

# Question Production in Agrammatism: The Tree Pruning Hypothesis

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This study investigated question production in agrammatic aphasia, focusing on the comparison between Wh questions and yes/no questions and on the interaction between the question production deficit and language-specific properties. A total of 16 agrammatic aphasics (13 Hebrew speakers, 2 Palestinian Arabic speakers, and 1 English speaker) participated in the study, which included sentence elicitation and repetition tasks. In addition, the patients' spontaneous speech, containing 2272 utterances, was analyzed. The main findings were that Hebrew- and Arabic-speaking agrammatics encounter severe difficulties in Wh question production but retain the ability to produce yes/no questions. English-speaking agrammatics do not show this dissociation and can form neither Wh nor yes/no questions. These dissociations as well as the error pattern, are explained by reference to the Tree Pruning Hypothesis, according to which the highest nodes of the syntactic tree, which are required for Wh questions in Hebrew, Arabic, and English and for yes/no questions in English, are impaired or inaccessible in agrammatism. © 2001 Elsevier Science (USA)

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An intriguing fact about the speech of agrammatic patients is that they find it difficult to produce certain types of questions. Since they retain the notion of what a question is (and the need to ask questions), they produce ill-formed questions and replace certain question types with others. It is the aim of the current study to explore the extent of the deficit in question production in agrammatic aphasics, to test empirically the existing accounts for agrammatism as they reflect on the question production deficit, and to suggest a unified account for the pattern of sparing and loss in question production that will also be able to capture a broader range of phenomena regarding production in agrammatic aphasia.

Question production has not gained as much attention and empirical investigation as have other types of complex sentences. The lack of subordination in agrammatic speech and the use of simple sentences have been reported time and time again (Bates, Friederici, Wulfeck, & Juarez, 1988; Gleason et al., 1980; Goodglass, Christiansen, & Gallagher, 1993; Goodglass & Mayer, 1958; Thompson, Shapiro, Tait, Jacobs, & Schneider, 1996). Agrammatic patients were reported to avoid subordination and produce significantly fewer embedded sentences than normals (Menn & Obler, 1990).

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Moreover, when they do produce an embedding marker (e.g., *that*), they are usually unable to proceed with the rest of the embedded clause (Friedmann, 1998). However, indicative embedded sentences are not the only complex sentence type that is scarce in agrammatic output. Some data suggest that agrammatic speakers also fail to produce well-formed complex *interrogatives*. The Thompson and Shapiro group, who have studied the production of various question types using treatment research, reported that the 17 agrammatic aphasics they tested had severe deficits in question production prior to treatment (Thompson & Shapiro, 1994, 1995; Thompson, Shapiro, & Roberts, 1993; Thompson et al., 1996; Wambaugh & Thompson, 1989). Myerson and Goodglass (1972) and Goodglass (1976) also reported a deficit in question production as one of the characteristics of agrammatism. In addition, an analysis of existing corpora of spontaneous speech in agrammatism has shown that this function is absent or ill formed in the narratives of agrammatic speakers (Menn & Obler, 1990).

In this article, a selective syntactic account for the deficit in question production, the Tree Pruning Hypothesis (TPH), is suggested. Its predictions are examined empirically, and it is compared to other accounts of the agrammatic deficit in production. The syntactic tree plays a major role in the TPH description of the deficit in agrammatic production, and therefore a brief linguistic background about it is provided, followed by a presentation of the predictions regarding question production that follow from the TPH.

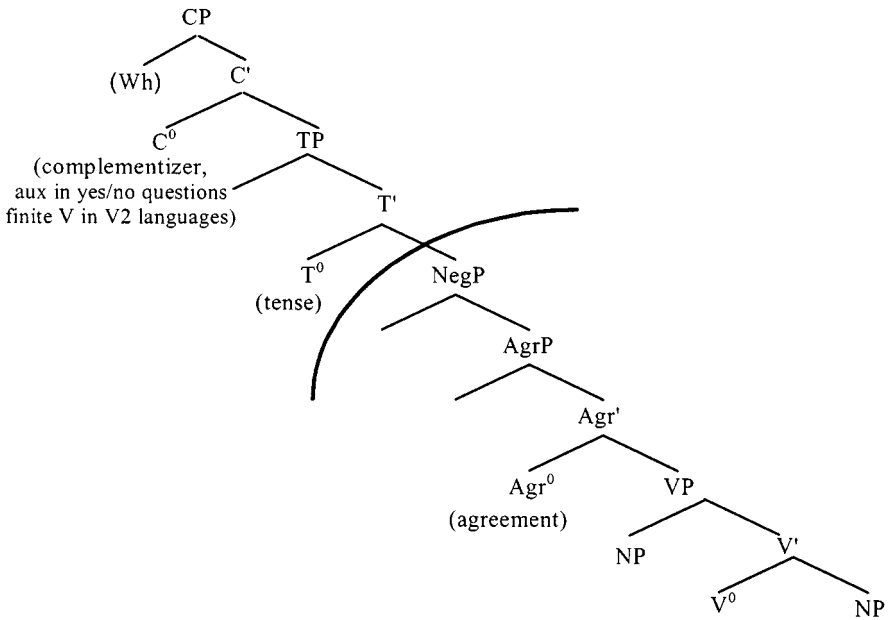
### *Syntactic Tree Pruning and the Question Production Deficit*

According to syntactic theories within the generative tradition (e.g., Chomsky, 1993), sentences can be represented as *phrase markers* or *syntactic trees*. In these syntactic trees, content and function words are represented in various nodes. Each of these nodes is a head node ( $X^0$ ), which projects to a phrasal node (XP). Phrases that host functional categories (functional phrases) include, among others, an agreement phrase ( $\text{Agr}_s\text{P}$ ), which is responsible for the agreement in person, gender, and number between the subject and the verb; a tense phrase (TP), which is responsible for the tense inflection of the verb (Pollock, 1989); and a complementizer phrase (CP), which hosts complementizers such as *that*, and Wh-question morphemes, such as *who* and *what*, that completed their movement from the base-generated position within the VP (to spec-CP).

Finite verbs move from  $V^0$ , their base-generated position within the VP, to  $\text{Agr}^0$  and then to  $T^0$  in order to check (or collect) their inflection. Noun phrases such as the subject move to the specifier position of functional phrases in order to receive case and check their agreement with the verb. Figure 1 presents a syntactic tree according to Pollock (1989).<sup>1</sup>

The Tree Pruning Hypothesis was originally suggested as an account for dissociations found between tense and agreement inflections. Friedmann (1994, 1998, 2001) and Friedmann and Grodzinsky (1997, 2000) found a dissociation between tense and agreement inflection in agrammatic sentence production. While tense was found to

<sup>1</sup> The relative order of TP and  $\text{AgrP}$  is subject to dispute, but we believe that the findings from aphasia from Hebrew and Arabic (Friedmann, 1997, 2001), as well as from Spanish (Benedet, Christiansen, & Goodglass, 1998), Dutch (Kolk, 2000), and English (Arabatzi, 2000; Benedet et al., 1998), support the original order advocated by Pollock (1989) of TP above  $\text{AgrP}$  (which was also the order advocated by Demirdache, 1988, and Ouhalla, 1994, for Arabic). In addition, in Fig. 1, a separate node for agreement checking is included, but see Chomsky (1995) for agreement checking that is not in a separate  $\text{Agr}$  node. The Tree Pruning Hypothesis remains agnostic as to whether an  $\text{Agr}$  node exists, but it is critical for the TPH that subject agreement is checked below TP or in a different mechanism.



**FIG. 1.** Split inflection phrase marker (Pollock, 1989). The arch represents the impairment site according to the TPH. Nodes below the arch are intact, and nodes above it are impaired.

be severely impaired (in a study with 14 Hebrew and Arabic speakers, there were 42% errors in tense completion tasks for which chance performance is 33%), agreement was surprisingly good (only 4% errors in completion tasks with the same participants). Since tense and agreement reside in different positions on the syntactic tree (and because other functions related to the tense node were also impaired), we suggested that the tense node in the agrammatical tree is impaired, whereas the agreement node remains intact.

Following data regarding different degrees of severity, which can be described by different pruning sites on the tree, the TPH was revised to claim that the agrammatical phrase marker is impaired at a certain node in the tree. The more severe patients are impaired in a lower site (TP) and show a deficit in larger parts of the tree, whereas the milder patients are impaired at a higher node (CP) and are impaired in a smaller part of the tree (Friedmann, 1998, 2001).

