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The relation between syntactic and morphological recovery in agrammatic aphasia: A case study

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Abstract

Background—Production of grammatical morphology is typically impaired in agrammatic aphasic individuals, as is their capacity to produce the syntactic structure responsible for licensing that morphology. Whether these two impairments are causally related has been an issue of long-standing debate. If morphological deficits are a side-effect of underlying syntactic ones, as has been claimed (Friedmann & Grodzinsky, 1997; Izvorski & Ullman, 1999), therapy which improves the syntactic deficit should remediate the morphological deficit as well. This paper reports a case study of one individual with such co-occurring impairments and describes their recovery in response to linguistically-motivated treatment targeting his syntactic deficits.

Methods & Procedures—MD is a 56 year-old male diagnosed with non-fluent Broca's aphasia subsequent to a left-hemisphere CVA, with limited capacity to produce syntactically complex utterances and grammatical morphology. He was enrolled in therapy using Treatment of Underlying Forms (TUF; Thompson & Shapiro, 2005), targeting production of sentences involving Wh-movement (object relative clauses). MD participated in twice-weekly treatment sessions for approximately two months, with daily probes assessing his production of treated and untreated sentence types. In addition, probes assessing his grammatical morphology and sentence production were administered pre- and post-treatment.

Outcomes & Results—Pre-treatment scores in tests of grammatical morphology and sentence production indicated deficits in both domains. During treatment, MD successfully acquired production of a variety of sentence with Wh-movement, though this did not generalize to sentences involving a grammatically distinct movement operation (NP-movement). Post-treatment scores also indicated a lack of improvement in production of grammatical morphology.

Conclusions—The dissociation between MD's morphological and syntactic recovery indicates that the recovery of syntactic and morphological processes in aphasia may occur independently. This result is thus surprising under approaches in which morphological and syntactic impairments are strongly and causally related in aphasia, such as the Tree-Pruning Hypothesis (Friedmann, 2001; Friedmann & Grodzinsky, 1997). Further, these results reinforce the conclusion that aphasia treatment can lead to generalization, but only to linguistic material which is in a subset relation to trained structures (Thompson, Shapiro, Kiran & Sobecks, 2003).

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INTRODUCTION

In English and many other languages, individuals with agrammatic Broca's aphasia often have both morphological and syntactic deficits (Menn & Obler, 1990; Rochon, Saffran, Berndt, & Schwartz 2000). They exhibit reduced syntactic complexity in their production, showing particular difficulty with production of complex sentences with syntactic movement like the ones in (1-3) (Ballard & Thompson 1999; Lee & Thompson, 2004; Thompson & Shapiro, 2005).

(1)

a. Who did the thief chase? (object Wh- question)

b. It was the artist who the thief chased. (object cleft)

c. I saw the artist who the thief chased. (object relative clause)

(2)

a. The artist was chased by the thief. (passive)

b. The thief seems to have chased the artist. (subject-raising)

(3) The man is falling. (unaccusative)

Sentences (1a-c) all involve Wh-movement: the wh- element “who,” which is underlyingly the object of the verb “chase,” is moved to a position before the verb's grammatical subject, resulting in a non-canonical order of subject and object. Sentences (2a-b) involve NP movement: the surface subject has been moved from another position in the sentence. “The artist” in (2a) is moved from its underlying object position following “chased,” and “the thief” in (2b) moves from the subject position of the embedded infinitival clause “to have chased the artist.” Unaccusative structures like that in (3) also involve NP-movement, in which the subject of the verb is raised to its surface subject position from an underlying object position (Perlmutter, 1978, among others). Such sentences present difficulty for persons with agrammatic aphasia, even though on the surface they are simple NP-V structures (Bastiaanse & van Zonneveld, 2005; Lee & Thompson, 2004; Thompson 2003).

Grammatical morphology is also significantly impaired in agrammatic aphasia (Kean, 1977, Menn & Obler, 1990), especially morphemes associated with verbs and clauses. For example, inflectional suffixes such as third-person singular -s and -ed are impaired, as are free-standing auxiliaries like was and is, and clausal subordinators or complementizers such as if, whether, and that appear to be particularly impaired. These patterns hold for languages as diverse as English (Milman, Dickey & Thompson, 2004), Japanese, French and Italian (Hagiwara, 1995), and Hebrew and Palestinian Arabic (Friedmann & Grodzinsky, 1997; Friedmann, 2001).

It is an issue of long-standing theoretical interest whether these two co-occurring deficits are causally related. A unified explanation of the two would be desirable for both theoretical and clinical reasons. Theoretically, such an explanation would provide a simpler and more restrictive characterization of aphasic language disorders, and it would predict which patterns of impairment should naturally co-occur (as well as what types of impairment should be expected not to co-occur). Clinically, such a unification would open up new venues for the diagnosis and treatment of aphasic language disorders. Treatment which results in improvement in one deficit should be expected to result in improvement for the other. For example, if the morphological deficit can be reduced to a syntactic one, then treatment which remediates the syntactic deficit could be expected to remediate the morphological deficit as well.

