

# SYNTACTIC THEORY AND SENTENCE PROCESSING\*

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As linguistic theory becomes more refined, linguists increasingly rely on subtle judgments about slight acceptability differences among complex sentences as the sole evidence motivating interesting grammatical hypotheses. It thus becomes increasingly important to make informed decisions about the role of processing factors in determining acceptability judgments in order to correctly identify the source of acceptability differences and to make appropriate assumptions about the division of labor between a theory of competence and theories of performance. Three areas are discussed where the results of sentence processing studies may constrain the appropriate grammatical treatment of linguistic phenomena: d-linking, focus and morphosyntactic feature manipulation.

## 1. PRELIMINARIES

In the early days of generative grammar, processing theory was almost entirely dependent on syntactic theory not only in drawing specific predictions but also in the flow of ideas. Most experimental studies attempted to show that processing complexity was a function of the derivational complexity of the sentence (see Fodor, Bever and Garrett's, 1974). Even today many linguists hope for the perfect 'demonstration' experiment – a single experiment that would convincingly prove the validity or invalidity of a particular grammatical hypothesis. Occasionally, a convincing argument of this sort can be made. For example, Kennison (submitted) notes that arguments generally are processed faster than adjuncts. She then shows that *by*-phrases in event nominals are processed faster than *by*-phrases in nonevent nominals, supporting Grimshaw's analysis where *by*-phrases are arguments only in the event nominals. Generally however the demonstration approach strikes me as being naive. Data do not wear their interpretation on their sleeve. Whether the data are gathered experimentally or not, various

interpretations of the data may exist depending on the particular framework of linguistic and processing assumptions in which the data are interpreted.

Why, then, would a syntactician be interested in going beyond the traditional source of linguistic evidence, intuitional data, to consider processing studies? One reason is that actual language data, intuitional or not, are always a reflex of both linguistic knowledge and processing. Determining whether an unacceptable string is ungrammatical, or just difficult to process, is largely a theoretical decision: it is a matter of which theory best accounts for the badness of a string and results in the best overall theory of language.

Another reason for a syntactician to be concerned with sentence processing is that processing data can provide a source of constraint on the best syntactic theory. Today there exists a large body of evidence on syntactic processing complexity, ambiguity resolution principles and the principles that guide syntactic analysis. Consequently it is no longer trivial to account for some problematic data by adopting some processing assumption just because it is convenient for the present purpose. Too much other data must be explained simultaneously. This is progress, of course. It means that by paying attention to the large body of linguistic and psycholinguistic evidence that must be explained, the range of viable grammatical and processing hypotheses can be narrowed down considerably. But in the end, perhaps, the most important reason for studying processing as well as grammatical representation is that it can help us to understand how language works. It can lead to a fuller picture of human language abilities and guide attempts to explain why grammars exhibit the particular properties they do.

In sum, syntacticians are making implicit decisions about what belongs in the grammar and what should be accounted for in a processing theory. Hence, why not make informed decisions? Further, by explicitly evaluating grammar-processor pairs a new source of constraint is added to the endeavor to understand language –a welcome outcome. Last but not least, processing is interesting and can help us understand language better. So read on.

In what follows three lines of investigation will be summarized. In part these studies have been selected simply because they are what my colleagues and I happen to have been working on recently. But in each case, there are implications for linguistic theory which I shall attempt to draw out.

## 2. D-LINKING

Pesetsky (1989) classified interrogative phrases as ‘d-linked,’ for discourse-linked (which man), or ‘non-d-linked’ (*who*). D-linked phrases imply the existence of an already available set of the type of the nominal (men) in the discourse representation and ask for a subset from this set. Non-d-linked phrases do not. He presented the examples in (1) noting that in (1b) “it is natural, almost obligatory, to assume that the question is asking for a choice among the men who entered the room.” In (1c), “considerations of textual correctness make this assumption possible but much less natural.” (Pesetsky, 1989: 120).<sup>1</sup>

- (1) (a) Some men entered the room. Mary talked to them.  
 (b) Some men entered the room. Which (ones) did Mary talk to?  
 (c) Some men entered the room. Who did Mary talk to?

Discussing *wh*-in-situ, Pesetsky notes that non-d-linked interrogatives obey Superiority which requires the higher of two phrases –*who* in (2)– to move at surface structure, as indicated in (2).

- (2) (a) Mary asked [*who*<sub>i</sub>[*e*<sub>i</sub> read what]]?  
 (b) \*Mary asked [*what*<sub>i</sub>[*who* read *e*<sub>i</sub>]]?

Surprisingly d-linked phrases may violate Superiority, as illustrated in (3).

- (3) (a) Mary asked which man<sub>i</sub> [*e*<sub>i</sub> read which book]?  
 (b) Mary asked which book<sub>i</sub> [which man read *e*<sub>i</sub>]?

