of the clinical evaluation of aphasia as performed by German neurologists in the early part of this century. The results, for agrammatic patients, were inconsistent (for reviews, see Goodglass and Menn, 1983; Kolk et al., 1982 [see Reference note 2]; Tissot et al., 1973).
<table>
<thead>
<tr>
<th>Subject</th>
<th>Age</th>
<th>Background</th>
<th>Etiology</th>
<th>Production sample</th>
<th>Comprehension (No. correct)¹</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Actives</td>
</tr>
<tr>
<td>A.T.</td>
<td>38</td>
<td>High school graduate; key punch operator; probable Black English dialect premorbidly</td>
<td>Ruptured aneurysm, L. temporo-parietal craniotomy (1973)</td>
<td><em>Cookie Theft</em>: “The boy is falling on the...almost falling floor. The mother is running...faucet...floor. The sister is passing cookie.” (What's the mother doing?) “Washing the things. Almost full, splashing water...”</td>
<td>15/24²</td>
</tr>
<tr>
<td>E.B.</td>
<td>45</td>
<td>Nurse</td>
<td>Encephalitis affecting L. frontal and parietal areas (1980)</td>
<td><em>Picture of a man sleeping</em>: “Man...bed.”</td>
<td>16/24³</td>
</tr>
<tr>
<td>V.S.</td>
<td>58</td>
<td>High school graduate; legal secretary</td>
<td>Infarct, L. middle cerebral artery distribution (1970)³</td>
<td><em>Cookie Theft</em>: “Mother is washing the...dishes...The David and Kathy...cookies. Fall on. The...the...water. The water is...clump...water is...flowing. The chair is...the...the boy is counter...no, fall off.”</td>
<td>22/24</td>
</tr>
<tr>
<td>L.S.</td>
<td>49</td>
<td>High school graduate; secretary</td>
<td>Occlusion, L. middle cerebral artery (1974)</td>
<td><em>Cookie Theft</em>: “A mother...a dish...drying...” (What?) “Plate...a faucet...running...a boy, eating cookies...eating the cookies...girl.”</td>
<td>20/24</td>
</tr>
</tbody>
</table>

¹See Schwartz, Saffran and Marin (1980) for details on this comprehension test. ²Description of “Cookie Theft” picture, from the Boston Diagnostic Aphasia Examination (Goodglass and Kaplan, 1972). ³Chance performance (p > 0.05) Binomial Test, one-tailed. ⁴Performance significantly worse than chance (p < 0.05) Binomial Test, one-tailed. ⁵CT Scan data for this patient may be found in Coltheart, Patterson and Marshall (1980).
Materials

Subjects made their judgments on a total of 451 sentences, of which 221 were ill-formed. Deformations of grammatical structure were systematic, representing ten classes of rule violation, as follows:

1. **Strict subcategorization**

   The ungrammatical sentences in this section violate lexically-stated constraints on the syntactic frames in which given words can occur. The ungrammaticality of sentence (4), for example, derives from the fact that *come*, an intransitive verb, is followed by a direct object.

   (4) *He came my house at six o’clock.
   (5) He came to my house at six o’clock.

   That this requirement on *come* cannot be inferred from real-world knowledge alone is demonstrated by the contrast with verbs such as *reach* which are similar in meaning but have different subcategorization properties. This is illustrated by the comparison of (4) and (6), the latter not a test sentence.

   (6) He reached my house at six o’clock.

   Other sentences in this section examined contrasts such as those in (7) and (8) below; in these sentences, the independence of subcategorization requirements from real-world knowledge seems even clearer.  

   (7) I want you to go to the store now.
   *I hope you will go to the store now.

2. **Particle movement**

   The sentences of this condition exploit the distinction between prepositions and particles. In ungrammatical sentences like (9), a preposition occurs to the right of its noun phrase object. Sentences of this type are contrasted with well-formed versions like (10), where the NP order is not violated, and others like (11) in which the item to the right of the NP is a particle rather than a preposition.

   (9) *She went the stairs up in a hurry.
   (10) She went up the stairs in a hurry.
   (11) She rolled the carpet up in a hurry.

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7 The relevant differences between *want* and *hope* may be represented in various ways, e.g., as S-bar deletion, but the differences are in any event lexically-stated.
3. Subject-aux inversion

The ungrammatical sentences in this condition involve aux movement in the formation of yes/no questions. Tokens like (12) contain a copy of the moved auxiliary in its original position; others such as (14) contain a moved aux which is inappropriate to the form of the verb.

(12) *Is the boy is having a good time?
(13) Is the boy having a good time?
(14) *Did the old man enjoying the view?
(15) Did the old man enjoy the view?

4. Empty elements

All sentences in this section contain phonologically unrealized noun phrases (empty elements) in subject or object position of infinitival or tensed clauses. Consideration of the conditions which make for well-formedness in sentences of this type is beyond the scope of this paper; see Chomsky, 1980, 1981. Speaking quite roughly, and considering only the range of sentences presented here, we can expect to find empty NPs only under the following two circumstances: either the empty NP is in subject position of an infinitive (as in (16)), or it corresponds to (i.e., is coindexed with) a moved wh-word (as in (19), (20)). Ungrammatical tokens violate one of these two conditions, posing the empty element as the object of an infinitive (as in (17)), or as the subject of a tensed sentence (as in (18)), with no association to a wh-word. (In examples (16)–(21) below, we use dashes and brackets to designate the empty elements and the clauses that contain them.)

(16) Frank was expected [ _ to get the job].

*Subject of infinitival clause

(17) *This job was expected [Frank to get _].

*Object

(18) *The workmen were expected [_ would finish by noon].

*In tensed clause

(19) Which job did you expect [Alfred to get _].