Recently, researchers have pursued exactly this hypothesis, attempting to explain the morphological deficits in terms of underlying syntactic ones. For example, the Tree-Pruning Hypothesis (TPH; Friedmann & Grodzinsky, 1997; Friedmann, 2001) claims that individuals with agrammatic aphasia have difficulty projecting hierarchical syntactic structure. Thus, underspecified higher-level functional projections result in impairments in both morphological and syntactic deficits associated with those projections. (See Izvorski & Ullman, 1999, for a related proposal.) As illustrated by the structure in Figure 1, the different syntactic projections associated with a clause are responsible for distinct syntactic and morphological processes. The functional projection IP licenses tense and agreement morphology and hosts the clause's subject (more generally, it serves as a landing site for NP movement, as in subject-raising, passive, and unaccusative sentences). The higher CP projection hosts complementizers and fronted auxiliaries in languages like English, and it serves as a landing site for Wh-movement.

Under the TPH, “pruning” a given layer of structure disrupts both morphological and syntactic operations associated with that projection. For example, patients who are unable to generate a CP layer will be unable to license grammatical morphology associated with CP, such as complementizers, and they will also be unable to carry out syntactic operations which target CP, such as Wh-movement. Furthermore, “pruning” a given layer of structure results in impairments not only to syntactic and morphological operations associated with that layer, but all layers above it. For example, an agrammatic individual who is unable to generate an IP layer will not be able to generate a CP layer: s/he will exhibit deficits in not only IP-related morphology and syntax but CP-related morphology and syntax as well.

Under this hypothesis, syntactic and morphological deficits go hand-in-hand: a single syntactic deficit (in generating higher levels of clausal syntactic structure) explains both the syntactic and morphological impairments characteristic of agrammatic aphasia. This approach also makes a treatment-related prediction, already described above. Treatment which ameliorates the more basic deficit (in this case, the syntactic one) should result in improvement in the secondary one (in this case, the morphological one). Improving aphasic individuals' capacity to produce higher levels of syntactic structure should result in improved production of grammatical morphology associated with that syntactic structure. It is possible that the improvements in morphological production might be delayed compared to the improvements in syntactic production, an issue we will return to in the Discussion below. However, if this hypothesis in is correct, improved syntactic production should in principle lead to improved morphological production, at least for some agrammatic individuals.

The TPH furthermore makes two specific predictions regarding how treatment targeting different levels of syntactic structure should generalize. First, improved production of sentences involving [Spec, CP] (such as Wh-movement sentences) should result in improved production of C, as well as the morphology licensed by C. There is some suggestion in the aphasia treatment literature in favor of this prediction: Thompson and colleagues (Thompson, et al., 1997) found spontaneous production of complementizers improved following treatment of Wh-movement (targeting Spec, CP). Second, treatment that improves production of CP should result in improved production of IP as well, since IP is lower in the tree. This in turn should improve production of morphology licensed by I^0, such as tense and subject-verb agreement.

This paper presents a case study testing these predictions, both the general prediction that improved syntactic production should lead to improved morphological production and the more specific predictions pertaining to the generalization patterns noted above. MD, an individual exhibiting both morphological and syntactic impairments as a result of non-fluent Broca's-type aphasia, was trained to produce object relative clauses (a structure involving CP) using Treatment of Underlying Forms (TUF; Thomspon & Shapiro, 2005). This linguistically

motivated approach improves production and comprehension of Wh- and NP-movement structures, which entail access to the syntactic projections which host and license movement operations (CP and IP, respectively). MD's ability to produce a variety of CP and IP structures, both syntactic and morphological, was assessed prior to and following treatment, with the expectation that grammatical morphology associated with CP would improve. In addition, production of syntactic structures and morphological material licensed by IP was expected to improve if the TPH and its assumptions about the roots of aphasic morphological deficits are correct.

Because this is a single case report, its findings must be treated and interpreted with caution. Nevertheless, it does provide the first test of the treatment-related predictions of the TPH, outlined above.

METHOD

Participant

The participant in the study, MD, was a 56-year-old, college educated white male. He was a monolingual native English speaker who suffered a single left-hemisphere CVA. At the time of testing, MD was 48 months post-stroke and reported no previous history of speech-language or neuropsychological disorders. Results of testing using the Western Aphasia Battery (WAB; Kertesz, 1982), revealed a WAB AQ of 68.8, and a language profile consistent with non-fluent agrammatic, Broca's aphasia: in spontaneous speech, he exhibited halting, effortful production with extremely reduced syntactic complexity and little or no use of grammatical morphology. In addition, testing with the Northwestern Assessment of Verbs and Sentences (NAVS; Thompson, 2005) revealed that he had difficulty comprehending and producing sentences with non-canonical Wh- and NP-movement (see Table 1).