Pesetsky attributes the contrast between (2b) and (3b) to the need for non-d-linked phrases to raise at LF (which is constrained by Subjacency) whereas the d-linked phrase need not raise at LF to obtain an interpretation.

In a variety of studies, my colleagues and I have been investigating the effect of d-linking on sentence processing. The investigation began with a surprising finding (Frazier, Plunkett and Clifton, 1996) that emerged in a reading comprehension study of reconstruction sentences like those in (4), where the “/” indicates frame breaks used for self-paced presentation of the sentences.

- (4) (a) Which rumor about herself did / the actress / claim / the newspaper / made up?  
 (b) Which rumor about herself did / the newspaper / claim / the actress / made up?  
 (c) Which rumor about herself did / the matron / claim / the actress / made up?  
 (d) Which rumor about herself did / every actress / claim / the newspaper / made up?  
 (e) Which rumor about herself did / the newspaper / claim / every actress / made up?  
 (f) Which rumor about herself did / the matron / claim / every actress / made up?

The reflexive must be bound by the matrix subject in (4a), by the embedded subject in (4b) and it is ambiguous in (4c). In (4d-f), the definite determiner in the *actress* was replaced by the universal quantifier *every*, resulting in a quantified antecedent in the unambiguous sentences (4d,e) and either a definite antecedent or a quantified antecedent in the ambiguous (4f).

Subjects were instructed to read the sentences at their own pace. After each sentence a two-choice question about the choice of antecedent appeared (Who was the rumor about?) along with two definite singular alternative answers (*The actress, the newspaper*). The results revealed a strong preference for matrix subject antecedents. Reading times for unambiguous matrix subject sentences averaged 85 ms/character and were significantly faster than reading times for unambiguous embedded subject antecedents which averaged 93 ms/character. (Here and throughout I will omit the statistical analyses of experimental results, referring the reader to the original studies for details. Only results reaching conventional levels of significance are reported.) Answers to questions about ambiguous sentences also revealed a preference for matrix subject antecedents (70%). Even the question-answering accuracy reflected an advantage for matrix-subject antecedents (93% vs. 69% correct). Surprisingly, in question-answering accuracy there emerged a significant interaction of antecedent position and antecedent type (definite vs. universal quantifier): subjects had particular difficulty with embedded antecedents that were universally quantified (4c). (See Frazier, Plunkett and Clifton (1996) for details.)

Imagine that perceivers set up a singular discourse representation for the d-linked interrogative by the time they encountered the embedded clause in (4). In (4d) this discourse assumption will have to be retracted

once the embedded clause is read due to the universally quantified embedded subject antecedent. This “Discourse Assumption Retraction Hypothesis” could explain the observed interaction where embedded subject antecedents are particularly difficult to process when the antecedent is universally quantified.

To test this hypothesis, Frazier et al. performed another self-paced reading study using sentences like those in (5).

- (5) (a) Which boy did Tom say that every girl saw?  
(b) Which boy did Tom say that every girl married?  
(c) Who did Tom say that every girl saw?  
(d) Who did Tom say that every girl married?

The Discourse Assumption Retraction Hypothesis predicts that by the time the embedded clause is read, a singular discourse representation will have been postulated in (5a,b) with d-linked interrogatives, but by hypothesis not for non-d-linked interrogatives in (5c,d). In (5a,c), the embedded verb *see* is neutral about the pairing of girls and boys. Either a one-one or a many-one relation is possible. By contrast, the embedded verb *marry* in (5b,d) is biased to a one-one pairing of girls and boys. Hence in (5b), where the processor will have set up a singular discourse representation for the d-linked interrogative, perceivers should have difficulty when they encounter the biased verb *marry*. In order to assign a plausible (one-one) interpretation to (5b), it will be necessary to retract the already made discourse assumption. In short, we expected the form of the interrogative (d-linked vs. non-d-linked) and the type of embedded verb (neutral vs. biased) to interact. As expected, the biased verb did slow the reading of the questions with a d-linked interrogative (5b) relative to (5a) but the biased verb did not slow the reading of sentences with non-d-linked interrogatives, i.e., (5d) took no longer to read than (5c).

What is interesting about these results? They suggest that Pesetsky is correct that d-linking is an important property of interrogative phrases. Further, a d-linked interrogative carries its own context which can be observed even in the processing of a sentence presented in isolation. To my mind, this is not a trivial conclusion. One might have thought that d-linked interrogatives would determine the form of the syntactic representation that perceivers construct for a question and that d-linking would constrain the distribution of questions in discourse but would not otherwise influence the processing of a question presented without context.

The idea that d-linked interrogatives are instantiated in the discourse representation shortly after they are encountered receives support from further studies. Clifton and Frazier (in progress) conducted a written questionnaire study using non-d-linked (a) and d-linked (b) versions of embedded and matrix question, as illustrated in (6) and (7).

