Syntactic dependencies versus trace deletion: evidence from Korean and Spanish

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1.   Introduction

It is a simple statistical fact that subjects tend to precede objects both in English sentences and in the languages of the world. Also, typically, subjects tend to receive thematic roles that are higher in thematic hierarchies, so the Agent role tends to occur before the Theme, and so forth. In linguistic theory, the relative linear order of thematic roles is not required by any principle but is merely epiphenomenal. However, one influential model of the patterns of sparing and loss in agrammatic comprehension, namely the Trace Deletion Hypothesis (TDH; Grodzinsky 1995), which claims to be motivated by linguistic theory is based squarely on these linear tendencies. Not only is this account tangential to linguistic theory, but it also fails to intersect with theories of linguistic processing.

It may, however, still be correct. It is possible that the "mild expectation" (Carlson and Tanenhaus 1988:287) that is set up in connection with thematic-role assignment is not compensated for by normal processing. Perhaps, then, agrammatic aphasics use some kind of processing strategy that is unrelated to the normal case.

The default assumption, however, must be that agrammatic comprehenders have the same linguistic representations as normals and that they use the same processes to interpret sentences (albeit processes that are restricted in some way) (for insightful discussion of these issues, see Frazier and Friederici 1991, Friederici and Gorrell 1998, and Linebarger 1990). At least one current model of agrammatic comprehension is consistent with this assumption, namely, the Double-Dependency Hypothesis (DDH; Mauner, Fromkin, and Cornell 1993). The DDH makes no reference to linear considerations at all.

The linear *vs* non-linear distinction, with its attendant ramifications for abnormal *vs* normal representation and processing, can be viewed as a fundamental divide in models of agrammatism. In view of this, it is important that these models be confronted with discriminating evidence so that the extant set of candidate models may be culled. In English, since word-order is relatively fixed, the opportunities to test linear hypotheses are rather few. In languages which have comparatively free word-order, by contrast, such opportunities abound. In Korean and Spanish, for instance, phrases can be 'scrambled', or left-dislocated, that is, moved to some sentence-initial position. Although this is possible in topicalization structures such as *Bill, I like (but Fred, I can't stand)* in English, the

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options are more varied in these other languages. Scrambling can have the effect that, even in simple active sentences which usually present no problem to agrammatics, the relative order of thematic roles is rendered non-canonical. Similarly, it can yield canonical thematic orders in sentences, such as passives, which traditionally frustrate agrammatics.

If agrammatic interpretation of non-canonical ordering of thematic roles in actives and of canonical ordering of thematic roles in passives were to conform to a linear account such as the TDH, it would provide startling evidence in its favor and against the DDH. In this paper, we present results from Korean and Spanish speaking aphasics using sentences with syntactic dislocations that preserve the relative linear order of arguments. The pattern of results is not predicted by the linear TDH. The non-linear DDH, on the other hand, can easily account for the observed data. The consequences are clear.

In what follows, we will briefly describe the models of agrammatism at issue and introduce the relevant dislocation structures before reporting the experiment.

2. Linear and non-linear models of agrammatism
2.1. The Trace-Deletion Hypothesis

Grodzinsky (1995:46) formulates the TDH as follows:

a. Traces in θ-positions are deleted from agrammatic representation (or are invisible to θ-assignment).
b. R-strategy: Assign a referential NP a role by its linear position iff it has no θ-role.

The TDH, then, proposes that in an otherwise normal representation, traces in theta-positions are deleted. Because the trace is lost, thematic information is also lost in moved referential NPs. Agrammatics apparently cannot infer the missing theta-role by consulting the theta-grid of the relevant verb, but instead resort to a default heuristic, the 'R-strategy'. The strategy assigns a referential NP a role by its linear position in the sentence (e.g., first NP = Agent) if it does not already have a theta role. So, for example, in a passive sentence, the NP argument of the *by*-phrase receives the Agent theta role in a normal representation. Since no movement is involved in this assignment, it is not linked to a trace, and no difficulties are predicted in agrammatism. By contrast, the subject of the passive is derived by movement, but since the trace it is linked to is deleted in an agrammatic representation, thematic role assignment is impossible syntactically. The default strategy operates on this incomplete output of the syntactic parser and assigns the role of Agent to the moved NP. The upshot is that the agrammatic representation of the passive contains two Agents, as in (1), where '*' indicates loss of trace:

(1)   [The lion] was bitten * by [the dog]
        AGENT   AGENT
        (by default)   (via syntax)

Confronted with a sentence-picture matching task, the representation in (1) forces them to guess which NP to interpret as Agent, and thus, agrammatic patients perform randomly.