Procedures

Measures for evaluating syntactic production—Production of semantically reversible, non-canonical Wh-movement structures (object relatives (OR), object clefts (OC), and object Wh-questions (OW)), as in (1) above) and NP movement structures (subject raising (SR) and passive (PA) sentences, as in (2) above) was assessed using a 50 item probe task (10 items for each of the five sentence types). A sentence production priming paradigm was used to elicit production of target sentences, with picture pairs presented showing two versions of a single transitive action (e.g., an artist chasing a thief; a thief chasing an artist). The clinician first described one picture using one of the five sentences types and then asked MD to describe the other picture using the same type of sentence. This procedure is identical to standard probe procedures for TUF (Thompson & Shapiro, 2005).

Second, MD's production of simple intransitive sentences was tested using both unaccusative verbs like fall, which involve NP-movement, and unergative verbs like swim, which do not. MD was first asked to name 25 pictures depicting intransitive events (13 unaccusatives and 12 unergatives) using a single action word and then to describe the same pictures (presented in a different order) using a complete sentence. These pictures were adapted from picture stimuli used in a previous study of agrammatic aphasic individuals' production of unaccusative and unergative verbs (Lee & Thompson, 2004). These images elicited the anticipated verb names 90% or more often with control participants in that study, with no differences in accuracy between unaccusative and unergative stimuli.

Measures for evaluating grammatical morpheme production—MD's production of complementizers (n=20) and verb inflection (n=40) was selected for testing CP and IP generated morphology, respectively. These structures were elicited in sentences using

procedures developed by Thompson, Milman, Dickey, O'Connor, Arcuri, & Choy (2006), in which pairs of cards were used for each item. One of the cards was an event card, depicting one of ten imageable transitive events (e.g., The dog is watching the cat). The other was a cue card, either depicting a sentential-complement verb like ask, know, care, or wonder, or with the word Nowadays or Yesterday. The verb cards were intended to elicit embedded clauses introduced by complementizers, such as if, that, or whether (e.g., They know that the dog is watching the cat), while the Nowadays/Yesterday cards were intended to elicit–s or –ed marking on the transitive verb, respectively (e.g., Nowadays the dog watches the cat,, Yesterday the dog watched the cat.).

The two stimulus cards were presented to the participant. He was asked first to name the action pictured on the event card and to identify the agent and theme, and then to read the word (Yesterday, Nowadays) or name the action (e.g., They wonder, They care) pictured on the cue card. The participant was then asked to make a sentence by combining the two cards. Two practice items were presented before the test stimuli. In separate testing, these stimuli and procedures elicited –s and –ed morphemes as well as complementizers with 95% or greater accuracy in a group of 8 age-matched controls.

To summarize, the study entailed a total of nine dependent variables, including both syntactic and morphological structures. Syntactic structures tested included three Wh-movment sentences (OR, OC, and OW) and three NP movement sentences (PA, SR and intransitive sentences with unaccusative verbs). Three morphological structures were also included: two measures of verb morphology (-s and –ed), and one measure of complementizer production.

Design—The study included pre- and post-treatment testing of all syntactic and morphological measures. In addition, five sentence types (ORs, OCs, OWs, SR, and PA forms) were tested on two separate occasions prior to treatment and administered daily throughout treatment to monitor treatment progress. This is a smaller number of baseline sessions than usual, due to time constraints for the participant, but his performance was at floor for the target Wh-movement sentence type (OR) in both sessions. Six weeks following the completion of treatment, all measures were once again administered to examine maintenance of treatment gains and generalization patterns.

Baseline and treatment probes—Procedures identical to those used of pre-testing of OR, OC, OW, SR, and PA production were used for baseline and treatment probing. During baseline sessions, the full 50-item probe was completed. During treatment, a full probe was completed every other session (i.e., half of the probe items were presented prior to the first treatment session and the other half were presented prior to the second session, and so on until treatment was completed) Thus, data from every two sessions were combined and plotted to compare with baseline performance.