- (6) (a) Rick knew who Janice sang a song to before he went to sleep.  
 (b) Rick knew which brother Janice sang a song to before he went to sleep.
- (7) (a) Who did Bradley send a rifle to when he was threatened?  
 (b) Which guy did Bradley send a rifle to when he was threatened?

Each item contained a feminine or masculine personal pronoun with two potential antecedents: the wh-phrase or a noun phrase matching the pronoun in gender and number. Each sentence was followed by a two choice answer: *Who went to sleep? Rick — The person Janice sang a song to.*

If the d-linked interrogative leads the processor to rapidly postulate a discourse entity but the non-d-linked interrogative does not, then the personal pronoun should take the d-linked interrogative as its antecedent more often than the non-d-linked interrogative assuming that pronouns readily take discourse antecedents. The prediction was confirmed: there were 56% wh-antecedents for d-linked (b) examples versus 41% for non-d-linked (a) examples.

The materials from the questionnaire study were then disambiguated by changing the gender of the non-wh antecedent, as illustrated in (8) and (9), for presentation in a self-paced reading study.

- (8) (a) Rick knew who John sang a song to / before she went to sleep.  
 (b) Rick knew which sister John sang a song to / before she went to sleep.
- (9) (a) Who did Barbara send a rifle to / when he was threatened?  
 (b) Which guy did Barbara send a rifle to / when he was threatened?

By hypothesis, in the d-linked (b) examples, the pronoun may find an antecedent in either the syntactic representation or the discourse representation. In the non-d-linked (a) examples, only a syntactic representation should be available. Thus we expected a reading time advantage for the d-linked examples. Reading times for the second

presentation segment confirmed this expectation (58.5 vs. 62.9 ms/character). Pronouns often do take discourse antecedents. Thus it is not surprising that d-linked antecedents are favored over non-d-linked ones in cases of ambiguity and, if d-linked interrogatives, but not non-d-linked ones are rapidly instantiated in the discourse representation, the speed advantage for d-linked antecedents is also explained.

The studies reported above have examined the effect of d-linked phrases on the processing of subsequent material. In another study, Clifton and Frazier (in progress) have examined differences between d-linked and non-d-linked phrases in terms of how they access linguistic representations. The basic idea behind d-linking is that d-linked phrases imply the existence of a context set of familiar entities of the type denoted by the associated nominal. From this observation we expected that d-linked phrases should be able to readily access discourse representations more easily than non-d-linked interrogatives can. To test this expectation we constructed sentences like those in (10) for presentation in a written questionnaire.

- (10) (a) Some girl saw that the principal hit some boy.  
 Guess who.  
 a. Who = which girl                      b. Who = which boy
- (b) Some girl saw that the principal hit some boy.  
 Guess which one.  
 a. Which one = which girl    b. Which one = which boy
- (c) Some girl saw the principal who hit some boy.  
 Guess who.  
 a. Who = which girl                      b. Who = which boy
- (d) Some girl saw the principal who hit some boy.  
 Guess which one.  
 a. Which one = which girl    b. Which one = which boy

In (10a,b) either the matrix subject or the embedded object is a potential antecedent for the interrogative in the sluiced sentence (see Chung, Ladusaw and McClosky, 1995 on the linguistic analysis of sluicing, see Frazier and Clifton (in press) for other experimental studies of comprehending sluiced sentences). In (10c,d) the embedded object occurs inside a relative clause –a position we assume is not readily accessible in the syntactic representation. Assuming that d-linked phrases may readily

access the discourse representation but that non-d-linked phrases cannot, we expect that fewer embedded object-antecedent responses should occur in (10c) than in (10a). By contrast, placing a potential antecedent in a syntactically inaccessible position should have little or no effect for d-linked interrogatives which may access the discourse representation. Hence (10d) should not receive substantially fewer object antecedent responses than (10b). These predictions were confirmed. Subjects were asked to select from two choices, e.g. "a. Who = which girl" or "b. Who = which boy". The embedded object was chosen most often (60% or more) in all examples except (10c) where it was chosen only 41% of the time.

Five studies have been presented showing that d-linking influences the processing of interrogatives. D-linking may interact with quantifiers, verb biases (*saw* vs. *marry*), selection of antecedents of pronouns, the ease of processing pronouns with *wh*- antecedents and the probability or ease of accessing discourse representations. But how, the reader may ask, do these results impinge on linguistic theory?