This example explains random performance by means of trace-deletion, the operation of a default heuristic, and competition for Agenthood. Above-chance performance, for example on active sentences, is also explained by trace-deletion and the action of the default strategy. The active is thought to contain a trace (of subject movement out of the VP). However, application of the default strategy does not result in impaired performance. Instead, the default strategy compensates for the loss of trace and ensures above-chance performance, as in (2):

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(2)   [The dog] * hit [the lion]
        AGENT   THEME
        (by default)   (via syntax)

The first NP is assigned the Agent role by default because the trace is missing, an assignment that just happens to be correct one, while the object-NP receives the role of Theme syntactically

To re-cap, the pattern of retention and deficit in agrammatism is explained by the deletion of trace and either compensatory or competitive default assignment of theta-roles.

2.2.   The Double-Dependency Hypothesis

Like the TDH, the DDH attempts to deal with chance performance by positing a deficit that will present the agrammatic subject with "at least two alternative representations where the normal only has one" (Mauner et al. 1993:348). The DDH maintains that in syntactic chains which are assigned only one theta-role, the dependency between a referential NP and the foot of the chain is disrupted. In sentences where there are *two* such dependencies, it is unclear which NP is co-indexed with what. Since the coindexation is ambiguous and since thematic role assignment is thereby also ambiguous, agrammatics must guess who is doing what to who. However, where there is only *one* such dependency, no ambiguity is possible, and therefore interpretation should be normal. For an example with two relevant dependencies, consider the passive sentence in (3):

(3)   [The lion]$_i$ was bitt[en]$_j$ t$_i$ by [the dog]$_j$

In (3), the two dependencies are as follows:

(4)   <[the lion]$_i$, t$_i$> <en$_j$, [the dog]$_j$>.

The referential NP, *the lion* and the foot of its chain, the trace *t*, form one dependency. The other dependency is between the referential NP, *the dog* and the foot of its chain, the passive morphology *–en* (assuming the analysis of passives in Baker, Johnson and Roberts 1989). In an agrammatic representation, the ambiguous interpretation would permit the correct coindexation, as in (4), and would also allow the anomalous coindexation in (5):

(5)   <[the lion]$_i$, en$_i$> and <t$_j$, [the dog]$_j$>

To summarize, the DDH makes the following stipulations (Mauner et al. 1993:349): (i) the deficit underlying asyntactic comprehension affects the processing of syntactic referential dependencies, and (ii) when there is only one such dependency, the resulting syntactic representation, though abnormal, is not ambiguous, but when there are two such dependencies, the resulting representation is ambiguous.

3.   Scrambling structures and their discriminating effect on models of agrammatism

In general, the TDH makes different predictions from the DDH exactly in cases where the linear order of arguments is preserved, despite the fact that syntactic operations have displaced constituents from their canonical positions. In languages with productive scrambling rules, it is possible to construct examples which produce such cases.

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3.1. Scrambled actives and clitic left-dislocation

Korean is an SOV language which also allows the object of a verb to appear linearly to the left of the subject, as in (6).

(6) saja-lul$_i$ key-ka$_j$ t$_j$ t$_i$ mul-eyo
     lion-ACC   dog-NOM   bite-COMP
     'The lion, the dog bit'

Saja-lul 'lion' is the direct object which has scrambled to some pre-sentential position, leaving a trace in object position. The subject *key-ka* 'dog' moves from a VP-internal position to IP. Thus, there are two movements of referential NPs. What predictions do the competing models of agrammatism make for this structure on a sentence-picture matching task? The DDH predicts at chance because there are two relevant dependencies. The TDH yields a clear below-chance prediction. Both theta-roles would be assigned via the default strategy according to their linear positions. Thus the Agent role would be assigned to *the lion* and the Theme role to *the dog*. This means that agrammatic interpretation should be consistently mistaken. Korean scrambled actives, then, discriminate between the TDH and the DDH.