Treatment—Treatment of Underlying Forms (TUF), a linguistically-motivated treatment for Wh- and NP-movement sentences, was used to train MD to produce one Wh-movement structure: object relatives (such as The man saw the artist who the thief chased). Fifteen pictures of imageable transitive events were used for treatment, with each depicting two participants performing an action using a transitive verb (e.g., a thief chasing an artist), with a third participant, a man, watching. A set of corresponding sentence constituent cards also were developed for each item, with words for the agent (e.g.,THE MAN), the verb (e.g., SAW), and theme (e.g., THE ARTIST) for the main clause and the agent (e.g., THE THIEF), the verb (e.g., CHASED), the theme (e.g., THE ARTIST) and a WHO card for building the embedded clause. The starting point for treatment provided an explicit model of the abstract underlying linguistic representation and derivation of object relatives, with the treatment cards arranged in two active sentences (i.e., THE MAN SAW THE ARTIST and THE THIEF CHASED THE

ARTIST), with the WHO card set aside. The clinician then introduced steps required to build the target structure by thematic role identification and demonstration of the Wh-movement operation needed to arrive at the surface non-canonical word order. MD then used the cards to reassemble the sentence himself and read the sentence aloud (with assistance from the clinician when needed). Treatment was conducted two times per week for 8 weeks. Each treatment session lasted approximately two hours and up to fifteen treatment trials were administered per session.

RESULTS

Data derived from baseline and daily testing of Wh- and NP-movement structures are shown in Figure 2. Production of wh-movement structures – object relatives (ORs), object clefts (OCs) and object wh-questions (WHs) – is shown in the top graph and production of NP-movement structures – passives (PAs) and subject-raising sentences (SRs) – is shown in the lower graph. These data showed that MD had little or no capacity to produce any of these structures in pre-treatment or baseline (consistent with his performance in the Sentence Production Priming Test of the NAVS (Table 1)). Upon initiating treatment, he showed immediate acquisition of Wh-questions, as well as noticeable improvement in production of object relatives and object clefts. His production of both complex Wh-movement sentence types (OR and OC) rose from 0% at baseline to as high as 40% by the end of treatment. However, he showed no consistent improvement over baseline levels in production of either NP-movement structure. Follow-up probes showed significant retention of the gains made for all three Wh-movement sentence types at six weeks (from 25% in baseline to 70% for WH sentences, and from 0% and 5% to 20% for OR and OC), but no change from baseline for the two NP-movement sentences.

MD's intransitve sentence production provided further data regarding the effects of treatment on syntactic structure production, for simple sentences with and without added NP-movement. Prior to treatment, MD's production of sentences with unaccusative verbs, which involve NP-movement, was impaired, and little change was noted on post-testing. This result indicates that Wh-movement treatment had no effect on simple sentences with NP-movement. However, a different pattern was noted for unergative verbs, which do not involve the same NP-movement operations. Prior to treatment, MD had little success in producing simple sentences with unergative verbs (i.e., 8% correct production). Following treatment, he showed large improvements in production of unergative sentences (i.e., 92% correct), indicating that treatment of complex sentence with movement impacted his ability to produce simple active sentences with no movement (see Table 2). Similar improvements in simple sentence production in narrative contexts following TUF treatment have been noted for other aphasic individuals, with greater numbers of verbs and grater numbers of correctly produced arguments (see Thompson, et al., 1997,Thompson & Shapiro, 2005, for discussion).

The overall pattern of changes in MD's syntactic production is summarized in Figure 3. The Wh-movement category represents his mean performance on OR, OC, and OW sentences, the NP-movement category represents his mean performance on PA, SR, and unaccusative intransitive sentences, and the no-movement category represents his performance on unergative intransitive sentences. Wh-movement and no-movement sentences improved pre- to post-treatment, while NP-movement sentences showed no change.

With regard to grammatical morphology, MD was significantly impaired pre-treatment in production of both verbal inflection morphemes tested: -ed and -s. His errors consisted of omissions (producing a bare verb form, 8/22 errors) or inappropriate use of the –ed or –s morpheme (e.g., using –s with Yesterday, 14/22 errors). However, he produced complementizers with 100% accuracy (see Figure 4). His production of functional morphology associated with IP thus appeared to be significantly impaired pre-treatment, while his

production of morphology associated with CP appeared to be intact. Post-treatment scores showed no evidence of improvement in his production of IP-related morphology: he continued to produce omission errors (8/18 errors) as well as to use –s and –ed inappropriately (10/18 errors). However, his production of CP-related morphology declined. We address this latter, unexpected finding below.

DISCUSSION

This study examined the connection between syntactic and morphological deficits in agrammatism, looking at one agrammatic individual's patterns of recovery in response to TUF. Treatment targeting production of object relative sentences with Wh-movement improved MD's production of not only those sentences but also related sentence types, also involving Wh-movement. Further, the recovery patterns noted among Wh-movement structures showed that treatment influenced production of the least complex of the forms (i.e., wh-questions) more than production of more complex forms (object clefts). This finding is in keeping with results showing complexity effects in generalization (Thompson, et al., 2003): generalization appears to proceed from more complex to less complex forms, provided that the forms are linguistically related to one another. This complexity effect may underlie MD's additional improvement with simple (unergative) intransitive sentences, as well. Such sentences involve an Agent subject and a verb. As such, their structure is a subset of the OR training sentences, which also involve an Agent subject and a verb (as a subpart of a more complex structure). Training Wh-movement structures thus implicitly trains structures involving an Agent subject and a verb, including simple intransitives.