Given the crucial role of heads in the projection of higher nodes, the TPH suggests that when a node is impaired, the tree is pruned from this node upward (or, in other words, when a node is inaccessible, all nodes above it are also inaccessible). Thus, if the tense node is impaired, then nodes in CP (which are situated higher than TP) would also be unavailable to agrammatical aphasics<sup>2</sup> (for a similar truncation claim regarding language acquisition, cf. Rizzi, 1994; for a similar claim regarding agrammatism, cf. Hagiwara, 1995). The Tree Pruning Hypothesis therefore has strong implications for a large number of structures. It predicts that when the tree is pruned at T, not only structures that require the tense nodes (e.g., tense inflection, copulas, subject pronouns) would be impaired but also all structures that depend on the nodes

<sup>2</sup> The part of the Tree Pruning Hypothesis that claims that if a node is not represented, no higher node can project, is borne out by a study by de Roo (1995) on Dutch agrammatical patients. She found that in 40 of 41 Dutch sentences that included tense violations (finiteness omission), the elements in CP were omitted as well.

in the higher maximal projection CP, namely  $C^0$  and spec-CP. When the tree is pruned at C, CP will naturally be impaired too.

A glimpse at some of the functions of  $C^0$  and spec-CP reveals the structures that are predicted to be affected in agrammatism as a result of CP impairment. The  $C^0$  head is the site of *complementizers* such as *that* and *for*. A functioning  $C^0$  is therefore required to produce embedded sentences of various types such as relative clauses and sentential complements of verbs and nouns.<sup>3</sup> A recent study of embedded structures (Friedmann, 1998, 2001) found that embedded sentences, such as relative clauses and sentential complements of verbs and nouns that require the  $C^0$ , are indeed impaired in agrammatic production, but reduced relatives, small clauses, and untensed sentential complements that do not involve CP are much better preserved in several languages such as Hebrew, English, and French.

In addition,  $C^0$  is required for the construction of questions. *Auxiliaries* such as *do* and *was* in yes/no questions in English reside in  $C^0$ , and therefore a  $C^0$  impairment is predicted to affect these constructions too. *Spec-CP* hosts Wh words such as *who* and *what* after they have completed an A-bar movement from their base-generated position inside the VP (such overt movement of the Wh element to spec-CP is required in English, Hebrew, Palestinian Arabic, and many other languages). Thus, an impaired spec-CP should impair the production of Wh questions in languages in which movement of the Wh morphemes to spec-CP is obligatory.

Therefore, speakers who have a CP deficit are predicted to fail in producing questions that involve  $C^0$  or spec-CP and to succeed in questions that do not require them. This entails dissociations both within and between languages.

#### *A Dissociation between Wh and Yes/No Questions in Hebrew and Arabic*

In Hebrew and Arabic, Wh questions and yes/no questions differ with respect to the use of CP. A *Wh question* such as (1) is formed from (2) by means of movement of the Wh morpheme to the beginning of the sentence (to spec-CP), which leaves a trace in the base position of the Wh morpheme.

- (1)  $Ma_i$  Miri mecayeret  $t_i$ ?  
*what Miri paints?*  
 What does Miri paint?
- (2) Miri mecayeret ma?  
*Miri paints what?*
- (3) Miri mecayeret portret?  
*Miri draws portrait?*

On the other hand, *yes/no questions* in Hebrew and Arabic usually differ from declarative sentences in intonation only, and they do not trigger movement to CP (at least in overt syntax) (3).<sup>4</sup> If agrammatic aphasia involves a deficit in the CP node, then a dissociation is expected: Wh questions, which in Hebrew and Arabic require the CP, are predicted to be impaired, but yes/no questions, which can be produced independently of the CP, are predicted to be intact.

<sup>3</sup> In Germanic languages,  $C^0$  has an additional role: It is the final landing site of verbs moving from V to I to C in order to fill the verb-second position. In verb-second languages such as German, Dutch, and Scandinavian languages, the verb is in  $C^0$  and spec-CP hosts the sentence initial element. The lack of  $C^0$  is probably the reason why agrammatic patients use nonfinite forms that do not raise to  $C^0$  in Germanic languages. See Friedmann (2000) for a detailed discussion of the V2 phenomenon and its relevance to the study of agrammatic production.

<sup>4</sup> There is also a yes/no question marker *ha'im*, which is mainly used in written Hebrew, is rarely used in spoken Hebrew, and was not used by the control subjects.

*A Cross-Linguistic Variation with Respect to Yes/No Questions*

A deficit in CP node opens a door to cross-linguistic variability as well. In languages such as Hebrew, in which yes/no questions are formed without the CP node, agrammatic patients should produce well-formed yes/no questions. However, in languages in which yes/no questions also require elements in CP, yes/no questions should be impaired. The TPH predicts, therefore, a difference between English, on the one hand, and Hebrew and Arabic, on the other. Compare the way the same yes/no questions are expressed in Hebrew (4,6) and in English (5,7):

- (4) ‘at ohevet xumus?  
*you like hummus?*  
 (5) Do you like hummus?  
 (6) ha-yare’ax haya male etmol?  
*the-moon was full yesterday?*  
 (7) Was the moon full yesterday?

Whereas in Hebrew no constituent moves to the beginning of the yes/no question (to CP), in English such a movement is obligatory, either in the form of ‘do support’ (5) or as subject/auxiliary inversion (7). A CP node impairment thus entails an impairment in the production of yes/no questions in English but not in Hebrew and Arabic. This, in turn, predicts that in English, for example, there will be no dissociation between yes/no and Wh questions because they both require CP, and therefore both are expected to be impaired. (An English Wh question such as (8) is derived from (9) by movement of the Wh morpheme to the beginning of the sentence, to spec-CP, and by movement of the auxiliary to C<sup>0</sup>, and (10) is derived from (11) by movement of the auxiliary to C<sup>0</sup>.)

- (8) When<sub>i</sub> was<sub>j</sub> the moon t<sub>j</sub> full t<sub>i</sub> ?  
 (9) The moon was full when  
 (10) Was<sub>j</sub> the moon t<sub>j</sub> full yesterday?  
 (11) The moon was full yesterday
- 

It is the goal of this study to assess these predictions of the TPH regarding dissociations within and between languages and to compare them to the predictions of other accounts for the question production deficit in agrammatism.

Potential explanations of the question production deficit can be derived from three general accounts of the agrammatic deficit in production. One type of explanation is a *lexical-based deficit*, which has two major variants: one ascribing the deficit to the stress pattern of certain morphemes (Goodglass, 1968, 1976; Kean, 1977) the other attributing it to a problem in accessing items (e.g., Wh morphemes) in a ‘closed class lexicon’ (Bradley, Garrett, & Zurif, 1980). A more recent lexicalist approach for the grammatical deficit in aphasia can be found in Bates and Goodman (1997). Goodglass (1968, 1976), for example, proposed that the deficit in question formation is due to inactivation of unstressed sentence openers. Since matrix questions start with unstressed openers, they cannot be correctly produced. This account predicts that a Wh morpheme that is not a sentence opener will be produced better than a Wh morpheme at the beginning of a question. Thus, embedded questions, for example, are predicted to be produced better than matrix questions. Furthermore, Goodglass’ account, as well as the ‘closed class lexicon’ deficit account, have a clear prediction about the type of errors patients will make when trying to produce a question. They might try to utter the question without the opening unstressed syllable, but they will not produce the Wh morpheme and then stop. Hence, both variants of the lexical account predict omissions and substitutions of Wh morphemes (and of auxiliaries in

yes/no questions in English) without a structural deficit. Another view concerning agrammatic speech production is that the deficit involves a general *loss of syntax* and that agrammatic aphasics rely on nonlinguistic strategies to concatenate words into simple canonical sentences (cf. Berndt & Caramazza, 1980; Caplan, 1985; Goodglass, 1976; Goodglass & Berko, 1960; Saffran, Schwarz, & Marin, 1980). Other theorists maintain that all *functional elements are impaired* in agrammatic speech production (Grodzinsky, 1984; Ouhalla, 1993). Within these frameworks, the deficit in question production is part of the general syntactic deficit in agrammatism. These accounts suggest that all types of questions—and virtually all types of embeddings and inflections—are impaired in agrammatism.

A more selective syntactic explanation is a *movement* deficit, which claims that agrammatic individuals are impaired in producing structures that are derived by movement. This account has proved to be effective in explaining the performance pattern in agrammatic *comprehension* (Grodzinsky, 1990, 1995a, 2000a). It would, of course, be desirable to have one theory to account for both input and output phenomena. Such an approach for Wh question (as well as for relative-clause) production deficits was suggested by Thompson and Shapiro (1995). Under such an account, the question production deficit is explained as follows. Wh questions require movement of a noun phrase, and since such movement is problematic for agrammatic aphasics, they cannot produce these questions. If we take a restrictive version that is similar to the movement account for comprehension (Grodzinsky, 1995a) according to which movement of NPs is impaired and head movement is intact, this account predicts a dissociation between questions that involve movement of noun phrases, such as object Wh questions, and questions that do not involve such movement but possibly involve head movement, such as yes/no questions in English. It predicts that the former will be impaired, whereas the latter will be intact. In addition, since according to this account production and comprehension share the same underlying deficit, it predicts similar patterns of loss and sparing in production and comprehension. Another version of the movement deficit in production that was suggested by Bastiaanse (2001) claims that movement to noncanonical positions is impaired in production. This has the implication that subject Wh questions would be produced better than object questions.