In Spanish, left-dislocation of a direct object requires a resumptive pronoun in the trace position, as shown in bold in (7):

(7) A la girafa   la   mujer   la está empujando
     A the giraffe the woman it is pushing
     'The woman is pushing the giraffe'

Current analyses agree that, because of this clitic pronoun, the object position is not occupied by a trace. However, following Zubizarreta (1998), the left-dislocated element has undergone movement from a position within the clause.

(8) [A la girafa]$_i$ [la mujer]$_j$ t$_j$ t$_i$ la està empujando

Given the analysis in (8), the TDH prediction must be for below chance agrammatic comprehension. The DDH expects chance-level performance because there are two relevant dependencies due to the movement of two referential NPs. Clitic left dislocation structures in Spanish, therefore, also distinguish between the TDH and the DDH.

3.2. Scrambled Passives

As mentioned above, the wider range of word orders in other languages allows for dislocated structures which do not upset the relative linear order of thematic elements. Both Korean and Spanish allow the *by*-phrase of a passive to be initial in the sentence, as in (9a) and (9b), respectively.

(9) a. key-ekey saja-ka   mul-hi-eyo
         dog-by   lion-NOM   bite-PASS-COMP
         'The lion is bitten by the dog'

     b. Por   la mujer   la girafa está siendo empujada
         by   the woman the giraffe is   being   pushed
         'The giraffe is being pushed by the woman'

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This word order is highly marked if not unacceptable in English. Since the scrambled passive in Korean and Spanish re-orders the displaced NPs canonically, this structure allows linear and non-linear models to be tested directly in these languages. This structure is particularly interesting because the TDH makes a surprising prediction, one that is distinct from the DDH prediction. It expects agrammatic performance to be unimpaired. This is surprising because normally agrammatics do not understand passives. Let us see how the TDH arrives at this optimistic promise.

There are two movements (of both the subject and oblique NPs) for the TDH to deal with. The oblique NP (the complement of the preposition *by*) is in initial position, so the default strategy assigns it the Agent role. By its linear position, the moved subject NP must accept the Theme role. This coincides with normal role assignment and thus agrammatic interpretation should be fine.

For the DDH, no such improbable prediction obtains. There are two relevant referential dependencies (the two traces and their antecedents), so agrammatic interpretation ought to be ambiguous.

Scrambled passives, as we have seen, provide us with a test that perfectly discriminates between the TDH and the DDH.

To test the predictions we have alluded to, we tested Korean and Spanish speaking aphasics on the kinds of sentences described above.

4.   Method
4.1.   Subjects

Spanish subjects were recruited from the Hospital Central, in Asturias, and from the Ubarmin and Adacen clinics, in Navarra. Korean subjects were recruited from the Kyunghee University Medical Center, in Seoul, and from the Kangdong Sacred Heart Hospital, also in Seoul. Criteria for inclusion were neurological, neuropsychological, and linguistic. The neurological criterion for inclusion was left-frontal CVA involving Broca's Area, confirmed by CT scan, at least three months prior to the study. The neuropsychological criterion was that a patient be diagnosed as a Broca's aphasic (based on evidence that speech is non-fluent, effortful, and telegraphic, and that comprehension is good at the conversational level, as confirmed by clinical workup (in the case of the Spanish patients, scores on the BDAE were also available). The linguistic criterion was asymmetrical performance on 'core' sentences in the direction expected in common by all of the models of agrammatism at issue in this study, that is, better on actives than on passives. (In addition, for the Spanish patients, it may be worth mentioning, since the data were available, that subjects understood subject-relative clauses better than object-relative clauses, another pair of core sentences.)

Three Korean and two Spanish subjects met these criteria. Details of each subject are given in the Appendix.

4.2.   Test Sentences

For the Korean segment, the experimental sentences were scrambled actives and scrambled passives along with simple actives and simple passives as controls. Subjects therefore heard 80 sentences comprising 4 types and 20 tokens of each type, plus fillers. For the Spanish segment, the experimental sentences were clitic left dislocation structures (equivalent to the scrambled active in Korean) and scrambled passives.