It is unclear why greater improvement was not noted for the directly-trained OR structure. This pattern has not been noted previously among aphasic individuals trained with TUF. However, MD's striking improvement in his production of Wh-questions shows that treatment generalized to sentences with different words but similar abstract structure. These data thus indicate that MD's ability to generate CP-level syntactic structure was improved with treatment.

However, MD's results also showed that Wh-treatment did not generalize to sentences involving NP-movement: subject raising or passive sentences, as well as intransitive sentences with unaccusative verbs. That is, the treatment and generalization effects were linguistically specific, with acquisition of Wh-movement structures having no effect on constructions with NP-movement. These results also replicate previous TUF findings (Thompson & Shapiro, 1995; Ballard & Thompson, 1999; Thompson, et al., 2003; Thompson & Shapiro, 2005). Further, they show that while CP-level syntax is higher in the syntactic tree than IP-level syntax, position in the tree alone does not predict a structure's improvement following treatment, as would be expected based on strongly tree-based accounts of agrammatism like the TPH.

MD's production of grammatical morphology also did not improve with treatment: complementizers and verbal inflection were produced at only 24% and 46% accuracy, respectively, on post-treatment testing. Compared to baseline performance, these data show that his production of verb inflections was unchanged. However, his production of complementizers actually declined. These patterns are inconsistent with both the general and the specific predictions of the TPH outlined above: improving production of the CP-level material did not improve production of morphology associated with C^0 immediately below it, nor did it result in improved production of verbal morphology associated with the more deeply embedded IP layer. Treatment which demonstrably improved production of even the highest level of clausal syntactic structure thus did not appear to help with production of grammatical morphology, at any level of hierarchical syntactic structure. This seems inconsistent with attempts to reduce morphological deficits in agrammatism to syntactic ones (Friedmann &

Grodzinsky, 1997, Friedmann, 2001; Ullman & Izvorski, 1999). More generally, these results indicate that syntactic and morphological recovery may proceed independently in aphasia.

There is at least one aspect of the current results that merits further attention: MD's unexpected decline in complementizer production following treatment. This result is not consistent with previous TUF results (Thompson, et al., 1997, e.g.). One possible explanation is that MD's pre-treatment performance with complementizers did not reflect his capacity to produce morphemes located in C^0. Consistent with this is his relatively poor performance in production of yes-no questions on the NAVS (Table 1: 40% correct), which involve the sentence-initial auxiliary "did" (also located in C^0). Another possibility is that the decline in complementizer production is an example of antagonistic recovery of CP. Focusing on Wh-movement (which targets Spec, CP) inhibited his performance with complementizers (which reside in C°). Further testing with other agrammatic individuals is needed to decide between these possibilities.

As noted above, these results must be treated with caution. They are from one agrammatic individual, whose behavior may not be typical. Potentially consistent with this is MD's good performance on some subtests of the NAVS (such as object-relative comprehension) and on the initial complementizer production probes (though these results are at odds with his NAVS performance, as discussed above). However, MD's recovery patterns do provide an initial test of the relationship between recovery in the syntactic and morphological domains in response to treatment, as well as the treatment-related predictions of the TPH. As such, they provide a starting point for further research. Additional testing is needed to determine whether MD's pattern holds for a larger sample of agrammatic individuals.

Further data are also needed to test another possibility described above: that morphological recovery may be delayed compared to syntactic recovery. Perhaps syntactic recovery proceeds as suggested by the TPH, with recovery of higher-level syntactic projections (like CP) entailing recovery of lower-level ones (like IP), and with morphological recovery following sometime later. It is possible that MD's morphological production may have recovered further following his syntactic recovery, given sufficient time. It is worth noting that MD's morphological production had not improved by the time of his post-testing six weeks following treatment. However, additional and more extended testing is needed to determine whether such delayed morphological improvement would occur for other individuals trained to produce Wh-movement sentences (and with them, CP-level structure).

CONCLUSION

In conclusion, the current results provide evidence that the syntactic and morphological impairments characteristic of agrammatism cannot be reduced to a single underlying deficit. In particular, they cast doubt on attempts to reduce the morphological deficit to a syntactic one. As indicated above, this conclusion must be treated with caution, as these data are from a single agrammatic individual. However, these results do suggest that the relation between syntactic and morphological processes in aphasia and aphasia recovery isn't a simple one. Training one will not automatically improve the other. The ability to generate complex syntactic structure is likely a necessary condition for producing related grammatical morphology, but it does not appear to be a sufficient one. Rather, the operations required to produce functional morphology must be trained separately (viz. Thompson, et al., 2006).

