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SYNTACTIC PROCESSING: EVIDENCE FROM DUTCH*

INTRODUCTION

Two experiments on the processing of Dutch were conducted to test the cross language validity of a model of human sentence processing developed on the basis of English. The results indicate that the constituent structure processing of Dutch and English is identical, despite the presence of head-final phrases in Dutch. The absence of any evidence indicating delays of analysis in the processing of head-final constructions argues against the view that phrasal nodes are postulated by projecting features of their heads (i.e., by directly exploiting the individual principles of $\bar{X}$ theory).

The evidence from Dutch supports the existence of a gap-filling system directly at odds with the system standardly assumed for English. But closer inspection reveals the existence of various discrepancies internal to the account of English gap-filling. In particular, both the Dutch findings and certain findings in English suggest we should abandon the assumption that the parser checks the incoming lexical string for items of the predicted syntactic category before postulating an empty category. Instead, a filler-driven system is motivated for Dutch. It is tentatively proposed that this system is also operative in English.

1. GENERAL BACKGROUND

Several studies suggest that the basic syntactic analysis of English proceeds by constructing a constituent structure representation of a sen-

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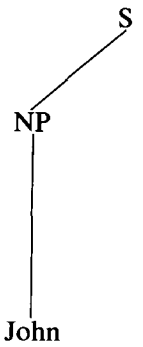
tence, roughly as its words are encountered. The process begins by attaching the first word of an input string as directly as possible to a sentence node. Each new input item is then incorporated into this structure following a MINIMAL ATTACHMENT principle (cf. Frazier and Fodor, 1978; Frazier and Rayner, 1982; Ferreira and Clifton, 1986; Kennedy and Murray, 1984; Rayner and Frazier, in press).

> *Minimal Attachment*: Attach each new item into the current phrase marker postulating only as many syntactic phrase nodes as is required by the grammar.

This procedure is illustrated in (1) for the string *John gave the note to Hans*.

(1)a.



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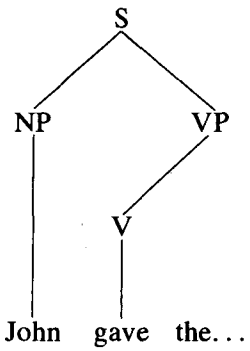

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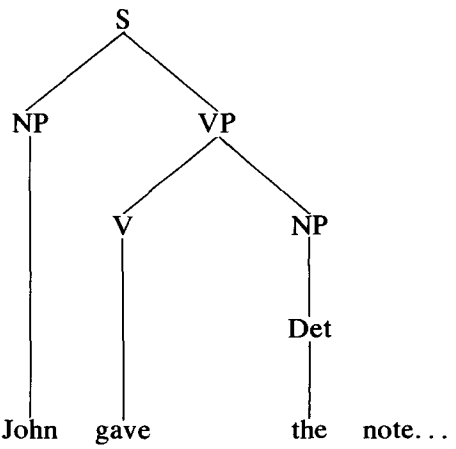

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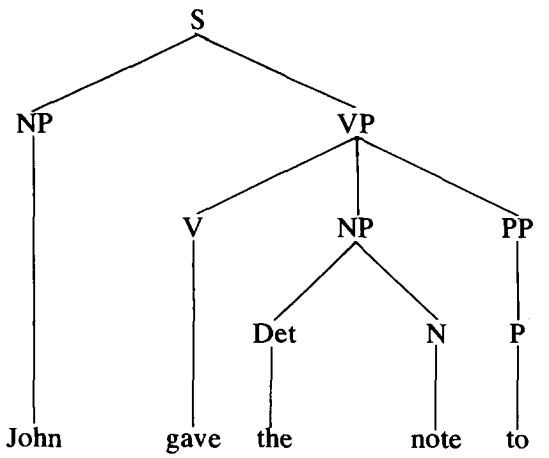
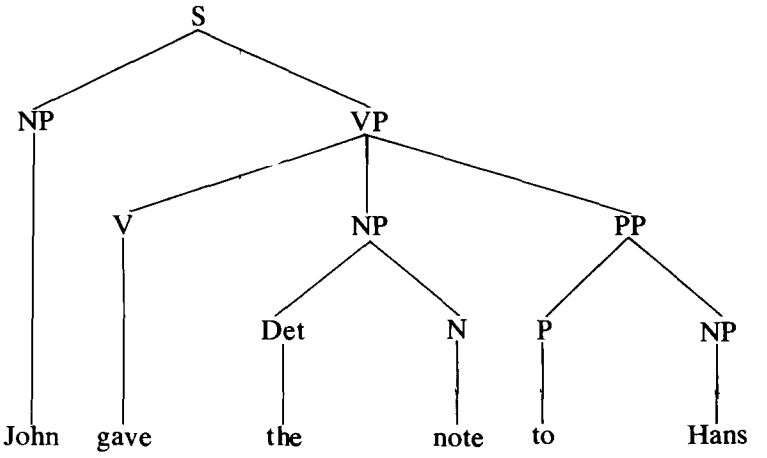
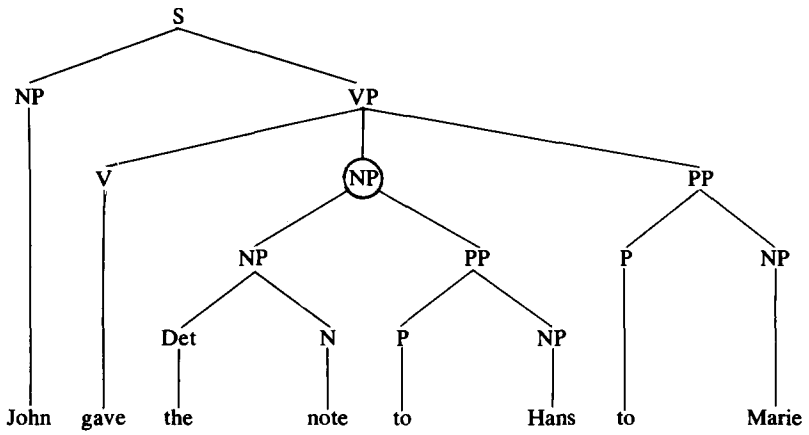