*Object, but coindexed with wh-word

(20) Who did you think [ _ would invite Mary Smith].

*In tensed clause, but coindexed with wh-word.

In addition, ungrammatical sentences such as (21) were presented, in which there are two gaps (given the transitivity of the verb) in the embedded clause but only one wh-word.

(21) *Who did you think [ _ would invite _]?
5. Tag questions: subject copying

Ungrammatical sentences in this section contain tag questions whose subject pronouns cannot be coindexed with the subject of the sentence.

(22) *The little boy fell down, didn’t it?
(23)  The little boy fell down, didn’t he?

6. Left branch condition

Ungrammatical sentences in this section violate the ‘left branch condition’ originally observed in Ross (1967, see Reference note 3). Only the specifier of an NP is fronted by wh-movement; the head noun of the NP is left behind. In most of the sentences, the fronted material is interpretable as an NP in itself (with ellipsis of the head): in (24), for example, how many can be taken as an NP, and the sentence would be grammatical (How many did you see in the park?) were it not for the presence of the actual head noun, birds.

(24) *How many did you see birds in the park?
(25)  How many birds did you see in the park?

In other sentences, such as (26), the moved expression (which old) is not construable as an NP in itself, and thus it is possible to determine from this expression alone that the left branch condition has been violated.

(26) *Which old did you invite men to your party?
(27)  Which old men did you invite to your party?

7. Gapless relative clauses

The unacceptability of sentences like (28) is due to the absence of any ‘gap’ in the relative clause; that is, there is no empty position in the relative clause to associate with bread. In contrast, sentence (29) contains a gap (in direct object position following baked, this verb being optionally subcategorized for a direct object) which corresponds to the head noun bread: the relative clause has the interpretation ‘I baked the bread’.

(28) *Mary ate the bread that I baked a cake.
(29)  Mary ate the bread that I baked.

8. Phrase structure rules

Ungrammatical sentences in this section contain phrase structure violations:8

 beyote 8. see overleaf)
Whenever possible, in this condition, sentences were constructed in sets of four, as shown below, where the first sentence exemplifies the unacceptable expansion of the category; the second, the correct expansion using function words or order reversal; the third, an acceptable occurrence of the original sequence (or one very similar to it) in the expansion of a different category; and the fourth, another starred sentence like the first, to balance the number of good and bad sentences.

(33) *The gift my mother is very nice.
(34) The gift for my mother is very nice.
(35) The gift my mother got is very nice.
(36) *Do you like the gift my mother?

9. Reflexives
Half the sentences in this condition contain reflexives in object position (e.g., (37), (38) and the other half in intensifier position (e.g., (39), (40)).

(37) *I helped themselves to the birthday cake.
(38) I helped myself to the birthday cake.
(39) *The famous man itself attended the ceremony.
(40) The famous man himself attended the ceremony.

Ill-formed tokens included some with single violations (of number, gender, or person) and others with double violations (of both number and person).

10. Tag questions: aux copying
Ungrammatical sentences in this section contain tag questions whose aux is not appropriate for the verb phrase of the main sentence.

(41) *John is very tall, doesn’t he?
(42) John is very tall, isn’t he?

*Unacceptable sentences in the phrase structure condition may be ruled out by different sub-component of the grammar; the impossibility of expanding AP as adjective + NP, for example, may derive from Case theory. See Chomsky, 1980, 1981.
Table 2. Summary of procedure

<table>
<thead>
<tr>
<th>Condition</th>
<th>No. ill-formed sentences</th>
<th>No. well-formed sentences</th>
</tr>
</thead>
<tbody>
<tr>
<td>Form A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Strict subcategorization</td>
<td>21</td>
<td>21</td>
</tr>
<tr>
<td>2. Particle movement</td>
<td>20</td>
<td>30</td>
</tr>
<tr>
<td>3. Subject-aux inversion</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>4. Empty elements</td>
<td>40</td>
<td>39</td>
</tr>
<tr>
<td>5. Tag questions: Subject copying</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>Form B</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Left branch condition</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>7. Gapless relative clauses</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>8. Phrase structure rules</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>9. Reflexives</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>10. Tag questions: Aux copying</td>
<td>20</td>
<td>20</td>
</tr>
</tbody>
</table>

In Table 2 we present a summary of these conditions and the number of sentences in each. Copies of our materials, and data sheets, are available on request.

Design

Two different test forms were constructed; Form A encompassing Conditions 1 through 5 (Table 2); Form B, Conditions 6 through 10. Within each test form, the conditions and tokens within them were scrambled in such a way that (a) consecutive trials sampled from different conditions, i.e., the conditions were not blocked; and (b) runs of good and bad sentences were no longer than four.

Test Form A consisted of 251 sentences; Form B, 200 sentences (Table 2). The two forms were administered consecutively to each of the four subjects (Form A always followed by Form B). For each subject, a maximum of 120 sentences were run per session, with a five to ten minute break after each group of 40 sentences. The entire procedure (451 sentences) thus spanned four test sessions (held once per week for four consecutive weeks).

The rationale for the two test forms has to do with the lengthiness of this protocol. We were concerned that some of our aphasic subjects might not be available for more than two or three sessions and wanted to guarantee a
complete set of data for at least Conditions 1 through 5. As it happens, all subjects run thus far have completed both test forms.

From the subjects' point of view, there was no discontinuity between test Forms A and B. The subjects were not told that they would be hearing new sentence types. The transition between the two forms generally occurred within a single session.

Procedure

The test sentences were recorded on tape by one of the authors (M.L.). Each sentence was read twice, slowly but with normal intonation. In the case of ungrammatical sentences, each was read with the intonational contour appropriate to a well-formed sentence derivable by substitution of one or two words. So, for example, the ungrammatical sentences (43) and (45) were read with intonation appropriate to (44) and (46), respectively.