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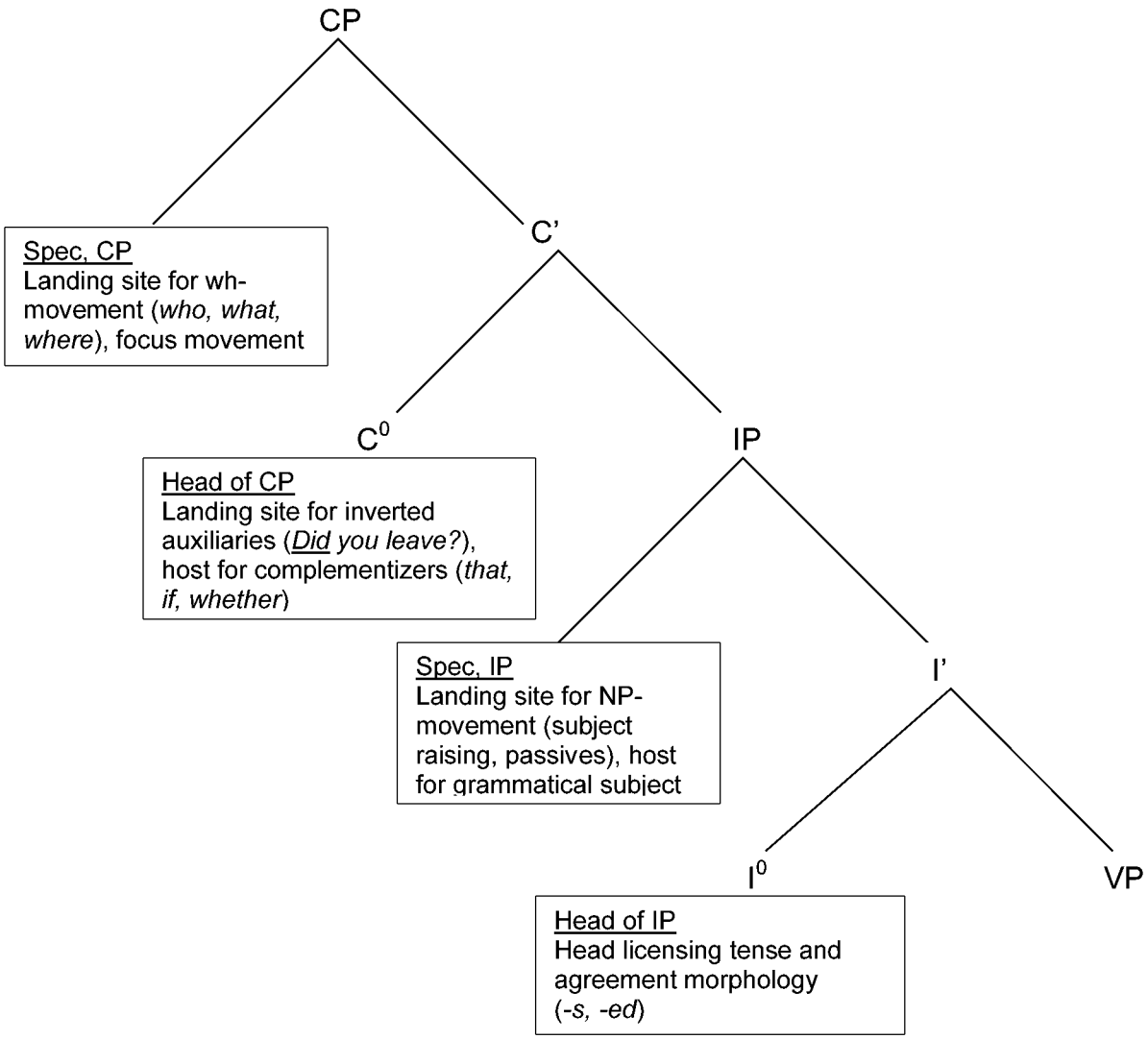

Figure 1.
Clausal functional projections and their morphological and syntactic functions