Acceptability judgments, the standard data of linguistic theory, are influenced by processing factors. This is uncontroversial in the extreme case of unparseable sentences such as multiple center-embedded sentences (e.g. #*"Dogs rats cats ate liked die"* versus *"The vase the man you met bought broke"*). But more subtle processing difficulties may also influence acceptability judgments especially when the processor must give up an already computed representation (see the Discourse Assumption Retraction Hypothesis discussed above). A better understanding of processing can guide the interpretation of acceptability data, informing the division of labor between the grammatical and the processing theory. In gathering crosslanguage data on *wh*-effects, the current results suggest caution in designing questions with pronouns. Properties of the pronouns as well as properties of the interrogative phrases may influence acceptability judgments for reasons irrelevant to the intended manipulation, given that not all interrogatives behave alike with respect to the ease of processing the *wh*-antecedent of a pronoun, as shown above. As linguistic theory becomes more refined, the data used to motivate hypotheses have also become more subtle with comparative judgments of slight differences in acceptability often the sole evidence for extremely interesting grammatical hypotheses. As more is learned about the processing of complex syntactic structures, we can factor out or control for more properties of sentences that may obscure grammatical properties of interest. And, I assume, grounding linguistic

theory on a more secure empirical base can only sharpen our grammatical insights.

The other implication of the above processing studies is that they highlight questions about the properties responsible for the behavior of d-linked phrases. It is unclear at present whether the behavior of d-linked phrases can be derived from the semantics of *which*. Another possibility is that many properties of d-linking, those associated with its rapid discourse instantiation, are due to the presence of a nominal with a determinate interpretation for the number feature.

Compare (11) and (12).

(11) Who was at the party last night?

(12) Which student was at the party last night?

In (11) the use of the singular feature may be a default. The speaker may in fact suspect that several people were at the party last night. However, in (12), the speaker does imply that just a single student was at the party. If phrases with a determinate number interpretation are rapidly instantiated in the discourse representation, then much of the d-linking behavior of *which N'* may be tied to the presence of a nominal marked for nondefault number.

Yet another possibility is that the d-linking of *which N'* follows not from its semantics or the interpretation of number but from pragmatics. How phrases are typically used may well guide perceivers' assumptions about their likely interpretation.

My purpose here is not to choose between the alternative grammatical analyses underlying d-linking but merely to point out that current grammatical hypotheses have explored the consequences of d-linking, e.g., for the representation of wh-in-situ, but they have not explored the underlying source of d-linking. I assume that ultimately the classification of interrogatives as d-linked, or not, will follow from the other properties of an interrogative and not need to be stipulated.

Before turning away from the discussion of d-linking, it should be noted that De Vincenzi (1991, 1996) reports extremely interesting studies of the effects of d-linked wh-phrases in Italian. Briefly she argues that only non-d-linked phrases obligatorily enter into chains. A series of reading studies are presented to support this claim. Assuming that moved d-linked phrases do obligatorily enter into chains in English, then we must either conclude that the grammar of d-linking is not universal or that Italian does, but English does not, contain a null pronominal that may

access discourse antecedents. (See De Vincenzi [1989] and references therein.)

### 3. FOCUS

It has been known for some time that focus influences sentence processing. Information is verified more quickly and accurately if it occurs in a focused constituent than if it occurs in a nonfocused constituent (Hornby, 1972, 1974). In monitoring tasks, responses are faster to items that are focused regardless of whether focus is conveyed by a pitch accent (Cutler and Foss, 1979) or conveyed semantically by a preceding question (Cutler and Fodor, 1979).

Focus is expressed differently in different languages. English relies heavily on pitch accents for expressing focus, whereas Hungarian has a syntactic focus projection (Radó, 1997). Apparently many Romance languages exploit word order differences in conveying focus. In other languages focus morphemes exist. Here I will concentrate on English and describe several recent psycholinguistic studies that elucidate some of the roles focus plays in sentence processing.

In English a pitch accent, which may be either a high tone or a low tone (H\*, L\*) or some combination of these, introduces a focus feature (F) in the syntax. This focus feature may project from an internal argument to the head of a phrase and from a head to its maximal projection (Selkirk, 1984, 1995). In an auditory acceptability judgment study, Schafer (1996) tested this hypothesis about focus projection, along with the Bounded Projection Hypothesis in (13).

#### (13) Bounded Projection Hypothesis (Schafer, 1996)

F-marking cannot project beyond the prosodic phrase which contains the accented material.

Some predictions of the Bounded Projection Hypothesis are illustrated in (14), where parentheses indicate the prosodic phrasing of the sentence and square brackets indicate the focal structure of the sentence. A pitch accent on POTATOES may not project, as in (14a), or it may project to the NP headed by POTATOES (14b).

- (14) (a) (The farmer delivered)(some [POTATOES]<sub>FOC</sub>)  
 (b) (The farmer delivered)([some POTATOES]<sub>FOC</sub>)  
 (c) \*(The farmer [delivered])(some POTATOES]<sub>FOC</sub>)  
 (d) \*([The farmer delivered])(some POTATOES]<sub>FOC</sub>)

In principle, the F-feature might project from the direct object (to the verb and on) to the VP, as in (14c), given Selkirk's projection rules. However, according to Schafer's Bounded Projection Hypothesis, the prosodic phrase boundary before the direct object prevents projection to the VP in (14c) or to the entire sentence (14d).