(43) *The boy put the book.
(44) The boy took the book.
(45) *He broke the door in order to save the children down.
(46) He broke the door in order to take the children down.

We expended considerable care in this aspect of the procedure in order to minimize a potential cue to the ungrammaticality of sentences (i.e., anomalous intonation). Other precautions were taken to avoid unconscious signalling by the examiner. Thus, two examiners were present throughout each test session. One, the scorer, sat opposite the subject, who listened to the tape through earphones, and recorded her responses. The scorer did not wear earphones and was thus unable to hear the test sentence. The tape recorder was controlled by the second examiner who did wear earphones but who did not at any time face the subject.

The second examiner played each test sentence (read twice in succession) and then halted the tape while the subject responded by pointing to a stimulus card on which was written 'good' (under a smiling face) and 'bad' (under a frowning face). Responses were not timed, but all subjects generally responded quickly, often after the first reading of the sentence.

Results

The question posed in this study is whether or not agrammatic aphasics are capable of differentiating sentences that are grammatically well-formed from those that are not. If, as postulated in the syntactic theory, agrammatic
Sensitivity to grammatical structure in so-called agrammatic aphasics

Figure 1. Contingency tables of stimulus and response summarizing results across all ten conditions for each of the four subjects.

<table>
<thead>
<tr>
<th>Stimulus Conditions</th>
<th>Sg</th>
<th>Sb</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>hits</td>
<td>178</td>
<td>52</td>
</tr>
<tr>
<td>false alarms</td>
<td>13</td>
<td>208</td>
</tr>
<tr>
<td>Rb</td>
<td></td>
<td></td>
</tr>
<tr>
<td>misses</td>
<td>223</td>
<td>7</td>
</tr>
<tr>
<td>correct rejections</td>
<td>60</td>
<td>161</td>
</tr>
</tbody>
</table>

aphasics are incapable of syntactically analysing sentences spoken to them, they should be insensitive to all, or at least most, of the distinctions that differentiate well- from ill-formed sentences in our battery, i.e., they should be just as likely to respond 'good' to an ill-formed sentence as to one that is well-formed.

That this is not the case can be seen from Fig. 1, which presents summary contingency tables of stimuli and responses for each of the four subjects.
Here, and throughout this report, the logic and notation of signal detection analysis is adopted.\(^9\) Sg and Sb designate well-formed (i.e., good) and ill-formed (bad) sentences, respectively. Rg is the response ‘good’; and Rb, ‘bad’. The critical cells of the contingency table are those that represent ‘hits’ (P(Rg/Sg)), the proportion of well-formed sentences to which the subject responds ‘good’; and ‘false alarms’ (P(Rg/Sb)), the proportion of ill-formed sentences to which she replies ‘good’.

Two important features of the data are seen in Fig. 1. First, there is clear evidence of discrimination in all four subjects; i.e., well-formed sentences are treated differently than ill-formed ones. Second, in three of the four subjects the tendency is to err by accepting ill-formed sentences. Thus, the proportion of false alarms (false alarms/false alarms + misses) is 0.64, 0.90, and 0.93 in patients L.S., E.B., and A.T., respectively. The fourth patient, V.S., displays a more conservative criterion, with a false alarm rate of only 0.20.

The summary tables of Fig. 1 collapse responses across the 10 stimulus conditions. More detailed summaries are provided in Fig. 2, where each condition is represented as a point on the conventional unit square of signal detection analysis.

Consider first the data from subject V.S. On all but two conditions her performance is near perfect, in that she consistently detects good sentences while producing few if any false alarms. This generalization breaks down with conditions 2 and 5, the two tag question conditions, where the tendency is to reject all tokens as ill-formed.

A similar effect of condition is evident in the data from subject L.S. Here again the cluster of points in the upper left of the square testifies to the accuracy of discrimination performance. But as with V.S., the two tag conditions, 5 and 10, fall out of the cluster of points, along with, now, Condition 9, the set of reflexive sentences.

The interpretation of E.B.’s and A.T.’s performance from this simple plot is more problematic, although it is worth noting that A.T., too, has disproportionate difficulty with the tags (especially in the aux copy condition, 10) and the reflexives (Condition 9). Indeed, the proximity of these points to the diagonal indicates that good and bad tokens of these grammatical types are essentially indistinguishable for her.

In the remaining points of A.T.’s data plot, and in all points of E.B.’s, there is the suggestion of a variable criterion for rejection of ill-formed sentences (i.e., false alarm rates vary over conditions while hit rates remain nearly constant). What is required in the analysis of these data is a statistic

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\(^9\)For lucid reviews of signal detection analysis, its assumptions, and its range of application in psychology, see Swets, 1973, and Pastore and Scheirer, 1974.
Figure 2. A breakdown of performance by condition for each of the four subjects. Proportion of hits (P(Rg/Sg)) is plotted against proportion of false alarms (P(Rg/Sb)). Each numbered point represents the outcome from one condition (e.g., point number one summarizes performance on good and bad sentences of the strict subcategorization condition; see text and Table 2).

which isolates this criterion, or bias, factor from the measure of sensitivity to the well-formedness of sentences. The statistic most commonly used, d', was rejected here because of the strong assumptions it requires about the statistical properties of the conditional probability density functions assumed to underly performance (Swets, 1973; and see footnote 10). Instead, we have made use of a non-parametric index of sensitivity, A', based upon the estimated area under the receiver-operating-characteristic (ROC) curve (i.e., the map of data points for all possible criteria at a fixed level of sensitivity).
According to Green (cited in Pollack and Norman, 1964) the area under the ROC curve is theoretically equal to the proportion of correct responses attainable in a two-alternative forced choice procedure. As such, it provides a pure measure of sensitivity, uncontaminated by the bias factor.\textsuperscript{10} It has been demonstrated by Pollack and Norman (1964) that the area under the ROC curve ($A'$) can be approximately estimated from a single point on the unit square; in their paper those authors provide a set of iso-sensitivity curves, representing loci of points on the unit square which yield equivalent values of $A'$.