This study empirically examined the main predictions that serve as critical test cases for the TPH and the above accounts. Wh and yes/no questions in Hebrew, Arabic, and English were compared, as were matrix and embedded questions and subject and object questions. In addition, the types of errors patients make when trying to produce a question were analyzed.

In the next section, a study of question production in Hebrew and Palestinian Arabic is reported, presenting data from spontaneous speech analysis and performance on structured tests. The subsequent section focuses on question production in English, using a review of data from the literature to bear on the competing theories as well as data from a study of an English-speaking aphasic patient.

## QUESTION PRODUCTION IN HEBREW AND ARABIC

The agrammatic production of different types of questions was examined through structured tests and analysis of spontaneous speech. Since patients tend to avoid asking Wh questions, spontaneous speech can provide only a general idea about the scarcity of these structures in agrammatic output and about the number and types of errors made by patients when trying to produce them. To quantify this information and to determine exactly which question structures are impaired and which errors



occur when patients are asked to produce questions, structured tests were devised to assess the patients' performance in various types of question structures.

### *Participants*

A total of 15 aphasic patients participated in this part of the study: 13 native speakers of Hebrew and 2 native speakers of Palestinian Arabic. They all were nonfluent aphasics, diagnosed as Broca's aphasics with agrammatism by the neuropsychological batteries used in Israeli rehabilitation centers—the Hebrew versions of the Western Aphasia Battery (WAB) (Kertesz, 1982, Hebrew version by Soroker, 1997) and the Psycholinguistic Assessments of Language Processing in Aphasia (PALPA) (Kay, Lesser, & Coltheart, 1992, Hebrew version by Gil & Edelstein, 2001) and clinical workup. All subjects had a single lesion in the left cerebral hemisphere, and all but one were right-handed. They were stable patients in Israeli hospitals and rehabilitation centers. (See Table 1 for background information on each subject.) All patients had characteristic agrammatic speech: nonfluent and short with incomplete utterances, reduction of sentence structure, and tense inflection errors. Only patients who had at least two-word utterances were included in the study.

### *Neurologically Intact Participants*

To test the tests, or to make sure that they were doable and that all items yielded the required responses, the tests were administered to 15 neurologically intact participants. They were matched to the agrammatic participants in age and education level. Their performance on all tasks was near ceiling (with an overall score of 99.7%).

## Questions in Spontaneous Speech: Hebrew and Arabic

### *Method*

Spontaneous speech was obtained from free conversation between the experimenter and the patient during the experimental sessions, in a quiet room with only the patient, the experimenter, and the patient's speech therapist present. Spontaneous speech was tape-recorded and transcribed fully, including false starts, repetitions, and extraneous comments by the patient. Number of utterances was counted according to predication units, along the lines of Berman and Slobin (1994). Any unit containing a unified predication—whether in the form of a verb, an adjective, or a copular construction—was counted as a single utterance. An utterance with a modal or auxiliary verb and a following verb was counted as a single utterance. Consecutively repeating utterances were counted only once. Every question and Wh morpheme produced by the patient was scored as either grammatical or ungrammatical, and the type of error was noted. Questions counted as grammatical even when they included wrong inflection, preposition, determiner, and so on. Yes/no questions were identified both by raising intonation and by context. Formulaic questions (e.g., *ma'inyanim?* = What's up?, *maztomeret?* = What d'you mean?) were not included in the table since they most probably are not syntactically derived and therefore do not indicate any syntactic ability. For reliability purposes, in addition to the author, two speech therapists who were native speakers of the languages under study scored the questions separately. The few disagreements (less than 5%) were discussed until agreement was reached in order to improve accuracy.

TABLE 1  
Background Information on Subjects

Subject	Age	Gender	Education (years)	Hand	Months post-onset	Hemiplegia	Etiology CT-lesion site
Hebrew-speaking patients							
KA	44	F	10	R	24	Right hemiplegia	Left CVA, no CT available
RS	70	F	14	R	58	—	Low-density area in the left hemisphere, specifically in the left anterior inferior temporal lobe
AL	16	M	9	R	12	Right hemiplegia	Left temporo-parietal infarct without mass effect following trauma
RA	23	M	12	R	51	Right hemiplegia	Left temporo-parietal hematoma following left frontal contusion
AG	67	M	12	R	5	Right hemiparesis	Left fronto-parietal craniotomy following astrocytoma
AD	53	M	10	R	7	Right hemiplegia	Left CVA, hemorrhage in left basal nuclei with pressure on left lateral ventricle
ML	48	F	9	R	6	Right hemiparesis	Left CVA, fronto-temporo-parietal operculum with subcortical extension to the lentiform nucleus and caudate nucleus posterior limb of internal capsule
HY	31	F	12	R	22	Right hemiplegia	Left CVA, Left fronto-temporal ischemic infarct hypodensity in basal nuclei
RN	30	M	13	R	60	Right hemiplegia	Left CVA, left frontal hemorrhage following angiography with subsequent infarct in the area of the left middle cerebral artery
TA	42	F	12	R	8	Right hemiplegia	Left CVA, left parietal ischemic infarct following bypass operation
IE	34	F	12	R	3	Right hemiplegia	Left CVA, left hemorrhage (hematoma in the area of left lateral ventricle)
PK	40	M	12	R	12	Right hemiplegia	Left CVA, infarct in the left hemisphere
MA	60	M	14	R	9	Right hemiparesis	Left CVA, hemorrhage in basal nuclei with extension to the internal capsule
Arabic-speaking patients							
HH	23	M	12	R	12	Right hemiplegia	Parieto-temporal craniotomy following accident, hemorrhage in left basal nuclei
SSH	33	F	12	L	6	Right hemiparesis	Left CVA, left hemisphere lesion following aortic valve replacement



## Results

The analysis of spontaneous speech of 13 participants who had enough spontaneous speech to allow for quantitative analysis is given in Table 2. The results showed a clear deficit in Wh question production, demonstrated both in the small number of well-formed Wh questions produced and in the large number of errors patients made when trying to form a Wh question. By contrast, patients were able to produce yes/no questions correctly and sometimes produced yes/no or disjunctive questions instead of Wh questions. The difference in the rate of grammatical-to-ungrammatical questions between Wh and yes/no questions was highly significant using the Mantel–Haenszel test for collection of  $2 \times 2$  tables,  $\chi^2 = 111.13$ ,  $p < .0001$ . The difference was significant for each of the 6 subjects that had more than one item per cell using  $\chi^2$ ,  $p < .05$ .

The grammatical Wh questions that were produced were seven untensed questions of the form Wh NP (“Where Yossi?”), two untensed questions of the form Wh infinitive (“How to-put belts”), two adjunct Wh exclamations (“How she knows to-treat the-baby!”), and two other adjunct questions (“Why sweat?”).

### Question Production Tests in Hebrew and Arabic

Spontaneous speech analysis thus suggests a deficit in Wh question production. Furthermore, it indicates that yes/no questions are less susceptible to the deficit than are Wh questions in Hebrew and Arabic, as predicted by the TPH. To be able to more accurately determine the target question from the sentence produced, and to compare different question structures, constrained tests in which it is possible to control for more aspects of the target questions are required. To this end, two types of tasks were administered: constrained question elicitation and question repetition. A total of 11 patients participated in the elicitation task and 10 in the repetition task. The elicitation task was administered in Hebrew and Arabic, and the repetition task was administered in Hebrew only.

TABLE 2  
Questions in Spontaneous Speech: Number and Grammaticality  
Rate of Wh and Yes/No Questions

Patient	Number of utterances	Grammatical/Total Wh questions	Grammatical/Total yes/no questions
Hebrew-speaking patients			
KA	172	0/4	0/0
RS	440	3/6	11/11
AL	320	2/21	40/42
RA	216	0/14	7/7
AG	38	0/1	1/1
AD	117	1/8	2/2
ML	56	0/1	0/0
RN	322	1/27	14/15
TA	249	3/11	2/2
IE	103	2/2	1/1
PK	18	0/0	0/0
MA	112	0/0	2/2
Arabic-speaking patient			
SSH	109	1/5	1/1
Total	2272	13/100	81/84

*Wh and Yes/No Question Elicitation*

To elicit Wh questions, sentences were presented to the patients in which one of the details (phrases) was replaced by a nonspecific term (someone, something, someplace). The task was introduced using a context for asking questions: ‘‘Imagine that your son comes home from school and tells you about his day. The problem is that he omits important details, and you ask him questions to find out about the missing details. For example, he tells you someone pushed him in school, and you want to know about this kid, so you ask, ‘Who pushed you?’’’ The patient was instructed to ask the experimenter about the missing detail. This method was used both for Wh question elicitation (12) and for yes/no question elicitation (13). The sentences were read aloud by the experimenter and concurrently presented in large print (18-point font). The nonspecific phrase was boldfaced. Two practice items preceded each session, and training proceeded until the patient understood the task.