The actual materials Schafer tested are illustrated in (15). (She also tested conditions with an accent on the verb which will not be discussed here.)

- (15) (a) What did the farmer deliver?  
(The farmer delivered)(some POTATOES)  
(b) What did the farmer do?  
(The farmer delivered)(some POTATOES)  
(c) What did the farmer deliver?  
(The farmer)(delivered some POTATOES)  
(d) What did the farmer do?  
(The farmer)(delivered some POTATOES)

In (15a,c) the question focuses the direct object; in the remaining forms (15b,d) the question focuses the VP. The answer in (15a,b) allows for NP focus but not VP focus, because F-marking cannot project beyond the prosodic phrase boundary. Hence, (15a) with a NP-focus question should be natural but (15b), with a VP-focus question, should not be. The answer in (15c,d) contain a prosodic phrase boundary before the VP. Hence, the F-marking may project only to the NP (15c) or to the VP (15d). Hence both (15c) and (15d) are predicted to be natural.

48 subjects were asked to listen to question-answer pairs like those in (15) and rate their naturalness on a 5-point scale. As predicted, a significant interaction emerged, with (15b) judged as the least natural of the pairs in (15).

Schafer's results are informative in two respects. The naturalness of (15c) and (15d) provides evidence that the F-feature may project to higher constituents. The unnaturalness of (15b) relative to the other forms indicates that the F-feature may not project beyond a prosodic phrase boundary. These conclusions are of interest in their own right. They also suggest a certain caution in eliciting judgments of written sentences. Much linguistic argumentation is supported by intuitions of sentences presented in written form without clear indication of their intended focal structure and with little concern for controlling factors like the length of the constituents which probably influence the reader's placement of

prosodic phrase boundaries. Yet clearly these factors influence the acceptability of sentences. (See especially the discussion of ellipsis below.)

Focus placement also influences the analysis assigned to syntactically ambiguous sentences. Schafer, Carter, Clifton and Frazier (1996) examined the processing of complex DPs followed by a relative clause, as illustrated in (16).

(16) The reporter recently interviewed the sister of the senator who was so controversial.

In one auditory comprehension study, they showed that placement of an accent on the head of the entire complex DP favored high attachment of the relative clause whereas an accent on the lower DP (senator) favored low attachment. In a second study, they showed that the nature of the accent also matters. An accent appropriate for contrastive material (L+H\*) had a stronger effect than an accent appropriate for new material (H\*).

In a series of comprehension studies of sluicing, Frazier and Clifton (in press) found that both recency and focus influence the interpretation of sluiced sentences, such as (17).

(17) (a) Somebody claimed / that the president fired someone, / but nobody knows who.

(b) Somebody claimed / that the president fired Fred, / but nobody knows who.

In a self-paced reading study, the final segment of (17) was read faster when the embedded object was indefinite, as in (17a) and thus could serve as the "inner antecedent" in the elided question, than when the embedded object was definite, as in (17b), and thus only the matrix subject could serve as the "inner antecedent". Frazier and Clifton hypothesized that the embedded object is a preferred "inner antecedent" because it is more recent than the alternative (the matrix subject) and because the embedded object is likely to be focused (whereas the matrix subject, as default topic, is not). To test this hypothesis, they conducted an auditory questionnaire study using sentences like (17a). The placement of a pitch accent was manipulated. Either it occurred on embedded object or on the matrix subject. Perceivers tended to select the embedded object inner antecedent when the object was focused (69% object antecedent responses) but not (only 46% object antecedent responses) when the matrix subject was focused. Thus it appears that recency and focus both influence the selection of an inner antecedent in processing sluiced

sentences. In short, focus placement influences both the difficulty of processing unambiguous structures like (17b) and it influences the preferred analysis of syntactically ambiguous structures.

The final study of focus to be discussed here was conducted by Kathryn Carlson, a graduate student at the University of Massachusetts. Carlson (1997) has been investigating the availability of the gapped reading of sentences like (18) in written and auditory studies.

- (18) (a) Josh visited the office during vacation and Sarah during the week.  
 (b) John visited Marjorie during vacation and Sarah during the week.