e.



If the sentence in (1) should happen to continue *to Marie*, then this initial analysis will have to be revised in order to find a legitimate analysis of the new items, as shown in (2).

(2)



The Minimal Attachment principle governing this process has been argued to follow from the time pressures involved in language comprehension (cf. Frazier and Fodor, 1978). Hence, it seems plausible that the principle governs the processing of all natural languages.

Other preference strategies have been proposed in the psycholinguistic literature. For example, it has been proposed that the choice of an initial syntactic analysis is determined by the relative frequency of occurrence of alternatives (Ford, Bresnan and Kaplan, 1983), by general non-linguistic perceptual strategies (Bever, 1970) and by presuppositional or discourse factors (Crain and Steedman, 1985). These preference principles can, at least in principle, be applied in a processing system which does not construct a constituent structure representation of the sentence. By contrast, Minimal Attachment is defined over the possible structural configurations of a language and thus can only be applied in a system which computes these structures. For this reason, establishing its validity is important not only for determining the principles underlying parsing preferences but also because of what it reveals about the basic characteristics of the language processing system, informing us, for example, about the representations computed and about the processing principles operative in the analysis of totally unambiguous inputs.

The idea that the language processing mechanism systematically builds a complete constituent structure representation of a sentence on an essentially immediate word by word basis meets with somewhat less resistance these days, in psychological circles, than it did just a few years ago, though it is still by no means uncontroversial or unchallenged (see Gerken and Bever, 1987, for example). However, in linguistics, the claim has become if anything more controversial in light of the recent move to

replace phrase structure rules with independently motivated principles of grammar (Stowell, 1981; Chomsky, 1981). Given a rule-based view of phrase structure, there is really no issue about whether the processor could determine the possible structural configurations of the language on a word by word basis, moving through the input string from 'left-to-right'. However, given a principle-based grammar in which individual principles (or their consequences) are not precompiled, it becomes an issue whether the processor could determine the permissible configurations of a language in this manner, as is required for the operation of Minimal Attachment in order to determine when a new node must be postulated.

If the individual principles of grammar are used directly in parsing, that is in isolation from each other, then we might expect phrasal nodes to be projected from their heads as dictated by $\bar{X}$ theory.

> *Head Projection Hypothesis*: A phrasal node is postulated by projecting the features of its head.

Though the Head Projection Hypothesis is in line with current syntactic analysis, it need not be correct. The processor may exploit whatever information is at its disposal (e.g., case theory, theta theory, precompiled phrase structure rules) to identify the existence and identity of major phrases. For example, in English a noun phrase might be postulated as soon as a determiner (such as *the*) occurred.

An issue closely related to the question of whether phrasal nodes are projected from their heads or postulated by some other means concerns the role of item-specific lexical information. In the illustration in (1) above, it was simply assumed that Minimal Attachment together with general (item-independent) structural information guides the formation of an initial syntactic analysis. This assumption is highly controversial. It implies that item-specific lexical information is used to evaluate or *filter* a syntactically-based hypothesis rather than to identify or *propose* an analysis. (See discussion of the Lexical Preference Principle in Ford, et al., 1983; Holmes, 1987). These two alternatives may be stated thus:

> *Lexical-Filter Hypothesis*: Item-specific lexical information is used to *reject or confirm* whatever analysis has been constructed on the basis of purely structural information.
> *Lexical-Proposal Hypothesis*: Item-specific lexical information (e.g., about the probable complement of a head) is used to *determine* the first syntactic analysis assigned to a phrase.