## (12) Wh question elicitation

Experimenter:

dani axal mařehu. at roca lish’ol legabei ha-mařehu ha-ze, az at řo’elet . . .

*Dani ate something. you want to-ask about the-something the-this, so you ask . . .*

‘‘Dani ate something. You want to ask about this thing, so you ask . . .’’

Target question:

ma dani axal?

*what Dani ate*

‘‘What did Dani eat?’’

## (13) Yes/no question elicitation

Experimenter:

dani lo ba-bayit. at roca lada’at im hu halax le-seret, az at řo’elet . . .

*Dani NEG at-the-home. you want to-know if he went to-movie, so you ask . . .*

‘‘Dani isn’t at home. You want to know if he went to the movies, so you ask . . .’’

Target question:

dani halax le-seret?

*Dani went to-movie*

‘‘Did Dani go to the movies?’’

The task consisted of 48 items, organized in four blocks of 12 items. Two blocks of Wh questions and two blocks of yes/no questions were presented in alternating order, starting with a Wh block. The Wh blocks were repeated after 2 months for 4 of the subjects.

Since *adjunct and argument questions* differ in some syntactically significant respects such as constraints on movement and their base-generated position (see e.g., Rizzi, 1990), and since previous studies of question production in agrammatism have shown dissociations in the treatment of argument and adjunct question production (Thompson et al., 1996), we compared these two question types. In addition, because according to some linguistic analyses matrix subject questions, unlike object questions, do not involve movement (for claims against vacuous movement, see Chomsky, 1973, 1986; for arguments in favor, see Clements, McCloskey, Maling, & Zaenen, 1983), and because some accounts predict a dissociation between the two as only object questions include movement to the noncanonical position (Bastiaanse, 2001), *subject and object questions* were also compared.

Target Wh questions consisted of 12 argument questions (subject and direct object) and 12 adjunct questions, randomly ordered. Argument questions were 4 subject, 4

animate object (who), and 4 inanimate object (what) questions. Adjunct questions were 4 where, 4 when, and 4 why questions.

### *Question Repetition*

The second task that was used to elicit interrogatives was a sentence repetition task that included matrix and embedded questions. This comparison was included to provide an empirical examination of Goodglass' (1968, 1976) lexically based account of agrammatism. Since Goodglass suggested that the deficit in question production is due to an inactivation of unstressed sentence openers, his account predicts that a Wh morpheme that is not a sentence opener will be produced better than a Wh morpheme at the beginning of a question, and thus it predicts that embedded questions will be produced better than matrix questions.

Target questions were read aloud by the experimenter at normal reading speed. Patients were asked to repeat the questions as accurately as possible. Patients who did not make any errors on the first 10 items were asked to count to three before repeating the sentence (delayed repetition). When the patients requested, the target sentence was repeated. When several attempts were made, the last repetition attempt was counted.

### *General Methodological Issues*

Since we were interested only in errors that stemmed from the underlying grammatical deficit, no time limit was imposed during testing, and subjects were encouraged to take as much time as they needed for each item, to correct themselves until they reached the best response they could (without feedback from the experimenter) and to ask for as many repetitions as they needed. They were also instructed to ask for a break, or to terminate the session altogether, whenever they felt tired. This led to a large number of sessions per subject and also to a different number of total items in every test administered to some of the patients. When a patient refused to continue on a certain test, this specific test was terminated at that point. Most of the sessions were on a weekly basis. Between tests, breaks of 5 to 10 minutes were given, which were usually used for free conversation (taped and later used for spontaneous speech analysis). The order of tests was randomly varied among subjects.

### *Results of Wh Question Production Tests*

The two main findings of the question production tests in Hebrew and Arabic are as follows:

1. A clear deficit in *Wh question* production, which was particularly evident in the elicitation task
2. A relatively preserved ability in *yes/no* question production

The elicitation results, summarized in Table 3, show a deficit in Wh question production. A clear difference was found between Wh questions and yes/no questions, and this pattern was similar across individual patients. All patients found Wh questions extremely hard to produce, whereas their production of yes/no questions was much better preserved. The group general tendency for better production of yes/no questions was significant using the Mantel–Haenszel test for collection of  $2 \times 2$  tables,  $\chi^2 = 171.5$ ,  $p < .0001$ . This difference was significant for each individual subject using  $\chi^2$ ,  $p < .005$  (for all subjects who were tested on both Wh and yes/no questions).

TABLE 3  
Elicitation of Wh and Yes/No Questions

	Wh questions	Yes/No questions
	Percentage correct (number correct/total)	Percentage correct (number correct/total)
Hebrew		
AL*	8 (2/24)	88 (21/24)
RA*	15 (7/48)	100 (9/9)
ML*	44 (21/48)	100 (24/24)
HY*	13 (6/48)	88 (21/24)
RN*	27 (13/48)	67 (12/18)
IE*	29 (7/24)	100 (24/24)
PK*	14 (3/21)	92 (22/24)
Arabic		
HH*	21 (5/24)	65 (15/23) <sup>a</sup>
Mean	22 (64/285)	87 (148/170)
Hebrew <sup>b</sup>		
RS	0 (0/20)	
AG	0 (0/6)	
TA	45 (5/11)	
Mean	13 (5/37)	

<sup>a</sup> All of HH's errors on the yes/no production block were that he tried (and failed) to produce Wh questions instead of the required yes/no question, probably because the yes/no block followed the Wh block and no pause to train the new block was made. Once HH started to produce yes/no questions on this block, he made no further errors.

<sup>b</sup> The performance of these patients was tested only in Wh questions (subject and object questions only) because they were tested early in the course of the investigation. When I started comparing Wh and yes/no questions, they were unfortunately no longer available for testing.

\* $p < .005$ .

As can be seen in Table 4, although in the elicitation task all question types tested were severely impaired, the production of adjunct questions was better than that of subject and object questions, both in Hebrew and in Arabic,  $\chi^2 = 8.51$ ,  $p < .005$ ; the production of adjunct questions was significantly better than that of complement object questions,  $\chi^2 = 8.02$ ,  $p < .005$ . (A priori alpha level of .05 was used for all contrasts. Bonferroni correction was applied for the multiple preplanned comparisons in Table 4.) This tendency toward better production of adjunct questions was also observed in the errors; patients substituted adjunct questions for subject and object questions. No significant difference was found between the different adjunct questions ( $p > .05$ ).

No significant difference was found between subject questions and object questions,  $\chi^2 = 0.94$ ,  $p > .10$ . The deficit in subject questions and the lack of asymmetry between subject questions and object questions are consistent with linguistic analyses

TABLE 4  
Different Question Types in Question Elicitation  
(percentages correct (numbers correct/total))

Subject	Object	Adjunct
19 (10/52)	13 (15/112)	28 (44/158)

TABLE 5  
 Repetition: Matrix and Embedded Wh Questions

Patient	Matrix Wh questions	Embedded Wh questions
	Percentage correct (number correct/total)	Percentage correct (number correct/total)
KA	8 (3/40)	—
RS	31 (4/13)	10 (1/10)
AL	73 (11/15)	13 (2/15)
RA	95 (20/21)	0 (0/10)
AD	—	40 (2/5)
ML <sup>a</sup>	80 (12/15)	53 (8/15)
TA	92 (23/25)	33 (9/27)
IE	81 (22/27)	56 (19/34)
PK <sup>a</sup>	100 (15/15)	80 (12/15)
MA <sup>a</sup>	100 (10/10)	100 (15/15)
Mean	66 (120/181)	47 (68/146)

<sup>a</sup> Delayed repetition.

according to which Wh elements in subject questions also undergo movement, although their movement is not phonetically discernible.<sup>5</sup>

In the repetition task, summarized in Table 5, both matrix and embedded questions were impaired, with embedded questions being more impaired than matrix questions. (Using the Mantel–Haenszel test for the collection of  $2 \times 2$  tables, the difference between matrix questions and embedded questions for the group was significant,  $\chi^2 = 12.86$ ,  $p < .0005$ . The difference was significant only for 4 individual subjects.)

The elicitation and repetition tasks differed with respect to the degree of performance. For all of the patients, repetition was better than elicitation. Some of the patients who failed completely on question elicitation succeeded in repeating most of the questions (this was true mainly for matrix Wh questions, which were very short—three or four words). This discrepancy indicates that repetition was an easier task and that, in some cases, correct repetition does not indicate a preserved production ability, as can be seen by comparing the performance of the same patient in the elicitation task and in spontaneous speech.

The control subjects were 99% correct on the Wh elicitation task (one subject was 92% and the rest were 100% correct) and were 100% correct on the yes/no elicitation. On the question repetition task, all control subjects were 100% correct.