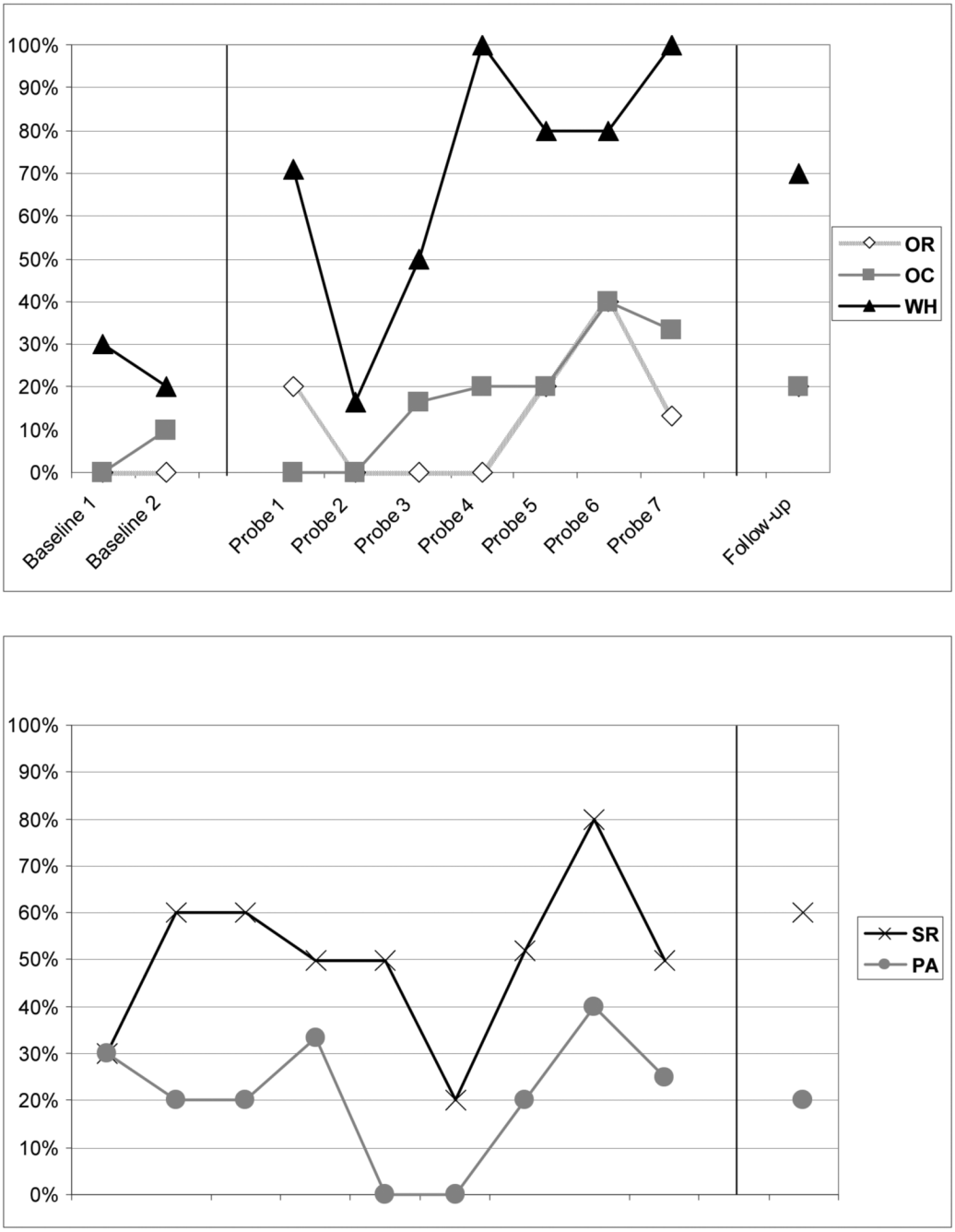

Figure 2.
Baseline and daily probes from TUF treatment, with follow-up probe, Wh-movement and NP-movement