The data from Fig. 2 have been redrawn, in Fig. 3, on these Pollack and Norman curves. In Table 3 are listed the values of $A'$ for all subjects in all conditions.\textsuperscript{11} Keep in mind that because of its relation to the expected correct score in a two-alternative forced choice experiment, the $A'$ can be interpreted quite naturally; an $A'$ value of 0.90 translates into an expected score of 90% correct on a good/bad forced choice procedure with these same sentence materials.

Figure 3. \textit{Data points from Fig. 2, summarizing performance by condition, are redrawn on this family of isosensitivity curves for $A'$, our area-based index of sensitivity.}

\textsuperscript{10}This is true under the set of assumptions underlying the signal detection analysis, i.e., that the subject, in deciding whether a particular event arose from one class of events or another, does so on the basis of two conditional probability density functions which are identical under the various experimental procedures. In contrast to $d'$, the area-based statistic $A'$ requires no further assumptions about the shape of these functions (Pastore and Schierer, 1974).

\textsuperscript{11}In determining these values we used the computational formula developed by Griess, 1971: $A' = 0.5 + (y - x)(1 + y - x)/4y(1 - x)$ where $x = \text{proportion of false alarms}$ and $y = \text{proportion of hits}.$
Table 3.  *Grammaticality judgments by four agrammatic aphasics*

<table>
<thead>
<tr>
<th>Condition</th>
<th>V.S.</th>
<th>L.S.</th>
<th>E.B.</th>
<th>A.T.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Hits(^a)  False(^b) Alarms</td>
<td>Hits  False Alarms  A'</td>
<td>Hits  False Alarms  A'</td>
<td>Hits  False Alarms  A'</td>
</tr>
<tr>
<td>1. Strict sub-categorization</td>
<td>0.90  0.00  0.98</td>
<td>0.90  0.05  0.96</td>
<td>1.00  0.19  0.95</td>
<td>1.00  0.48  0.88</td>
</tr>
<tr>
<td>2. Particle movement</td>
<td>0.90  0.10  0.94</td>
<td>0.93  0.00  0.98</td>
<td>0.97  0.40  0.88</td>
<td>1.00  0.50  0.88</td>
</tr>
<tr>
<td>3. Subject-aux inversion</td>
<td>1.00  0.05  0.99</td>
<td>0.90  0.00  0.98</td>
<td>0.95  0.10  0.96</td>
<td>1.00  0.50  0.88</td>
</tr>
<tr>
<td>4. Empty elements</td>
<td>0.90  0.13  0.94</td>
<td>0.92  0.23  0.90</td>
<td>1.00  0.08  0.98</td>
<td>1.00  0.45  0.89</td>
</tr>
<tr>
<td>5. Tags: Subj. copy</td>
<td>0.05  0.00  0.76</td>
<td>0.80  0.35  0.81</td>
<td>0.95  0.60  0.81</td>
<td>0.85  0.30  0.86</td>
</tr>
<tr>
<td>6. Left branch condition</td>
<td>1.00  0.65  0.99</td>
<td>1.00  0.10  0.98</td>
<td>0.95  0.35  0.89</td>
<td>1.00  0.55  0.86</td>
</tr>
<tr>
<td>7. Gapless relatives</td>
<td>1.00  0.10  0.98</td>
<td>0.95  0.10  0.96</td>
<td>0.95  0.40  0.87</td>
<td>1.00  0.65  0.84</td>
</tr>
<tr>
<td>8. Phrase structure</td>
<td>0.85  0.00  0.96</td>
<td>0.90  0.05  0.96</td>
<td>1.00  0.00  1.00</td>
<td>1.00  0.35  0.91</td>
</tr>
<tr>
<td>9. Reflexives</td>
<td>0.95  0.10  0.96</td>
<td>1.00  0.70  0.83</td>
<td>0.95  0.70  0.77</td>
<td>1.00  1.00  -</td>
</tr>
<tr>
<td>10. Tags: Aux copy</td>
<td>0.00  0.00  -</td>
<td>0.65  0.30  0.76</td>
<td>0.95  0.10  0.96</td>
<td>0.70  0.65  0.55</td>
</tr>
</tbody>
</table>

\(^a\)P(Rg/Sg), i.e., 'good' responses to well-formed sentences.
\(^b\)P(Rg/Sb), i.e., 'good' responses to ill-formed sentences.
\(^c\)A' = index of sensitivity (see text); A' = 0.5 + (y - x)(1 + y - x)/4y(1 - x) where x = P(Rg/Sb) and y = P(Rg/Sg).
For V.S. and L.S., the A' analysis confirms what the data in Figs. 1 and 2 already indicated. These subjects consistently achieve values above 0.90, indicating a high degree of sensitivity to the grammatical well-formedness of sentences. It is only on the tag conditions (5 and 10) and the reflexive condition (9) that there is any sign of diminished sensitivity.\textsuperscript{12}

The A' analysis shows a similar pattern of results for patients E.B. and A.T. The overall level of sensitivity is somewhat less for these two patients, but again, with the exception of tags and reflexives, they achieve impressively high A' values, in the range 0.84–1.00.