To ensure that the resumptive clitic itself did not pose problems for the Spanish subjects, structures in which the direct object is doubled by a clitic, as in (10) were used as a control in addition to active sentences without the clitic (11) that were used in the screening. The clitic doubling sentence serves as a relevant control because, while it includes a clitic, there is no movement of the object NP (i.e., no left-dislocation).

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(10) La   mujer   la   está empujando a   la girafa
     The   woman   her   is   pushing   A   the giraffe
     'The woman is pushing the giraffe'

(11) La mujer   está empujando a la girafa
     the woman   is   pushing   A the giraffe
     'The woman is pushing the giraffe'

The Spanish subjects therefore heard 100 sentences comprising 5 types and 20 tokens of each type, plus fillers.

For both languages, each sentence was semantically reversible.

4.3. Procedures

A sentence-picture matching comprehension task was used. For each sentence, subjects were presented with two pictures representing action relationships between two actors (one Agent and one Theme) both of whom could perform the action with equal plausibility. Since each picture was encountered more than once, the Agent was reversed half the time so that it would not be possible for subjects to guess the answer based on previous experience.

Of the two pictures for each sentence, one matched the corresponding test sentence. The second picture represented the same actors in inverse thematic relation.

Task instructions and test sentences were presented by native speakers in single sessions with each individual. Subjects were requested to look at the two pictures, listen to a sentence, and point to the picture that best matched the sentence. The order of presentation of sentences was random except that more than two sentences of the same type were not adjacent to one another.

5. Predictions

The predictions for the active sentences (including the Spanish control sentence, the clitic doubling active) are provided in Table 1.

Table 1
Predictions for Scrambled Actives

Structure	TDH	DDH
Korean & Spanish Scrambled Active	Below	Chance
Clitic Doubling Active (Span Control)	Above	Above

Table 2 presents a summary of the predictions for each account on scrambled passives.

Table 2
Predictions for scrambled passives

Structure	TDH	DDH
Korean & Spanish Scrambled Passive	Above	Chance

6. Results

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Table 3 presents the raw scores for the three Korean patients (KTS, JJP, and KKM) and the two Spanish patients (FER and FCO). The simple actives and passives which formed part of the screening test also serve as controls.

Table 3
Raw scores for each patient by sentence type (correct out of 20)

Structure	JP	TS	KM	ER	CO
Active (Control)	17	16	18	14	16
Active Scrambled	11	11	13	15	7
Clitic Doubling (Control)	-	-	-	16	18
Passive (Control)	13	11	7	12	11
Passive Scrambled	10	10	11	10	16

Comparing actual performance on each sentence-type with chance (set at 50%), a t-test revealed the pattern given in Table 4. It may be seen from this table that patients who consistently perform above chance on simple actives (and, for the Spanish patients, on clitic-doubling actives), nevertheless perform at chance on scrambled actives, and patients who perform at chance on simple passives also perform at chance on scrambled passives in both Spanish and Korean.

Table 4
Significance patterns for agrammatic performance compared with chance

Sentence Type	Spanish	Korean
Actives (screening/control)	$p < .01$	$p < .01$
Clitic-Doubling Actives (control)	$p < .01$	--
Scrambled Actives	ns	ns
Passives (screening/control)	ns	ns
Scrambled Passives	ns	ns

Pooling the Spanish and Korean data on actives, scrambled actives, passives, and scrambled passives, an ANOVA showed no significant difference for patients, but did reveal a significant difference for sentence-type, $F(3,16)=5.50$, $p<.008$. Post hoc analysis, using LSD, indicated that simple actives were significantly different from the other three sentence types, none of which were significantly different from each other.

Finally, Table 5 provides a comparison of the outcomes on the experimental sentences (the scrambled actives and passives) and the predictions made by the two accounts at issue in this paper. What is striking is that these results are conducive only to the DDH whose predictions are consistent with fact in each case. The TDH is frustrated because its predictions are contrary to fact in both scrambled active and scrambled passive conditions.

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Table 5
A comparison of predictions and results

Sentence Type	TDH	DDH	FACT
Scrambled Actives	Below	Chance	Chance
Scrambled Passives	Above	Chance	Chance

7.   Discussion

The crosslinguistic data reported here support the hypothesis that competing referential dependencies are preferable candidates for the locus of impairment in Broca's aphasics than what is offered in the linear TDH.