#### *Error Types in Wh Question Production*

When trying to produce Wh questions, agrammatic speakers produce various types of errors. Exploring these errors is theoretically interesting, as they contribute to our understanding of the agrammatic deficit in question production. Next, the distribution of errors in spontaneous speech and in the structured tests is presented and briefly discussed.

In *spontaneous speech*, only very few well-formed questions were produced, but many attempts to produce such questions were detected. The unsuccessful Wh question attempts were of the following types:

<sup>5</sup> Similar lack of preference for subject questions was found in language acquisition. Stromswold (1995), for example, even found that in the course of language acquisition, subject questions were acquired after object questions.

1. Incomplete questions with only a Wh morpheme and nothing else (41%)
2. Ill-formed Wh questions of the form ‘‘What NP’’ or ‘‘NP what’’ (17%) (14,15)
3. Sequences of Wh morphemes (17%) (16)
4. Other ungrammatical starts of Wh questions, usually in the form of a Wh morpheme followed by a clause with no gap (12%) (filled gap, 17)
5. False starts of Wh questions with a Wh morpheme, or with a Wh *in situ*, that became yes/no or disjunctive questions (7%) (18,19)
6. Wh *in situ*: correct Wh morpheme at its base-generated position (5%) (20)

Examples from spontaneous speech:

- (14) ma . . . ma wokmen?  
*what . . . what walkman?*
- (15) iša ve-yalda ma?  
*Woman and girl what?*
- (16) After completing an exceptionally tiresome test of embedded sentence repetition, RA said:  
na'ama, ma . . . lama? ma, lama?  
*Naama, what . . . why? what, why?*

Examples from the elicitation task:

- (17) ma dani hidlik et ha-'or?  
*what Dani lit ACC the-light*
- (18) (target ‘‘when’’ question)  
eifo rami daxaf et shlomit, ba-'erev o ulai ba-cohorayim?  
*where Rami pushed ACC Shlomit, in-the-night or maybe in-the-noon?*
- (19) (target ‘‘where’’ question)  
shalom xibek et ruti eifo? ba-mis'ada o ba-bayit o  
ba-te'atron?  
*Shalom hugged ACC Ruti where? in-the-restaurant or in-the-house or in-the-theater?*
- (20) shalom xibek et ruti matai?  
*Shalom hugged ACC Ruti when?*
- (21) eifo uri gile'ax eifo?  
*Where Uri shaved where?*

In the *structured question production tests*, errors were generally similar to those found in spontaneous speech. There was, however, a difference in the distribution of error types, which can be attributed to the different nature of the tests and to the fact that test constraints required the patients to try to produce question types they usually avoided in spontaneous speech. In addition, several error types, such as Wh morpheme substitutions and omissions, that could not be reliably detected in spontaneous speech were found. This demonstrates again the advantage that structured tests have over spontaneous speech analysis. Error types in the elicitation and repetition tasks were the following:

1. Producing a yes/no question instead of a Wh question, sometimes after a false start with a Wh morpheme (27% of the errors in elicitation)
2. Wh morpheme omission (37% in repetition, some of them in the form of change into yes/no questions)
3. Wrong Wh morpheme selection, mostly substitution of an adjunct question for a subject or object question (22% in elicitation, 13% in repetition, and additional 9% in repetition of Wh replaced by the complementizer *that*)
4. ‘‘Don't know’’ responses (17% in elicitation, 16% in repetition)



5. Production of miscellaneous ungrammatical questions (9% in elicitation, 11% in repetition)
6. Wh *in situ* (8% in elicitation, 1% in repetition)
7. Filled gap: Wh morpheme in the beginning of the sentence and a filled gap (5% in elicitation, 2% in repetition)
8. Doubling: Wh morpheme in the beginning of the sentence and a Wh morpheme *in situ* (5% in elicitation) (21)
9. Production of only a Wh word without the rest of the question (6% in elicitation, 10% in repetition).

These error types offer some interesting insights regarding the underlying deficit in agrammatic production; a survey of these follows.

*Use of adjunct questions for argument questions.* The patients had a tendency to erroneously produce adjunct Wh questions instead of argument questions and had a slightly better performance for adjunct questions in the elicitation task than for argument questions (although both argument and adjunct questions were severely impaired). A possible explanation for the preference for adjunct questions might be that both question types are impaired, but while it is possible to adopt a nonsyntactic strategy for constructing an adjunct question, it is much harder to do so in argument questions. In Hebrew and Arabic, adjunct questions only add a Wh morpheme to the beginning of the declarative sentence (“Why Goldilocks ate the porridge?”), whereas subject and object questions require deletion of either the subject or the object from the declarative sentence and creation of a dependency between the gap and the Wh morpheme (“What Goldilocks ate \_?”). Thus, patients who succeeded in producing adjunct questions may have just added the Wh morpheme to the beginning of the sentence rather than project the whole tree and move the Wh morpheme to spec-CP. In the case of adjuncts, adding a Wh element (e.g., *why*) to the beginning of the sentence results in a well-formed question; in the case of argument Wh elements such as *who* and *what*, however, adding the Wh- morpheme to the beginning of a declarative sentence results in a “filled gap” error.

*Filled gap.* In the “filled gap” errors produced by the patients, a Wh morpheme was produced as required at the beginning of the sentence, but the trace position was filled by another noun phrase (17). A similar error was reported by Thompson et al. (1996) (“co-referencing error,” in their terms). Co-referencing error accounted for 42% to 98% of the errors in the baseline stage of their 7 subjects (22).

- (22) Who is the soldier pushing the woman? (Thompson et al., 1996. p. 199)

Since the alleged base-generated position of the Wh word is filled, this might indicate that the Wh element is located at the beginning of the sentence not as a result of a movement but rather as an element “glued” to the beginning of the sentence (as some type of quantifier over the whole sentence without a bound variable or a trace).

*Wh in situ.* Another error type that points in a similar direction, is the “Wh in situ” error, in which the Wh morpheme was produced in its base-generated position within the VP. In most cases, it appeared only in the base-generated position; in other cases, it appeared both in the beginning of the question and in the base-generated position (“doubling error”). Such an error again indicates that the problem is structural rather than lexical and that the structural problem involves the movement of the Wh morpheme to the beginning of the sentence.

*Yes/No questions instead of Wh-questions.* The comparison between yes/no questions and Wh questions in both elicitation tasks and spontaneous speech has shown a clear dissociation between the two. Wh questions were impaired, but yes/

no questions were relatively intact. A similar tendency is revealed in errors in the Wh question elicitation tasks, where patients preferred to produce a yes/no counterpart of the required Wh question. Examples from two patients are given in (23) and (24).

(23) Experimenter: Danny bought something, and you want to know about the thing he bought, so you ask . . .

RA: dani kana. . . sograyim. az ma: riba? hu kana xalav?

*Dani bought . . . parentheses. So what: Jam? He bought milk?*

(24) Experimenter: The sun rose today at a certain time. You want to know about the time. So you ask . . .

ML: be-šeš . . . ha-šeš zarxa . . . ha-šemeš hayom . . . lo yoda'at. ha-šemeš zarxa hayom?

*at-six. . . the-sun rose. . . the-sun today . . . (I) don't know. The-sun rose today?*

This type of error provides further illustration for the superiority of yes/no questions over Wh questions in Hebrew and Arabic, which was also demonstrated by the difference in performance in question elicitation and spontaneous speech. As suggested in the Introduction, a possible explanation for the dissociation in Hebrew and Arabic between Wh questions and yes/no questions is that they differ structurally in their use of the high syntactic nodes. While in Wh questions the Wh morphemes move to the beginning of the sentence (to the specifier of CP), in yes/no questions in Hebrew and Arabic such a movement is not required. If this is indeed the reason for the dissociation, then production patterns should look completely different in a language such as English, in which yes/no questions also require movement to the beginning of the sentence (movement of the auxiliary). In such a language, no dissociation between Wh questions and yes/no questions is expected. The next step, therefore, was to examine data in the literature concerning question production in English and to compare the production of Wh questions and yes/no questions in English.

## QUESTION PRODUCTION IN ENGLISH

### Previous Reports of Question Production

Very few studies have been concerned with assessing the ability of agrammatic individuals to form questions, and with the difference between Wh and yes/no questions. The data presented below are taken from studies aimed at treating question production deficit in English, a study that included a yes/no question elicitation test, and from the description of questions in spontaneous speech in two other studies.

#### *Wh Questions in Treatment Studies*

Thompson and Shapiro and their colleagues (Thompson & McRenolds, 1986; Thompson & Shapiro, 1994, 1995; Thompson et al., 1993, 1996; Wambaugh & Thompson, 1989) have studied Wh question production from a treatment perspective. They examined the effect of syntactic-based treatment on Wh question production in agrammatic patients. To measure the efficiency of their treatment, Thompson and Shapiro compared Wh question production before treatment (baseline) to question production during and following treatment using constrained production tasks. For the purpose of the current study, the baseline state contains the critical data. An analysis of baseline performance of 17 participants in four studies (extracted from the charts in the articles) showed a severe deficit in Wh question production in constrained tasks. The 4 agrammatic patients in Thompson and McReynolds (1986) were

tested in a task of question production with pictures and produced 0% to 8% correct Wh questions, compared to 82% to 100% produced by normal controls. The 4 agrammatic patients in Wambaugh and Thompson (1989), the 2 subjects described in Thompson et al. (1993), and the 7 agrammatic patients in Thompson et al. (1996) were tested using a story completion task and produced 0% to 24% correct Wh questions with an average of 4%, compared to 94% in the normal controls.