The empirical difference between these hypotheses is subtle and difficult

to establish, especially in head-initial phrases. Available experimental techniques typically provide evidence about the output of whatever processing subsystems contribute to language comprehension; rarely do they provide unambiguous evidence about the process by which that output is developed. Hence most existing experimental evidence may be interpreted in accord with either principle.

It may not be obvious why one should care whether lexical information is used to filter or, alternatively, to propose syntactic analyses. After all, the outcome is the same. Nevertheless, it is precisely this sort of detail that allows us to choose between alternative processing theories. In psycholinguistics assessing the validity of various proposals concerning the principles underlying the analysis of sentences, the interaction of theoretically-distinct information sources, and the decomposition of the comprehension mechanism into subsystems depends on just this sort of subtle difference. Further, it is likely to be the same type of evidence that distinguishes these hypotheses which will ultimately reveal the precise format in which grammatical information is mentally instantiated and organized (or not) for language use. It could indicate, for example, whether possible phrasal configurations are computed on the fly from lexical information and general principles or whether they are determined in advance and stored in some relatively superficial form such as phrase-structure rules.

The Head Projection and Lexical-Proposal hypotheses are easier to test in Dutch than in English, due to the presence of head-final phrases in Dutch. Also, in many respects, a comparative study of English and Dutch is an ideal way to test the cross language adequacy of a parsing model based on English. Given the historical and synchronic closeness of the two languages, it should be possible to determine the source of any difference observed in their processing, e.g., to see whether it results from applying the same principle to different languages or, alternatively, truly represents the operation of distinct processing principles. Ironically, a comparative study of the processing system of languages with more radical or extensive differences between them is probably *less* likely to turn up interpretable differences in the processing system for specific languages (if any exist), since it would be difficult to show that observed perceptual differences could not be traced directly to differences between the grammars per se.

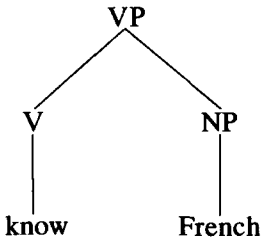
After a brief sketch of relevant properties of English and Dutch, we will turn to an experimental test of Minimal Attachment in Dutch. This experiment by itself does not directly address the validity of the Head Projection Hypothesis. However, the results allow us to interpret other

(preference) data which are relevant to head-projection only if Minimal Attachment is operative in Dutch. We will then proceed to a second experiment which further examines the possible operation of the Head Projection and Lexical-Proposal principles, together with issues about gap-filling.

2. Constituent Structure Processing

English is a language where phrasal heads precede their complements as illustrated in (3).

(3)a.



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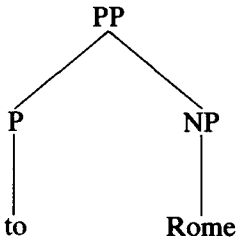

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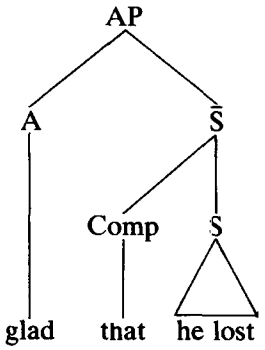

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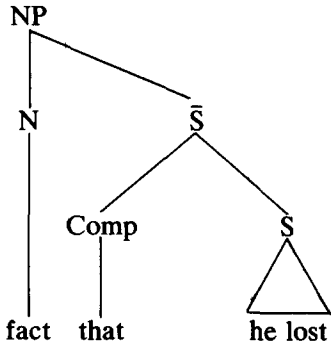
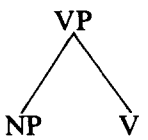


In consistently 'head-final' languages (e.g., Japanese or Turkish), one may find just the opposite order, illustrated in (4).

(4)a.