Earlier, we talked about culling accounts of agrammatic comprehension by pitting them against each other. Evidence that bears unevenly on different accounts is exactly the sort of evidence that is required if progress is to be made in eliminating rival models from the candidate pool. The evidence from scrambling structures in Spanish and Korean certainly bears unevenly on the TDH and the DDH, favoring only the DDH and finding clearly against the TDH.

Linearity, we submit, is not a concept that is relevant to discussions of aphasic comprehension deficits, on both empirical and conceptual grounds. First and foremost, the evidence is solidly against it. Secondly, a consensus is forming that agrammatics retain much, if not all, of their syntactic knowledge—indeed, this view is held by the proponent of both the TDH and the DDH. An important consequence of this view, however, is not always fully appreciated. If structural knowledge is largely intact, then it suggests that structure-building processes are also substantially preserved in comprehension. It would be truly astonishing if agrammatics were able to understand all of the structures that they do without extensive resources for structural analysis. Agrammatic comprehension of actives, clitic-doubling actives, subject relatives, subject clefts, adjectival passives, raising constructions, to name but a few, has been well-established (many studies report such findings, but see for example Beretta et al. 1999, Beretta and Campbell In Press, Grodzinsky, Pierce and Marakovitz 1991). Assume, then, that in order to understand these structures, they must possess resources to perform considerable structural analysis. The question immediately arises as to where these resources come from. The most parsimonious explanation is that they were always there, but now perhaps limited following brain damage. If we adopt this line of reasoning, then we are committed to grounding our approach to agrammatic comprehension in relation to a model of normal comprehension.

Not all models assume this, the TDH for example. As Friederici and Gorrell observe, a weakness of the TDH is that "it lacks any connection to theories of sentence comprehension in normals" (1998:260).

It might be asked how aphasics come to be guided by the proposed linear default strategy given how little evidence there is for it in normals. And what would be the motivation to try to develop an extralinguistic theory of linear heuristics absent any demonstration that aphasics use processes that are different from those used by normals?

With regard to the DDH, while it is true that it has yet to be determined if the relevant processing deficit is something quite specific, related to the marking of co-reference relations, or something more general related to complexity and computational cost, nevertheless, because it is framed in purely structural terms, it attempts, in Frazier and Friederici's words, "to honor the grammar" (1991:60). In our view, the conclusion to draw is that the DDH has at least started off on the right foot.

To conclude, our objection to linear approaches to agrammatic comprehension is partly conceptual. We see little motivation for proposals that shun normal processing. This in itself would not mean that they are wrong. Hence the experiment reported here.

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Empirically, it has been demonstrated that the linear TDH just does not work. The alternative, to pursue more structural (non-linear) approaches—and the DDH meets the case here rather well—and seek to establish a connection to normal processing is more likely to prosper.

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Appendix
Details of the Korean and Spanish patients

KTS: DOB October 1949, period post onset 5 years. Diagnosed as Broca's aphasic by clinical workup. CT, acute left middle cerebral artery infarction. Right-handed. Severe right hemiparesis. Kyunghee University Medical Center, Seoul

KKM: DOB August 1942, period post onset 9 years. Diagnosed as agrammatic by clinical workup and Western Aphasia Battery. CT, left frontal and anterior parietal infarct. Right-handed. Moderate right hemiparesis. Kyunghee University Medical Center, Seoul

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JJP   DOB May 1962, period post onset 4 years. Diagnosed as Broca's aphasic by clinical workup. MRI, left middle cerebral artery infarct. Right-handed. Slight hemiparesis. Kangdong Sacred Heart Hospital, Seoul, Korea.

FER: DOB October 1947, period post onset 3 years. Diagnosed as Broca's aphasic by clinical workup and BDAE. CT, left middle cerebral artery infarct. Right handed. Right hemiparesis. Clínica ADACEN, Navarra.

FCO: DOB February 1965, period post onset 7 years. Diagnosed as Broca's aphasic by clinical workup and BDAE. CT, left middle cerebral artery infarct. Right handed. Clinica ADACEN, Navarra.

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