In a written questionnaire, subjects were asked to choose a paraphrase for each sentence and to indicate whether the sentence could mean anything else. For sentences like (18a) with an inanimate object in the first clause, 35% of the responses indicated a gapped reading ("Sarah visited the office during the week") with 43% of these indicating that a nongapped or VP-conjunction reading was also possible.<sup>2</sup> For sentences with an animate object in the first clause (18b), only 4.6% of the responses indicated a gapped reading. This result is dramatic given that the animacy of the object is not really expected to be relevant to the grammatical status of these structures. Indeed, Carlson argued that the difficulty of gapped structures is based on the general preference for perceivers to compute the simpler syntactic structure (conjoined VPs). Factors like the non-parallelism of the first and second clause, say, in the animacy of the direct object and the DP after *and*, can provide evidence in favor of the structurally unpreferred (gapped) analysis.

In a follow-up study, Carlson presented subjects with sentences like (18b) spoken with an ambiguous prosodic structure, which had an accent on each DP and downstepping throughout the sentences. With ambiguous prosody, the results closely mirrored the results of the written study. However she also tested sentences like (19) with a prosody biased toward the gapped structure by placing contrastive accent (L\*H-) on the subject of the first clause (19a) or prosody biased to a nongapped structure (19b), with an accent on the direct object of the first clause. In all cases, the DP following *and* was accented.

- (19) (a) BOB insulted the guests during dinner and SAM during the dance.  
 (b) Bob insulted the GUESTS during dinner and SAM during the dance.

There was a highly significant effect of prosody. With the prosody in (19a) 44% of the responses indicated a gapped reading whereas in (19b) only 27.5% did. The close comparability of the results for the written questionnaire and the ambiguous prosody sentences in the auditory study suggests that a default prosody lacking contrastive accents may have been assigned by readers in the written study. (See Bader (in press) for further evidence that default accent assignments are made by readers.)

In linguistics, gapped structures like those in (18) and (19) have at times been considered to be ungrammatical (see Hankamer, 1971). But Carlson's results suggest a different picture. Perceivers preferentially assign a minimal syntactic structure (VP conjunction) and revise this structure only when there is evidence favoring the alternative (gapped) structure. Parallelism in the corresponding arguments of the two conjuncts (e.g. the animacy of the direct objects) is one form of evidence. A prominent or contrastive pitch accent on corresponding arguments in the two conjuncts is another form of evidence. On this view gapped structures like (18) and (19) are perfectly grammatical, much like multiply center embedded sentences. They are just difficult to process. Drawing out judgments of grammaticality in such cases may require a detailed understanding of processing mechanisms so that processing complexity can be minimized.

#### 4. FEATURE-CHECKING

In the Minimalist Program, syntactic differences among languages are largely relegated to one type of parameter, namely whether inflectional features are "strong", hence checked at surface structure, or "weak" and checked at LF. Coupled with the assumption that features are checked only in particular Spec-head configurations, this view attributes features a central role in motivating movement and more generally in determining syntactic wellformedness.

In sentence comprehension studies, the role of features has not been particularly prominent. There exist various indications that features may not be critical to the initial construction of a syntactic representation of an input. Instead features may contribute to the evaluation of that structure (see Deevy, in progress; and the data in Deutch, in press).

For the purpose of developing an explicit account of sentence comprehension, the hypothesis that features are checked in Spec-head configurations is not sufficiently detailed. How does this checking occur? Are features passed through the phrase marker? For example, in checking subject-verb number agreement, does the number of the subject get passed

from N to NP (= Spec TP) to TP and down to T? Alternatively, does the processor simply cosuperscript Spec TP and T (or something comparable) and enforce the feature compatibility of the cosuperscripted nodes? [Note: The node labels are not at issue here. Substitute AgrP for TP if you like.]

Clifton, Frazier and Deevy (in press) have been exploring these alternatives by exploiting an observation made by Kimball and Aissen (1971).

- (20) (a) (\*)Lucine dislikes the people who the manager think know the answers.  
 (b) Lucine dislikes the people who the managers think know the answers.  
 (c) \*Lucine dislikes the people who think the manager know the answers.  
 (d) Lucine dislikes the people who think the managers know the answers.

Kimball and Aissen reported that (20a) is acceptable for them despite the local number mismatch between the subject and verb in the relative clause. But the mismatch between a plural verb (*think*) and a singular subject (*the manager*) is allowed only if it is on the extraction path between the (plural marked) relative pronoun and its trace.

For Clifton and co-authors (and the subjects they tested), (20a) is ungrammatical. Nevertheless (20a) is not on a par with the flagrantly bad (20c). Clifton et al. hypothesized that the processor had difficulty rejecting (20a) because the plural feature on *who* is passed down the tree as illustrated in Figure 1.