Wambaugh and Thompson (1989) found a considerable impairment in question production in an analysis of the narrative too. In conversation, the patients produced 0 to 0.14 questions per interview, compared to 1.80 for the normal control subjects, and produced 0 to 0.33 in prompted interviews, compared to 4.25 for the control subjects.

### *Yes/No Questions*

Several studies indicate that yes/no questions are impaired in English-speaking agrammatics. Goodglass, Gleason, Bernholtz, and Hyde (1972) tested the production of various sentence structures in English, among them yes/no questions.<sup>6</sup> Their patient made errors on all of his yes/no question trials (0/14 correct). Gleason, Goodglass, Green, Ackerman, and Hyde (1975) noted that their 4 severe patients omitted 20/40 of the opening auxiliaries in yes/no questions and that the mild patients omitted only 4/40 (but no data were given as to the grammaticality of the questions that did not include omission). Thompson et al. (1993) observed that the English-speaking agrammatic aphasic patients they examined produced mainly questions that did not include movement of any kind prior to treatment, neither Wh movement nor subject/auxiliary inversion. Their patients used only rising intonation to express a question. These English-speaking patients were also impaired in yes/no questions and produced them without the initial *do* (e.g., “You like guava?”). The same tendency was also reported by Myerson and Goodglass (1972). Although they did not refer specifically to yes/no questions, they remarked that their 3 English-speaking agrammatics used only intonation to indicate a question in their spontaneous speech.

To conclude, the data on question production in English-speaking agrammatics indicate that in English, unlike in Hebrew and Arabic, both Wh questions and yes/no questions are impaired, and subject–auxiliary inversion is particularly difficult.

### Elicitation Test: Wh versus Yes/No Questions in English

To directly compare the production of Wh and yes/no questions in English, an English-speaking agrammatic aphasic, KCL, was tested using an English version of the elicitation test described in an earlier section. KCL suffered a left hemisphere stroke 13 years before testing. His CT scan showed a large low-density area in the fronto-parietal cortex and in the basal ganglia region and deep white matter. He was diagnosed as a Broca’s aphasic on the basis of clinical consensus, the Boston Diagnostic Aphasia Examination (BDAE) (Goodglass & Kaplan, 1983), and the WAB (Kertesz, 1982).

As in Hebrew and Arabic, the test consisted of 48 items: 24 items for matrix Wh question elicitation and 24 items for yes/no question elicitation (presented in four alternating blocks of 12 items each, starting with a Wh block).

<sup>6</sup> Goodglass et al. (1972) also tested Wh questions and reported that they were one of the best preserved structures (5/15 “conventional” questions). However, since Wh questions were scored as correct even when they were ungrammatical (“where put shoes” was counted as containing all elements required for a positive score), and since the elicitation cues ended with the required opening Wh word, this part of their results will unfortunately have to be ignored.

The results showed that *unlike* in Hebrew and Arabic, both yes/no and Wh questions were impaired. KCL performed poorly on both subtests, yielding 0/24 correct in Wh questions and 0/24 correct in the yes/no questions subtest. The patient showed a marked tendency to produce (ungrammatical) yes/no questions both in the yes/no subtest and in the Wh subtest instead of Wh questions. His yes/no questions did not begin with an auxiliary or a copula, and some of them included the auxiliary in a position after the noun, as they would appear in a declarative sentence. All of the attempted questions were accompanied by rising interrogative intonation. His responses were as follows: *WH target questions*—9 disjunctive yes/no questions (“Midnight or 2 o’clock?”), 7 single noun yes/no questions (using a possible answer: “Park?”), 3 single verbs (“Shout?”), 2 single Wh morphemes (“Why?”), 2 “don’t know” responses, and 1 ungrammatical yes/no question (questioning a possible answer to the target Wh question: “Six hours about sleep John?”); *yes/no target questions*—13 yes/no without auxiliaries first (“They went to the movies?”), 3 of them followed by “yes or no?”, 5 NP + “yes or no” (“School? Yes or no?”), 4 yes/no questions without auxiliary first and without a subject (“Water the plant?”), one of them followed by “yes or no?” (“Rain outside, yes or no?”), and 2 disjunctive yes/no questions (“Seven-Up or orange Mary?”).

Thus, this English-speaking subject’s results are in line with the data reported in the literature regarding questions in English; both Wh and yes/no questions were impaired in English.<sup>7</sup>

## DISCUSSION

The basic finding of these studies is that question production is impaired in agrammatism, but the deficit is selective along the following lines:

1. Wh question production is severely impaired in Hebrew, Palestinian Arabic, and English.
2. In Hebrew and Palestinian Arabic, a dissociation was found between Wh and yes/no interrogatives. Yes/no questions are much better preserved than Wh questions.
3. In English, yes/no and Wh questions both are impaired.
4. Both matrix and embedded Wh questions are impaired.
5. Subject and object questions are equally impaired.
6. Errors in Wh questions include structural errors such as doubling and Wh *in situ*, false starts that include only the Wh morpheme, and substitution by yes/no questions.

This profile of results and dissociations is the one predicted by the Tree Pruning Hypothesis and therefore provides support for this theory of agrammatic production. Recall that the main claim of the TPH is that agrammatic aphasics cannot project their syntactic trees up to the highest nodes. As a result of tree pruning, syntactic structures that require the highest nodes of the tree are impaired (i.e., all elements that are base generated in TP and CP, those that move to these nodes, and the structures that depend on them). The pruning of the syntactic tree thus has direct consequences for dissociations in question production within and between languages. In any given language, questions that are formed without the CP (and the TP) node are well formed in agrammatic production; questions that require elements in CP, on the

<sup>7</sup> Importantly, it was not a general floor effect in production that was responsible for KCL’s poor performance in questions. In Small Clause repetition, for example, he was 71% correct (Friedmann & Taranto, 2000).

other hand, are impaired. In light of this, we can now examine how the results of the current study follow from tree pruning:

1. Wh questions in Hebrew, Palestinian Arabic, and English involve movement of the Wh element to spec-CP. Since spec-CP is unavailable for agrammatic individuals, Wh questions are unavailable for them.<sup>8</sup>
2. The dissociation between Wh questions and yes/no questions in Hebrew and Arabic follows from the different structure of these questions. Whereas Wh questions involve movement to spec-CP and therefore require an intact CP, yes/no questions in Hebrew and Arabic can be produced independently of the CP. For this reason, Wh questions are impaired, and yes/no questions are preserved and even used instead of Wh questions, both in spontaneous speech and in structured tasks. The finding that yes/no questions are intact in some languages indicates that the agrammatic aphasics do not suffer a general deficit in asking questions and that the deficit is not a pragmatic deficit in the speech act of Questions (contrary to the claim of Zaidel et al., 2000). Syntactically it also means that the interrogative force is available to agrammatic patients, although their CP is impaired. This is problematic for theories that claim that force (and specifically interrogative force) resides in C (e.g., Rizzi, 1997).<sup>9</sup>
3. Yes/no questions in English, on the other hand, require a functioning C<sup>0</sup> as the position of *do* in ‘do support’ constructions or of the auxiliary in subject–auxiliary inversion sentences. Thus, in English, both Wh and yes/no questions involve the CP, and therefore no dissociation is present and both question types are impaired.
4. The finding that both matrix and embedded Wh questions are impaired follows from the fact that they both require a CP, and therefore they both are affected by CP impairment.
5. Subject and object questions are impaired to the same degree because both involve movement to CP. Given the tendency of the patients to produce Wh morphemes *in situ*, it is possible that the small and insignificant difference between subject questions and object questions is actually due to the Wh *in situ* error, as some of the questions that were coded as correct subject questions could have actually been subject questions with the Wh element *in situ*, which are indiscernible from the correct form.
6. Patients who do not have access to the high nodes in the syntactic tree but do have intact lexical knowledge are expected to produce some of the necessary lexical items but not to be able to incorporate them into a well-formed question structure if this structure requires high nodes. This is exactly what the patients in this study did. In many cases, they produced questions that included the Wh morpheme but contained structural errors of different types. In some cases, they produced only the Wh word without the rest of the question. In other cases,

<sup>8</sup> A different performance is expected for questions such as ‘‘Why go to work everyday?,’’ in which some analyses hold the Wh morpheme to be VP adjoined. Structures in which the Wh element is attached to a low phrasal node are expected to be preserved, and we are currently running an experiment to assess this prediction. In addition, Egyptian Arabic (and French) can make for an interesting test case, as it allows for Wh elements to stay *in situ* (*‘auez eh, ya aam?* = need what, sir?).