Discussion

Recall that the four aphasic subjects in this study all demonstrated the pattern of comprehension impairment which some are claiming to be typical of the Broca’s aphasia syndrome (Berndt and Caramazza, 1980; Zurif, 1980); on picture-pointing tests of sentence comprehension they did not reliably assign semantic roles consistent with syntactic structure. The syntactic theory of agrammatism explains this failure in terms of the inability of such patients to parse sentences, i.e., to construct syntactic representations of the input sentences.

We interpret the results of our grammaticality judgment test as providing strong counter-evidence to this explanation of the comprehension defect in Broca’s aphasia, and, consequently, to the syntactic theory itself. In particular, we take the performance of these Broca’s aphasics to indicate that they are in fact able to perform complex syntactic analyses of sentences.

In presenting preliminary findings from this study, we have met with a variety of objections to this claim. Some have argued that genuine syntactic analysis is not required by this task and that our patients could have achieved the same level of performance by using some constellation of special strategies, e.g., template matching, transitional probabilities, or semantic strategies utilizing open class word meaning alone. In the discussion below, we will attempt to show why such alternatives fall short of accounting for our findings.

Let us examine the general syntactic abilities that we believe this test reveals in our subjects.\textsuperscript{13}

\textsuperscript{12}V.S.’s performance on the two tag question conditions cannot be unambiguously interpreted under this analysis. Her consistent rejection of all tokens of this type may reflect, on the one hand, a true loss of sensitivity to the structural information that distinguishes well-formed tags from ill-formed ones. Alternatively, she may simply have a dislike for any and all constructions that pose questions in this way (i.e., an extreme conservative bias).

(continued on facing page)
Awareness of subcategorization requirements

All four subjects, but in particular V.S., L.S., and E.B., showed a very high level of accuracy on the sentences of Condition 1 (strict subcategorization). We maintain that this is testimony to their considerable knowledge of the subcategorization requirements of lexical items, that is, of the lexically-stated restrictions on the kinds of complements that the head of a phrase may have. For example, by rejecting (47) while accepting (48') our subjects demonstrate that they recognize that talk is syntactically intransitive, that is, that it may not take a direct object, and that they are able to determine the constituent structure of the input sentences sufficiently to ascertain that (47) but not (48) violates this intransitivity.

(47) *The policeman was talking a woman.
(48) The policeman was talking to a woman.

What are possible alternative accounts for their ability to make this distinction? First, it might be suggested that the judgment here is a purely semantic one, i.e., that a general appreciation of the action denoted by talk would lead subjects to reject a sentence in which it was followed by a direct object. However, it is widely observed that although subcategorization requirements are related to meaning, they are not predictable from meaning alone: contrast (47) with (49) below (not test sentences).

(49) The policeman was haranguing a woman. lecturing

It is highly unlikely that the difference between the action denoted by talk on the one hand, and those denoted by harangue and lecture on the other, is sufficient to predict the fact that only talk is unable to take a direct object. Most of the sentences in Condition (1) utilized verbs for which the English lexicon contains such approximate synonyms with different syntactic properties.

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13 We have been deliberately vague throughout in our use of the terms ‘syntactic knowledge’ and ‘syntactic representation’ vis-à-vis levels of linguistic representation. Many of the ungrammatical sentences in our task are currently analysed as violations of principles of logical form (LF) rather than as, e.g., misapplications of transformational rules. LF (as elaborated in Chomsky (1981) and elsewhere) is a level of linguistic representation derived from the structure which is the output of the transformational component, i.e., S-structure (‘surface structure’ in an earlier usage). It is at the level of logical form that quantifier scope, bound anaphora, disjoint reference, and other properties of meaning determined strictly by sentence grammar are stated. This level of logical form is to be distinguished, however, from a full representation of sentence meaning: word meaning, for example, is not expressed at this level.

14 There are certain uses of talk in which it is followed by a direct object, e.g.,

(1) The policeman was talking a woman into going home.
(2) The policeman was talking a blue streak.
Another possible account for our subjects' correct judgments on sentences like (47) and (48) attributes their success not to an awareness of the syntactic property of intransitivity but rather to the expectation of a certain prosodic pattern following the verb. Thus an intransitive verb might 'sound funny' if followed by an NP, not because that NP is syntactically disallowed but rather for purely prosodic reasons. This would not be a successful strategy, however, since it would lead the subject to judge incorrectly many sentences in which there is an identical prosodic pattern but which differ with respect to their satisfaction of these subcategorization requirements. For example, sentence (50) below (not a test sentence), has a stress pattern very similar to that of (47) and yet is clearly acceptable.

(50) The policeman was talking a lot.

Furthermore, subjects utilizing such a prosodic strategy might be expected to reject all sentences in which a subcategorized-for element is fronted by wh-movement, since this would disrupt the prosodic pattern upon which they were relying. Thus if we explain our subjects' sensitivity to the requirement of invite for a direct object (demonstrated on several different conditions of the test) as the prosodic expectation of a few extra beats after the verb, then we would expect them to reject test sentences such as (51) below; but, in fact, such rejections did not occur.

(51) Who did he invite?

The inadequacy of both of these alternative accounts to deal with our subjects' proficiency on the subcategorization condition is even clearer when we examine test sentences like the following (see footnote 7):

(52) I want you to go to the store now.
(53) *I hope you to go to the store now.
(54) *I want you will go to the store now.
(55) I hope you will go to the store now.

All of our subjects made the correct judgments on the above sentences. What combination of special strategies can account for this? Appreciation of the mental states denoted by want and hope, or that plus prosodic expectations of the sort described above, will not suffice to determine the correct response in such cases: (52) and (53), for example, are close to synonymous and have the same stress pattern, yet are correctly differentiated by the patients. Given that they accurately differentiated these and other such 'minimal contrasts', it would have to be assumed that the 'templates' against which our subjects were matching the inputs expressed nothing less than the constituent structure of the complements of particular verbs. Thus the
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Information relevant to the determination of constituent structure was extracted by the subjects from the spoken inputs. But it is precisely this ability that is denied to agrammatic aphasics by the syntactic theory.