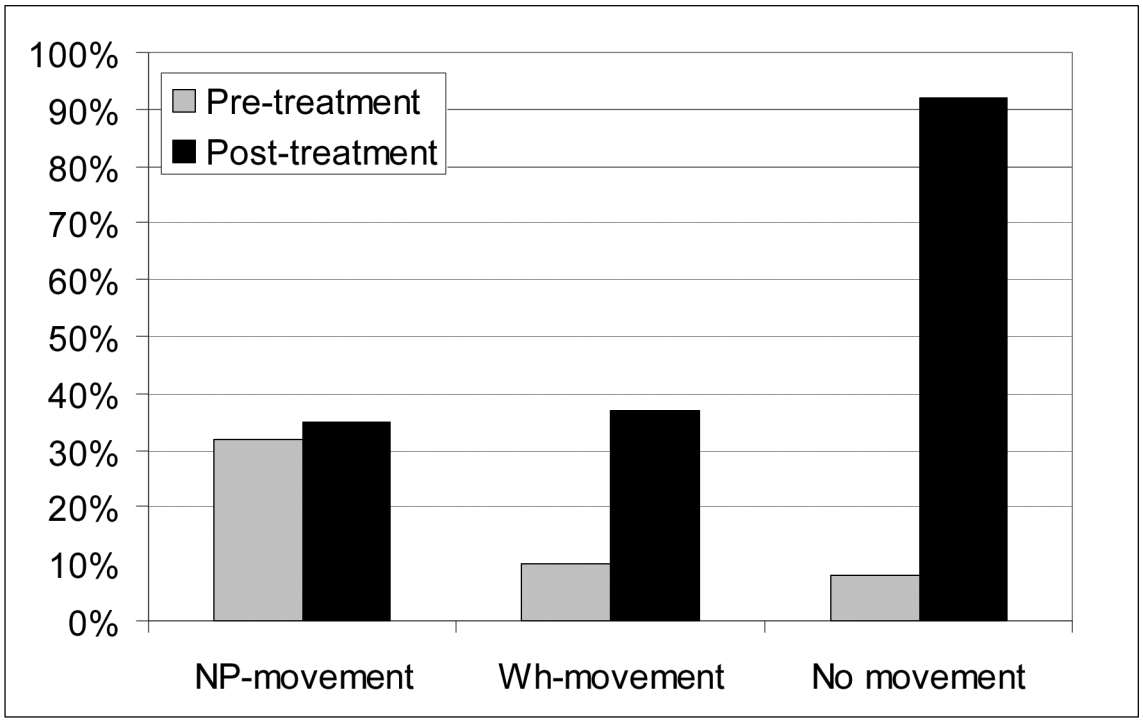

Figure 3.
Mean accuracy in production of Wh-movement, NP-movement, and non-movement sentences, pre- and post-treatment

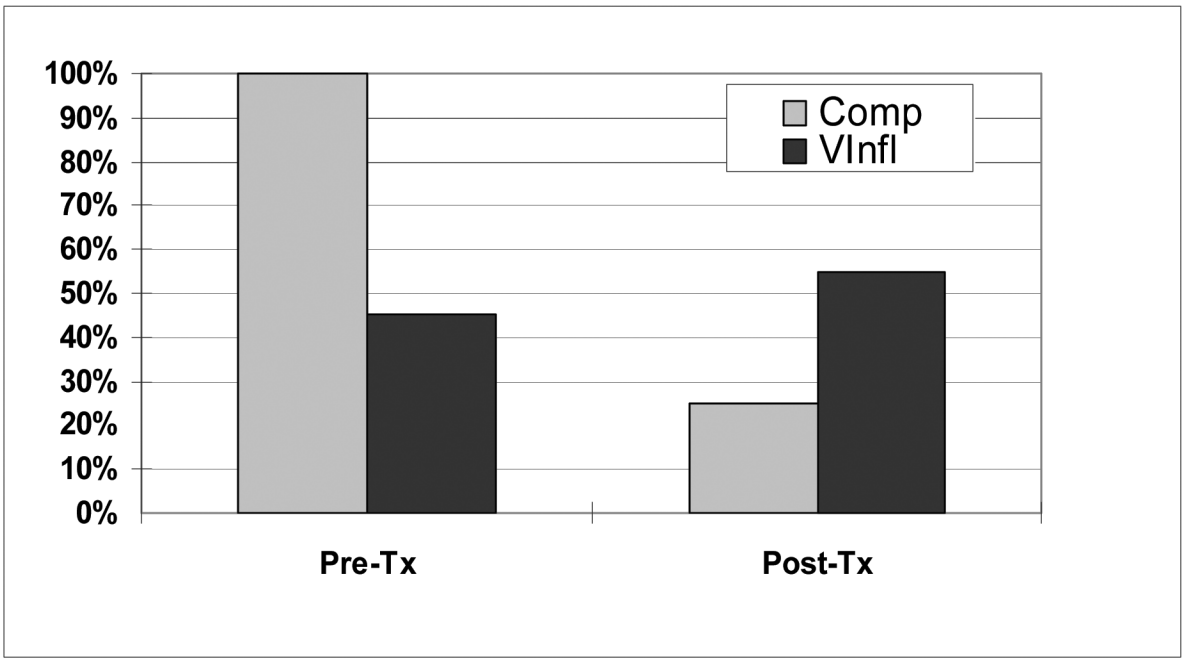

Figure 4.
Mean accuracy in production of IP-related and CP-related grammatical morphemes, preand post-treatment

Table 1

NAVS scores (in percentage correct), for Sentence Production Priming Test (SPPT) and Sentence Comprehension Test (SCT)

	SPPT	SCT
Active	60%	100%
Passive	20%	60%
Yes/No Q	40%	60%
Subject Wh-Q	80%	100%
Subject Relative Clause	80%	80%
Object Wh- Q	20%	60%
Object Relative Clause	20%	100%

Table 2

Accuracy in verb naming and sentence production for unaccusative and unergative instransitive verbs, pre- and post-treatment

	Verb naming		Sentence production	
	Pre-treatment	**Post-treatment**	**Pre-treatment**	**Post-treatment**
Unaccusative (sink)	54%	31%	0%	15%
Unergative (swim)	92%	100%	8%	92%