<sup>9</sup> Still, a question remains unanswered here. Under standard analyses, uninverted yes/no questions also involve a null Q operator in the CP layer. How can we reconcile this with the good production of yes/no questions by individuals who have no CP? Several types of answers are possible. For example, it might be that agrammatics do not represent the null operator, but this is not discernible since the operator is phonetically null. It might be that in these languages at least, the Q operator of yes/no questions is located lower than the CP. Another possibility is that agrammatics adjoin or merge the Q operator to what is left of their tree.

they did not move the Wh morpheme to the beginning of the sentence and instead left it in a lower position (a Wh *in situ* error), or they “glued” a Wh morpheme to the beginning of a declarative sentence, producing a doubling or filled gap error. These errors point to an inaccessibility of spec-CP and, at the same time, to the accessibility of the lexical Wh items. This cannot be explained within strong lexicalist theories such as Bates and Goodman’s (1997), which claim for a common factor for grammatical and word-finding problems and for closed class items being the “weak link in the processing chain” (p. 21).

Note that it is not clear why agrammatic patients do not use *in situ* structures more often (in elicitation, they produced 13% Wh morphemes *in situ*). By analogy to verb movement to high nodes, we would expect the Wh *in situ* to be a more frequent manifestation of the blocking of Wh movement to CP. When verbs cannot move to their position in C (in V2 languages such as Dutch and German), agrammatics leave verbs in their base-generated position, as infinitives. In Dutch, for example, Kolk and Heeschen (1992) observed this structure in 53% of the sentences (for discussions, see also Bastiaanse & van Zonneveld, 1998; and Friedmann, 2000). Why don’t they do the same with Wh morphemes they cannot move to CP? A possible reason for the difference in error behavior between moving verbs and moving Wh morphemes might lie in the difference in their licensing in low nodes. While Dutch and German verbs are licensed in their base-generated position as infinitives, Wh morphemes are not licensed in the low node in any form (except for echo questions, which require a very specific pragmatic context).

Thus, the pruning of the syntactic tree can account for the intricate pattern of dissociations found in agrammatic production of questions. Furthermore, in a broader view, tree pruning not only provides an account for the dissociations in question production it also covers a larger portion of the data and provides a unified account for the deficit in other domains such as the selective deficit in verb inflection and subordination, which have been regarded as unrelated until now. The selective deficits in production of verb inflections, subordination, and questions are all accounted for by one assumption: the inability of agrammatic speakers to project their syntactic trees up to the highest nodes (TP and CP). Since Wh questions, yes/no questions in English, tensed sentential embeddings, and tense inflections depend on high nodes in the syntactic tree, agrammatics cannot “climb” as high and therefore cannot construct them in a well-formed way; on the other hand, yes/no questions in Hebrew and Arabic, untensed embeddings such as reduced relatives and small clauses, and verb agreement inflection can be formed without the high nodes and are therefore intact (for a detailed discussion, see Friedmann, 2001).

What does “tree pruning” mean here? Is it a deficit in representation or in processing? Are the nodes nonexistent, difficult to project, or difficult to access? At this point, it is hard to say, as there are no empirical ways to determine between these possibilities. The finding that milder patients can use more nodes than can severe patients and the occasional success (above chance performance) of some patients on some tasks give the flavor of a processing deficit, but no definite answer can be given at this point. The TPH can be taken as a linguistic characterization of the representational deficit whenever it occurs; on the other hand, it can just as well be taken as a linguistically detailed characterization of a processing failure that impairs either the projection of high nodes or the access to them. The important point here is that the deficit, be it representational or processing based, is to be characterized with reference to the hierarchical structure of the syntactic tree. So if we take, for example, a theory such as the adaptation theory, (Hartsuiker & Kolk, 1998; Kolk & Van Grunsven, 1985), which is a processing-based account that bases the description



on processing limitation and syntactic simplification, then the claim here is that both limitation and simplification should be captured in terms of high and low in the tree: Limitation impairs projection or access to high nodes; a simple syntactic structure is a structure that involves only low nodes.

The pattern of results is thus consistent with the Tree Pruning Hypothesis. Is it also consistent with any of the alternative accounts that were presented earlier? In the following, I consider lexical deficit accounts, syntax loss accounts, and movement impairment accounts in light of the new results.

### *Alternative Accounts*

*A lexical deficit of unstressed or closed class items?* One group of theories ascribes the agrammatic impairment in production to a lexical deficit. This type of explanation has had several variants. Goodglass (1968, 1976), for example, suggested that the deficit in question production is due to inactivation of unstressed sentence openers. Other lexical accounts ascribe the agrammatic deficit to poor access to the closed class lexicon (Bradley et al., 1980) or omission of phonologically unstressed words and inflections (Kean, 1977).

The current results show that these lexical-based accounts are not adequate to account for the agrammatic deficit in question production. The agrammatics' failure in embedded question repetition rules out Goodglass' explanation because Wh questions are shown to be impaired even when the Wh morphemes are not sentence openers but rather located well inside the sentences. Furthermore, the pattern of production evinced in patients' attempts to produce Wh questions is not consistent with any lexical account. Such accounts predict closed class word omission but not a structural deficit. Yet when trying to produce a question, patients frequently produce the Wh morpheme (either the correct one or an incorrect one) but fail to come up with the rest of the question, and they make structural errors (e.g., doubling, Wh *in situ*). In addition, lexical accounts are unable to explain why some unstressed closed class words are spared and even overused (e.g., coordinators [Friedmann, 1998; Menn & Obler, 1990]), while other unstressed closed class words are impaired. Thus, the question production impairment cannot be explained by an inability either to access specific lexical items or to produce unstressed opening morphemes. It requires, rather, a structural-based account.

*A complete loss of syntax?* In agrammatism research, accounts that claim that agrammatic individuals do not have syntactic structure are abundant. Different versions of this claim were advocated by Goodglass and Geschwind (1976), Berndt and Caramazza (1980), Saffran et al. (1980), Caplan (1985), and Ouhalla (1993). For example, Berndt and Caramazza claimed that agrammatic individuals speak "without a planned syntactic frame to guide production" (p. 271). Saffran et al. claimed that they cannot map semantics to the syntactic order and that agrammatic speech is generated without underlying structures that represent logical relations (p. 278). Later, Caplan (1985) claimed that agrammatics do not have a syntactic hierarchy, only major lexical category information and linear ordering of lexical categories (p. 138). Another type of account that has suggested a broad syntactic deficit is the loss of all functional categories. For example, Ouhalla (1993) claimed that agrammatics do not have any functional category or any part of the syntactic tree above VP.

This latter variant has already proven to be too strong, as various syntactic abilities and functional categories have been shown to be intact in agrammatic production (De Bleser & Luzzatti, 1994; Friedmann, 1994, 1998, 2001; Friedmann & Grodzinsky, 1997; Lonzi & Luzzatti, 1993; Menn & Obler, 1990; Ruigendijk & Friedmann,

2002). However, even if we consider a less inclusive version of this account, according to which not all syntax but only all complex structures (including questions) are impaired in agrammatic production, the selectivity that is reflected in our data shows that any such account is still too strong. There are types of complex sentences that agrammatic speakers can produce, as can be seen from their spared ability to construct yes/no questions in Hebrew and Arabic. Moreover, other studies show that other complex structures, such as small clause embeddings, reduced relatives, and other special types of embedding, are also preserved (Friedmann, 1998, 1999).

Thus, a general syntactic basis for the deficit in interrogative production is untenable. The data call for a more selective syntactic account that would be able to draw the line between the spared syntactic structures and the impaired syntactic structures.

*A deficit of movement?* One possibility for a selective syntactic account ascribes the intricate pattern of syntactic impairment to a movement deficit, just like the deficit in comprehension. The current formulation of the movement account for agrammatic comprehension assumes a deficit restricted to movement of phrasal constituents (e.g., noun phrases) (Grodzinsky, 1995a, 1995b). An analogous movement account for production would predict that the production of structures that are derived by movement of noun phrases will be impaired, whereas verb movement structures will be intact. Such an account correctly predicts impairment in Wh questions, but it incorrectly predicts no impairment in head movement (e.g., the movement that is required for yes/no questions in English). The empirical evidence suggests that agrammatic production differs from comprehension, and some instances of head movement are impaired in production. For example, while the 4 English-speaking agrammatic patients of Linebarger, Schwartz, and Saffran (1983) were able to correctly judge violations of subject/auxiliary structures and “do support” with wrong verb inflection, data from production show that English-speaking patients are incapable of constructing such yes/no questions. Another instantiation of impaired head movement in production is the deficit in tense inflection and its implications for verb position, described in Friedmann (1998, 2000); agrammatics fail to move verbs to high inflectional nodes for tense inflection checking, a fact that cannot be explained under a theory of phrase movement deficit.<sup>10</sup> In addition, the use of nonfinite verbs in sentence-final position in V2 languages (Bastiaanse & van Zonneveld, 1998; Kolk & Heeschen, 1992) also shows that verb movement is impaired. Thus, an NP movement account that excludes a head movement deficit can account neither for the deficits in yes/no question production nor for findings regarding verb inflection and verb position.