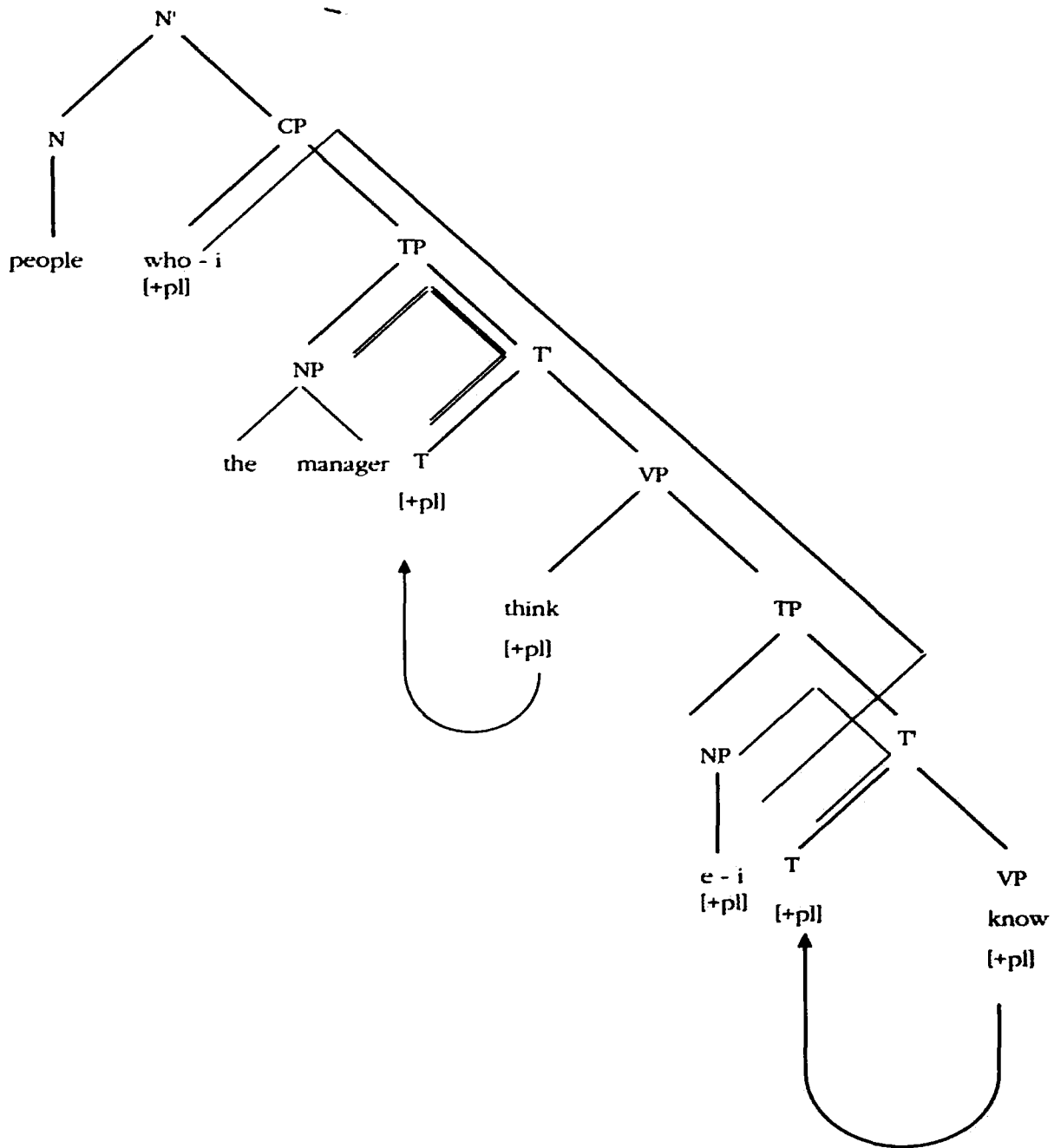


Figure 1.

When the processor is checking the agreement of *think* in T, it appears that the plural *think* is legitimate because T' is marked with a plural feature. To test this possibility, Clifton et al presented sentences like those in (20) in a visual word-by-word incremental grammaticality judgment task, where the subject presses a "yes" button for each word of the sentence providing that the sentence is still grammatical. If the sentence becomes ungrammatical the subject is to press a "no" button and presentation of the sentence stops. The experimental items were embedded in a list of 102 sentences, of which 28 were clearly ungrammatical and another 20 were only marginally acceptable.

Assuming that subjects pass features down the tree from the relative pronoun to its trace, then the ungrammaticality in (20a) should be more difficult to detect than the ungrammaticality in (20c). As expected, (20a) was rejected slightly, but significantly, less often than (20c). To check the interpretation of the result, Clifton et al. then manipulated the number of the relative pronoun, as in (21).