Sensitivity to the functor vocabulary

As discussed in the Introduction above, the possible special role of the functor vocabulary in sentence processing, and the alleged impairment of this role in agrammatism, have been important elements of the syntactic theory. In six of the seven conditions in which all of our subjects performed well, the functor vocabulary plays a crucial role in distinguishing grammatical from ungrammatical sentences. Let us briefly examine the role of functors in several of these conditions.

Recall from the preceding discussion that grammaticality in the subcategorization condition frequently hinges upon the presence or absence of a functor: it is the presence of a preposition, for example, that distinguishes the well-formed sentence (48) above from the ill-formed (47). Furthermore, it is not merely the presence of a functor but also its identity that must be responded to in order to make the correct distinctions in pairs such as (52)/(54), and (53)/(55) above: here the distinction between to and will is crucial. Listeners who were simply marking stress patterns in association with particular lexical configurations, or who had a vague expectation of the presence of just any element from the functor vocabulary, could not be expected to discriminate between ‘minimal pairs’ of this type.

Functors play equally important roles in several other conditions. Condition 2 (particle movement) deals entirely with the behavior of function words such as in and up. In many sentences of Condition 3 (subject-aux inversion), both the presence and the identity of a given element of the function word vocabulary must be observed in order for the correct judgments to be made; in the sentences below, for example, the subject must distinguish was from did in order to make the correct judgments.

(56) Was the girl enjoying the show?
(57) *Was the girl enjoy the show?
(58) *Did the old man enjoying the view?
(59) Did the old man enjoy the view?

In Condition 4 (empty elements), the presence or absence of the relative pronoun is essential in distinguishing between sentences such as (60) and (61), since the object of invite (for which invite is obligatorily subcategorized) can
be phonologically unrealized only if it corresponds to a \textit{wh}-word. Functors also distinguish between tensed and infinitival clauses in this condition; thus it is the distinction between \textit{to} and \textit{would} that is crucial in sentences (62) and (63), which are identical in all other respects including prosodic pattern.

(60) *My sister thought that he would invite.
(61) Who did you think that he would invite?
(62) You promised to invite me to your party.
(63) *You promised would invite me to your party.

Clearly, our subjects' ability to make such judgments reveals a sensitivity to the functor vocabulary which cannot be explained by appeal to semantic strategies utilizing open-class lexical content. Their good performance on Condition 8 (phrase structure) further demonstrates this awareness of the role of functors in phrasal geometry coupled with an ability to override open-class semantic considerations, e.g., to reject syntactically ill-formed structures whose open-class lexical items nevertheless allow for some quite plausible semantic interpretation. In many of the sentences in this condition grammaticality hinges upon the presence of a single function word, and the ungrammatical sentence has a potentially misleading plausibility arising out of the meanings of its open-class elements.

(64) *The starving man was hungry food.
(65) The starving man was hungry for food.

In rejecting (64) and accepting (65), the subject demonstrates a syntactic awareness that \textit{hungry food} cannot be an adjective phrase with \textit{hungry} as its head; i.e., that (64) is ill-formed under the interpretation of \textit{hungry food} as 'hungry for food' (see footnote 8). This is the most semantically plausible reading, given the open-class items \textit{starve}, \textit{hungry}, and \textit{food}, but this plausibility does not lead the subjects to accept the sentence. The analysis of (64) which is syntactically acceptable is that in which \textit{hungry food} is a noun phrase with \textit{food} as its head; this would have the semantically implausible interpretation 'food that is hungry', and subjects can presumably rule out this particular reading of (64) on semantic grounds. Thus the correct judgment on (64) requires both syntactic and semantic analysis: syntactic analysis, in order to determine that \textit{hungry food} must be a noun phrase meaning 'food that is hungry' rather than an adjective phrase meaning 'hungry for food', the latter interpretation being the most natural one given the meanings of the open-class items; and semantic analysis, in order to determine that the syntactically correct reading in which \textit{hungry food} is a noun phrase is not likely to be the intended reading of the sentence. 15
By their accuracy on these and other conditions involving functors, for which there appears to be no alternative explanation in terms of semantic or prosodic expectations, our subjects reveal that they are in fact computing the syntactic consequences of the closed class vocabulary.

**Ability to handle discontinuous syntactic dependencies**

Our data also suggest that in addition to their awareness of subcategorization frames and sensitivity to the functor vocabulary, our subjects also have the capacity to handle discontinuous syntactic dependencies, sometimes inter-clausal. This is especially clear in the case of Condition 3 (subject-aux inversion), in which the listener must 'reconstruct' the verb phrase by associating the moved item with elements still in the VP. In Condition 4 (empty elements), the association of a sentence-initial *wh*-word with an empty NP position must be carried out in order for the correct judgment to be made in pairs like (60)/(61) above; furthermore, in order to detect the ungrammaticality of a sentence like (66) below the subject must keep track not only of the presence of the *wh*-word but also of whether it has already been associated with an empty NP position.

(66) *Who did you think would invite?  
(Both subject and object positions of embedded clause are empty.)

(67) *Who did you think that he would invite?  
(Direct object position empty)

(68) Who did you think would invite Mary Smith?  
(Subject position empty)

This sort of bookkeeping is not what one might expect from these subjects in the light of their agrammatic comprehension and production.