Is it possible to explain the impairment pattern in production by assuming a nonrestrictive version of the movement deficit account, according to which all types of movement, and not only movement of phrases, are impaired? Apparently not. Although such an explanation will be able to account for both Wh and yes/no question deficits, as well as for verb inflection and verb position findings, in other syntactic areas it predicts impairment for structures that were shown to be intact and sparing for impaired structures. For example, a nonrestrictive movement deficit predicts a sweeping deficit for all types of verb movement and therefore for all types of inflections. This is unsupported empirically, as the data show that agreement inflection, for example, is unimpaired or is much less impaired than tense inflection (Benedet, Christiansen, & Goodglass, 1998; De Bleser & Luzzatti, 1994; Friedmann, 2000; Friedmann & Grodzinsky, 1997; Kolk, 2000). Such a general movement deficit ac-

<sup>10</sup> It is important to note here that the TPH also does *not* claim that head movement is impaired in agrammatic production; it does not even claim that XP movement is impaired. What the TPH suggests is that movement—every type of movement—is hampered whenever its target is a node in the high (“pruned”) part of the tree.

count is, moreover, not strong enough. In the realm of embedded sentences, for instance, it predicts that only embedded structures that involve movement (e.g., relative clauses) will be impaired, but the data show that other embedded structures that are not derived by movement, (e.g., clausal complements of verbs) are impaired (Thompson, Lange, Schneider, & Shapiro, 1997; Thompson, Shapiro, Li, & Schendel, 1994) to the same degree as relative clauses (Friedmann, 1998, 1999, 2001).

To account for the deficit in sentential complements of verbs, a movement account for production has to add more assumptions. Thompson et al. (1997), for example, suggested that the deficit in sentential complements lies in the complexity of the Predicate Argument Structure (PAS) of the verbs that require them. However, the usual PAS complexity definition, determined by the number of possible PAS frames (as in Shapiro, Zurif, & Grimshaw, 1987, 1989), does not account for the data, as this model would predict that verbs that have the same PAS complexity (same number of arguments and same number of possible PAS frames) should be equally accessible. However, the data show that verbs that take only obligatory sentential complements (e.g., ‘‘think’’) are more impaired than verbs that take only an obligatory theme argument (e.g., ‘‘hug’’). Therefore, their notion of complexity must include an additional assumption that CP complements make the PAS of a verb more complex. And then the question is what makes CP complements more complex (note also that this model would still fail to address the deficit in adjunct sentential embedding). A movement account would thus have to assume, in addition to the inability to move NPs, a deficit in PAS and a special deficit with CP complements to account for the deficit in sentential complements. The TPH, on the other hand, suggests a different type of complexity definition, which takes into account phrase structure and the involvement of CP and thus explains the deficit in relative clauses, sentential complements of verbs, and sentential adjuncts within the same assumption.

A recent version of movement account to production was suggested by Bastiaanse (2001). According to this version, only movement to noncanonical position is impaired. However, this version too is not supported by the current results because it predicts, for example, a dissociation between subject questions and object questions, contrary to the findings of impaired production of both subject and object Wh questions. In addition, it predicts good production of subject relatives, which are impaired in production (Friedmann, 1999, 2001), and it cannot account for the deficit found in sentential complements that include no movement. (It also has to assume an additional deficit in verb movement to account for findings regarding verb inflection and position.)

To conclude, a difference between production and comprehension is apparent from the data. The movement account, which proved to be effective in explaining agrammatic comprehension, is not adequate to account for the deficit in production (as was originally claimed by Grodzinsky, 1986, 1990, 2000b).<sup>11</sup> In its restrictive formulation, which excludes a verb movement deficit, it cannot account for the deficit in yes/no

<sup>11</sup> An additional possibility that should be considered is that agrammatic aphasics have an NP movement deficit in production *in addition to* tree pruning. This will give us a unified account to comprehension and production, with an additional assumption regarding the deficit in production. The price would be that we will have to assume two different deficits when one, tree pruning, is enough. This possibility lends itself to empirical investigation. The structures that one should examine to decide between a TPH account and a movement + TPH account are structures that include phrasal movement to sites that are lower than the pruning site. These are predicted to be impaired according to a movement account since they involve phrasal movement but are predicted to be intact by the TPH since they stay in the accessible zone of the tree. Preliminary results regarding object scrambling in Dutch suggest that agrammatics prefer not to perform a short movement as well (Bastiaanse, 2001). A study we are currently running on the production of postverbal versus preverbal subjects in Hebrew might bear on this issue too.

question production in English, tense inflection substitution, the use of nonfinite verbs, or the relation between verb inflection and position. In its nonrestrictive formulation, it is both too strong and too weak; It does not cover parts of the data such as the deficit in sentential complements, and it predicts errors where they do not appear, in verb agreement, for example.

### *Future Directions for Treatment*

Another finding that is explained by the tree pruning account, but that cannot be explained by a movement deficit, is the improvement of sentential embedding production after Wh question treatment. Thompson et al. (1996) were very successful in their treatment program. Their patients made progress in the trained Wh question types and also in questions requiring similar operations. Furthermore, they also reported an improvement in their patients' complex sentence production; following treatment, the patients produced a greater proportion of complex sentences and more embedded clauses per utterance. They reported that following treatment, their patients produced a greater number of relative clauses and, crucially, also a greater number of "that clauses" (sentential complements of verbs and nouns).

The improvement in sentential complements following Wh production treatment again suggests a relationship between Wh question production impairment and subordination production impairment. This relation does not lend itself to explanation under a movement account (as sentential complements do not involve movement) but is naturally explained within the TPH. Since the whole CP node is affected, question formation is impaired together with sentential embedding. A successful treatment that manages in some way to improve the accessibility of CP, should also improve the production of other structures that depend on CP, among them embedding constructions.

The tree Pruning Hypothesis, taken together with these results, suggests a promising direction for treatment. If indeed treating one aspect of CP can improve the production of other functions of CP, then treating Wh questions should be an effective way to treat embedding production (and probably also vice versa). Furthermore, given the nature of the syntactic tree, an intact node does not promise the intact functioning of a higher node (for data regarding patients who experience deficit only in CP, with intact TP, see also Friedmann, 1998, 2001), but a functioning high node guarantees the functioning of the nodes below it. Thus, treating CP should also affect TP and improve the production of structures that require TP such as tense inflection (see related results regarding effectiveness of treating the complex structure first in Thompson, Ballard, & Shapiro, 1998).

Preliminary results from a treatment study (Friedmann, Olenik, & Gil, 2000) confirm this direction. A Hebrew-speaking agrammatic patient who suffered left frontal CVA 5 years prior to treatment, and who was impaired in both TP and CP (showing impairment in tense inflection, embedding, and question production), received only Wh question production treatment for 3 months. Following treatment, not only did his Wh questions significantly improve (24% correct before treatment, 89% after), but also his ability to produce embedded sentences (significant improvement in relative clause elicitation and in untensed embedding repetition, nonsignificant improvement in relative clause repetition). Importantly, his ability to correctly inflect verbs for tense also improved significantly following the Wh question treatment (from 76% correct before to 91% after). These results support the treatment direction suggested by the TPH. Somewhat counterintuitively, we suggest that treatment should start at the treetop, with the functions of CP. Once the tree is established up to this node,

an improvement of other structures that rely on lower nodes in the syntactic tree should follow.

## CONCLUSION

The results of the current study show that the impairment in agrammatic production of questions is selective. Some questions, such as Wh questions in Hebrew, Palestinian Arabic, and English, are impaired, whereas others, such as yes/no questions in Hebrew and Arabic, are intact. In addition, error analysis points to a structural deficit rather than a lexical deficit. Several accounts for the deficit have been considered and compared, and the pattern of selectivity as well as the error types have been found to be most consistent with the Tree Pruning Hypothesis. According to the TPH, the high nodes of the syntactic tree are inaccessible for agrammatic speakers, and the selectivity in several syntactic domains follows: Structures that rely on high nodes such as CP and TP are impaired, but lower structures are intact. This accounts for dissociations found in verb inflections and subordinations, and it also accounts for the pattern found in question production. Questions that do not require CP, such as yes/no questions in Hebrew and Arabic, are spared, but structures that require CP, such as tensed Wh questions, are impaired. The Tree Pruning Hypothesis thus suggests a unified account for several seemingly unrelated facts about agrammatic production. It suggests that the deficit in tense inflection production, the selective deficit in subordination production, and the selective deficit in Wh question production are all part and parcel of the same underlying deficit—the pruning of the syntactic tree.

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