- (21) (a) (\*) Lucine dislikes the people<sub>i,pl</sub> who<sub>i,pl</sub> the manager<sub>sg</sub> think<sub>pl</sub> e<sub>i</sub> know<sub>pl</sub> the answers.  
 (b) Lucine dislikes the people<sub>i,pl</sub> who<sub>i,pl</sub> the managers<sub>pl</sub> think<sub>pl</sub> e<sub>i</sub> know<sub>pl</sub> the answers.  
 (c) \*Lucine dislikes the person<sub>i,sg</sub> who<sub>i,sg</sub> the manager<sub>sg</sub> think<sub>pl</sub> e<sub>i</sub> knows<sub>sg</sub> the answers.  
 (d) Lucine dislikes the person<sub>i,sg</sub> who<sub>i,sg</sub> the managers<sub>pl</sub> think<sub>pl</sub> e<sub>i</sub> knows<sub>sg</sub> the answer.

If (21a) is difficult to reject because the processor is confused about the source of the plural feature on TP or T', then a sentence like (21c) should be easy to reject because no plural feature is passed down the tree. In an experiment like that described above, (21a) was rejected less accurately than (21c).

In short, the difficulty perceivers have in rejecting sentences like (21a) has been attributed to a confusion which results because number features are passed through the syntactic phrase marker. Simply holding an unassigned plural filler in memory does not give rise to the effect. Although these results are preliminary (we are currently planning auditory counterparts to these studies), the results are intriguing. What they suggest is that (i) marked features (plural) are passed through the tree, and (ii) links shared by two 'feature paths' can interact during processing.

[+wh] is a marked feature. Imagine that it interacts with other [+wh] feature paths, e.g. in (22).

- (22) (a) Who<sub>i</sub> did John give t<sub>i</sub> what?  
 (b) What<sub>i</sub> did John give who t<sub>i</sub>?

In (22a), the chain headed by *who* is terminated before another wh-element is encountered. By contrast, the Superiority violation in (22b) has a chain headed by *what* which is not terminated until after another wh-element has been processed. One might speculate that judgments indicating a slightly degraded status for (22b) might be influenced by the interaction of the features of the animate and inanimate interrogatives at surface structure on a par with the interaction of plural features established above.

My purpose here is not to convince you that feature confusability contributes to an explanation of Superiority effects. The point is only to raise the possibility that a better understanding of actual feature manipulation in sentence processing could be helpful in distinguishing the multiple wh-effects that must be explained in the grammar from those that may arise due to difficult or confusing processing operations.

## 5. SUMMARY

To summarize, studies of d-linking suggest that the words or phrases of a sentence may carry their own context. Hence, discourse effects can be observed even for a sentence presented in isolation. D-linked phrases are rapidly instantiated in a discourse representation and therefore make better antecedents for pronouns than non-d-linked phrases do. Results from sluicing further suggest that d-linked phrases can access prior context in the discourse representation more readily than non-d-linked phrases can. D-linking has been shown to interact with a variety of apparently irrelevant properties of a sentence, including the processing of universal quantifiers in particular positions, verb biases, pronoun interpretation and antecedent selection in sluiced sentences.

Focus also influences sentence processing. It can influence acceptability judgments for spoken and written sentences and determine the preferred analysis of ambiguous sentences. Evidence from Schafer indicates that F-marking in the syntax can project to higher phrases but not beyond a prosodic phrase boundary.

Feature-checking during sentence comprehension is only now being investigated systematically. Preliminary evidence indicates that marked features (plural, [+wh] but not singular or [-wh]) may be passed through the phrase marker, resulting in perceptual confusions when one branch of the phrase marker participates in more than one 'feature path'. It was

speculated that a better understanding of feature passing mechanisms may ultimately bring a new perspective on multiple wh-effects.

Could linguists investigate a grammatical process, say wh-movement, without considering the processing effects of d-linking, focus, or feature-checking, to mention only the examples discussed here? Of course this is possible. But the resulting account of wh-movement is likely to be limited. Further, that approach increases the risk of incorporating complicated grammatical mechanisms into linguistic theory that may be unnecessary if processing mechanisms are also considered.

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## NOTES

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1. Fiengo (1998) points out that *who*, like *which N'* exhibits implicit restrictions limiting the domain of discourse to relevant entities. I agree. However, the difference between *who* and *which N'* seems to be whether the restriction is assumed to be already available in the discourse representation. Imagine for example that we are discussing what color to paint the living room. We are looking at two paint chips –a cherry red and a wine red. I ask you: “Which do you like best?” or “What do you like best?” My intuitions suggest that you may felicitously answer “blue” only to the second question.

On Fiengo's analysis, d-linking has no theoretical status. *Which N'* requests an exhaustive answer whereas *who* does not. From the request for an exhaustive answer, the perceiver may be likely to assume that implied restrictions on the domain exist simply because the speaker could not otherwise expect the perceiver to answer exhaustively. Whether or not *which N* differs from *who* in requesting an exhaustive answer, this analysis does not offer a ready explanation for the results reported below in the text.

2. To treat the ungapped analysis as VP conjunction, presumably the nodes conjoined must be assumed to be extended projections of VP, such as T'.

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