Further evidence that these subjects are doing more than just local phrasal analysis, i.e., that they are able to handle long-range dependencies, comes from Condition 6 (left branch). Here, most of the ill-formed sentences are in fact locally grammatical; (69) below would be grammatical without the final noun (*birds*) or without the initial specifier (*how many*).

(69) *How many did you see birds?  
(70) How many birds did you see?  

---

15Thus strictly speaking sentence (64) should not be cited as ungrammatical, since it has one grammatical (albeit semantically anomalous) reading.
A similar analysis holds for Condition 7 (gapless relatives); consider the following sentence, in which an embedded clause (nobody would eat the pie), although locally grammatical, nevertheless fails to provide the gap required by the relative clause construction.

(71) Sally baked a cake that nobody would eat the pie.

To summarize the discussion so far, an examination of the kinds of discriminations required by the seven conditions in which our subjects performed well suggests that at least the following kinds of syntactic ability are required by our task: an awareness of strict subcategorization frames, considerable sensitivity to the functor vocabulary, the ability to compute hierarchical phrase structure, and the ability to handle discontinuous syntactic dependencies. It appears that the task could not be performed successfully by using general semantic knowledge or an appreciation of transitional probabilities and/or prosodic patterns associated with particular lexical items. In general, any appeal to ‘template matching’ as an alternative strategy for performing this task seems to us to require templates which are in fact generalizations over structures of considerable syntactic specification.

We wish to be clear about what it is that we are and are not claiming to be true of the syntactic abilities of our subjects. We are not, for one thing, claiming that grammatical analysis is entirely normal in the aphasic listeners, even in the grammaticality judgment task. We do not yet know, for example, whether the sort of cross-clausal bookkeeping referred to above would remain possible with longer or more complicated sentences. Nor do we know how these subjects would deal with syntactic ambiguities; whether they would, for example, commit themselves early in the sentence to one or another interpretation; and how, if at all, they would recover from ‘garden-pathing’. These are interesting questions to pursue, but regardless of how they come to be answered it is clear from what we have learned so far that the parsing capability of these agrammatic aphasics is far greater than the syntactic theory would predict.

Furthermore, although our patients are clearly able to perform syntactic analysis of sentences on this judgment task, we do not wish to assume that they achieve such analyses in all other circumstances (although such an assumption would follow from the view that complete parsing is mandatory and resource-cheap; see, for example, Fodor, 1983). We must at this point leave open the possibility that these same patients are unable to recover syntactic structures in other types of sentence processing tasks (see below).

Finally, we make no claims on the basis of these data about the nature of the agrammatic deficit in sentence production; that is, it is perfectly possible that a central problem in agrammatism is the inability to retrieve
syntactic structures for the purposes of expressing propositional thought. We
would merely point out that the present findings are incompatible with the
view that what underlies the output problem is the agrammatic speaker's
lack of any access to information about what constitutes a well-formed
sentence in his language. Additional evidence on this point is found in
Goodglass et al. (1972).

We come now to the question of how to resolve the discrepancy between
our subjects' high levels of accuracy on this grammaticality judgment task and
their very poor performance on picture-pointing tasks of sentence com-
prehension, even those involving sentences much less complex than those
used in the judgment task. We will consider two possible explanations for
these comprehension problems in Broca's aphasia, although there may well
be others.

(1) One possibility is that the problem agrammatic listeners have is not in
constructing syntactic representations but in exploiting them in semantic
interpretation. Such a possibility was put forward by Schwartz et al. (1980)
as one way to account for the unexpectedly poor performance of their
agrammatic aphasic subjects on a sentence-picture matching task involving
simple active declarative sentences. These authors attempted to locate the
problem of agrammatic comprehension in the use of syntactic structure to
construct representations in which thematic roles are specified. Such an
account is perfectly compatible with the results of the grammaticality judg-
ment task, since it locates the problem not in the syntactic analysis itself,
but in the use of the products of this analysis.

This hypothesis, in its strongest form, can at least be disconfirmed if there
exists some task in which these subjects do succeed in carrying out such a
mapping from syntactic to semantic representations, exploiting syntactic
structure for the recovery of information about thematic roles. In this con-
nection we are currently exploring a semantic anomaly judgment task, in
which the subject is asked to evaluate auditorily presented sentences as 'silly'
or as 'OK'. The crucial sentences in this task are those in which semantic
anomaly is determined by syntactic structure:

(72) The little girl carries the kitten around.
(73) The kitten carries the little girl around.

The implausibility of (73) cannot be determined purely by open class lexical
content, as demonstrated by the acceptability of (72), nor can it even be
determined locally within subparts of the sentence. Thus The kitten

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16A similar discrepancy is observed in Goodglass et al. (1970), where evidence is presented for a dis-
sociation between the comprehension of prepositions and the appreciation of their 'stylistic' contribu-
tion to sentences. The former, but not the latter, was impaired in a severe global aphasic.
carries... is not in itself implausible (e.g., if the direct object is the mouse) nor is... carries the little girl around (e.g., if the subject is the man). The processing requirements of this task are certainly different and perhaps less severe than those imposed by sentence-picture matching tasks, in which representations of visual material must be computed and compared with the stored results of sentence comprehension. Thus the semantic anomaly judgment task seems to be a possible vehicle for examining the plausibility of our first hypothesis, that agrammatic aphasics are able to compute syntactic representations but are unable to exploit them.

(2) A second possibility is that there is in agrammatism a tradeoff between syntactic and semantic processing, so that subjects achieve their optimal performance in one domain only by sacrificing accuracy in the other. Such a situation might arise from any of a number of possible restrictions on the patients' computational resources. We will consider one possible mechanism.

Let us suppose that agrammatic aphasics are simply less efficient parsers than normal listeners; that they are capable of carrying out all of the necessary operations to achieve a full parse of input sentences, but at greater effort and computational expense than is normally the case. Indeed, one might view the functor impairment argued for by Bradley and her colleagues as providing a mechanism for this reduced efficiency: the lack of special access routines for the closed class vocabulary slows down parsing, on this view; it does not necessarily prevent it from happening.

The added cost of syntactic processing should be least evident in tasks like the present one, where extra-syntactic demands are kept to a minimum; but it will become increasingly evident with additional demands for semantic interpretation, storage for later recall, and the like. On the hypothesized tradeoff between syntactic and semantic processing, any of several outcomes are possible, depending at least in part on the task demands. Where semantic interpretation is at issue, the parser may become prone to error, or it may fail to operate at all. On the other hand, where substantial syntactic analysis is called for, semantic processing may be unusually 'shallow'.

This notion of shallow semantic processing points the way toward an explanation of the poor performance of our subjects on the tag question and reflexive conditions of the grammaticality judgment task. It may be that in processing such sentences the aphasic subject attends quite minimally to lexical features such as gender, number, and person; merely noting, perhaps, whether these features are in agreement with those of closely-linked elements of the sentence such as the verb.17 In the tag question and reflexive

17: Should be noted that a tradeoff hypothesis need not predict that there will be absolutely no semantic processing in tasks such as the grammaticality judgment test which require and emphasis on (continued on facing page)
sentences, the information expressed in these features is crucial to determining the acceptability of an element (a reflexive pronoun or the pronoun in a tag question) which comes later in the sentence. Thus, for example, the subject does not know until the last word of a sentence like (74) that the number, gender, and person of the subject NP will have to be retained in order to determine whether it matches the pronoun in the tag question. The poor performance of our subjects on such sentences might in this way be attributable to their shallow decoding of the lexical content of the subject NP, given the hypothesized tradeoff between syntactic and semantic processing.

(74) *The little boy fell down, didn’t it?

Similarly, reflexives generally follow their overt antecedents; thus in (75) the subject will not have been ‘warned’ to retain the information about the gender and so forth of the antecedent that will be crucial to determining the acceptability of the reflexive pronoun.

(75) *The little boy cut itself while playing.

In contrast, consider a sentence like (76). The presence of the auxiliary in sentence-initial position signals that elements will follow with which it must agree; thus the subject is warned in advance to retain a full lexical specification of the fronted auxiliary.

(76) *Did the old man enjoying the view?

The excellent performance of our subjects on subject-aux inversion sentences like (76) underscores the inadequacy of any explanation for the difficulty of the tag and reflexive conditions in terms of a general insensitivity to closed-class elements (pronouns, reflexives, auxiliaries in these conditions). If failure to detect the unacceptability of (77) below is to be ascribed to an inability to distinguish does from other auxiliaries such as is (which would be the correct aux) then why did our subjects perform well on sentences like (76), where much the same contrast (do versus be) is involved?

(77) *John is very tall, doesn’t he?
If it is true that as a result of 'shallow processing' our agrammatic subjects are in some cases building structural descriptions of the input which are too impoverished to support the judgment of grammaticality, why don't they simply back-up over the sentence trace to recover the relevant structural information? Surely this is what the normal listener does in recovering from similar 'garden path' situations. We would argue that the aphasics' lack of a veridical (i.e., phonological) record of the input string prevents them from carrying out such a recovery. The very restricted immediate memory span of these and other agrammatic aphasics certainly supports this conclusion.

What emerges most conclusively from this discussion, perhaps, is that it will be necessary to learn a great deal more about information processing in these aphasic patients and about sentence processing more generally before we can provide a satisfactory account of our observations. The results themselves, however, and their implications for the status of syntactic knowledge in agrammatism, are quite clear: the comprehension deficit in agrammatism does not reflect loss of the capacity to analyse syntactic structure. We are left now with the important question of why agrammatic aphasics seem unable to make use of this capacity in the comprehension and production of sentences.

References


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18 The restriction of immediate memory span in Broca's aphasia is well-documented (Goodglass *et al.,* 1970). The four patients in this study have spans only in the range 2–4 items, even when tested with non-verbal report procedures. This limitation is of substantial theoretical interest, particularly in light of the finding that conduction aphasic patients, with similar span restrictions but no agrammatism in speech, perform in a manner indistinguishable from agrammatic aphasics on standard tests of sentence comprehension (Caramazza *et al.,* 1981; Caramazza and Zurif, 1976; Heilman and Schoules, 1976; Saffran and Marin, 1975). It is altogether possible that it is the failure to maintain a stable phonological trace of the sentence input that provides the complete account of the comprehension problems of these two groups of patients. (For further discussion of this issue, and some relevant data, see Caramazza, Basili *et al.,* 1981; and Caramazza, Berndt *et al.,* 1981.)
Sensitivity to grammatical structure in so-called agrammatic aphasics


Reference notes


**Résumé**

Les échecs de compréhension des aphasiques agrammatiques ainsi que leurs difficultés à construire des phrases ont été attribués à un déficit sous-jacent impliquant la recherche de la structure syntaxique. Dans cette étude les performances de quatre sujets agrammatiques dans une tâche de jugements grammaticaux montrent que ces sujets font preuve d'une remarquable sensibilité pour l'information structurale. Ces résultats indiquent que la connaissance syntaxique n'est pas atteinte chez l'agrammatique et suggèrent que les troubles de compréhension de phrase ne reflètent pas une perte dans la capacité à retrouver la structure syntaxique. L'interprétation selon laquelle les déficits seraient dus à un échec dans l'utilisation de l'information transmise par la classe fermée (mots fonctions) du vocabulaire est rémise en cause. D'autres interprétations sont proposées pour rendre compte des problèmes de compréhension des agrammatiques.