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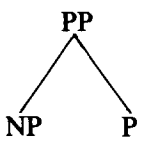

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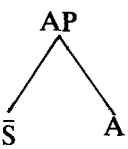

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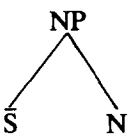


There are also inconsistent languages which exhibit a mixture of the structures in (3) and (4). Dutch is one such language. It is basically head-initial, like English. But the verb phrase is head-final. The verb occurs at the end of the verb phrase in all subordinate structures, as illustrated in (5) and (6). However, like many Germanic languages, the tensed verb of the highest clause must appear in second position, as illustrated in (7a); and, sentential complements must follow the verb, as illustrated by (7b) and (7c).[1]

(5)a. dat Jan het huis zag
that John the house saw

b. *dat Jan zag het huis
that John saw the house

(6) de meisjes die het huis zag-en
the girls who the house saw-PLURAL

the girls who saw the house

(7)a. Ik heb Jan gezien.
I have John seen

b. Ik heb gezien dat Jan vlak bij het station woont.
I have seen that John (right) near the station lives

c. *Ik heb dat Jan vlak bij het station woont gezien.
I have that John (right) near the station lives seen

The presence of head-final phrases may have important consequences for the way Dutch is processed. If the Head Projection Hypothesis is correct, then there will be considerable delays of analysis in head-final phrases, that is, VP and S will not be postulated until the end of the clause when V and INFL are encountered (assuming INFL to be the head of S). Similarly, if the Lexical Proposal Hypothesis is correct (and universally applicable), analysis of potential complements of a verb should be delayed until the verb is presented. Further, either due to the presence of head-final structures per se, or to their consequences for the processing of other elements (delays of analysis, the particular ambiguities that will arise, etc.) the principles governing the constituent

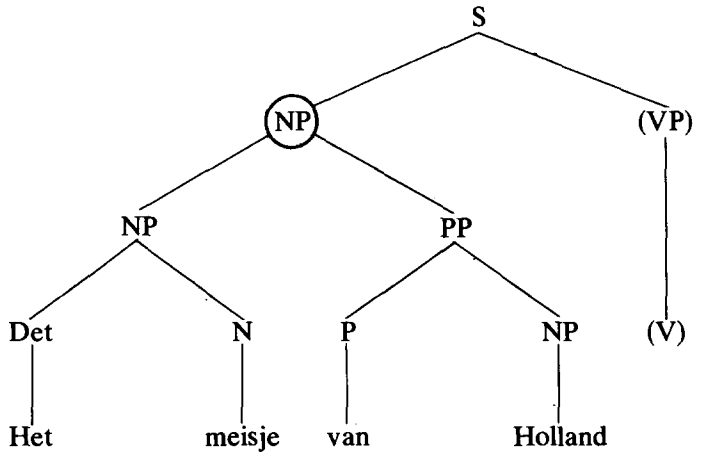
[1] While Dutch is basically prepositional, a limited class of nonreferential items do occur in postpositional configurations. See van Riemsdijk (1978) for discussion.

structure analysis of a language containing such structures might differ from those implicated in a head-initial language like English. Consider a Dutch structure like (8), for example.

(8) ...dat het meisje van Holland houdt.
that the girl from Holland likes

that the girl likes Holland

a.



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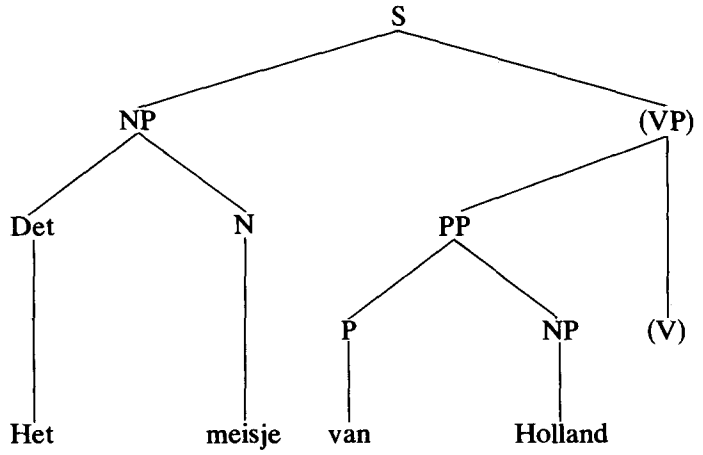


The object of the Dutch verb **houden** 'to like' is marked by the preposition **van** which is the same in form as the English preposition *from*. In a subordinate clause like (8), the processor will encounter the noun phrase (**het meisje**) and the prepositional phrase (**van Holland**) before it encounters the verb. The noun phrase and prepositional phrase may be

structured together to form a complex noun phrase ('the girl from Holland'), as indeed they must be if it turns out that the verb only takes one argument, like **glimlachen** 'to smile' in (9).

(9) dat het meisje van Holland glimlachte
that the girl from Holland smiled

Thus, especially if the VP-node in (8) is not postulated until the verb is encountered, we might expect the processor to initially assign (8) the structure in (8a), since this at least allows the PP to be attached to some phrase. In general, structured material seems to be easier for humans to hold in memory (Miller, 1956) and the structure in (8a) will permit the noun phrase and prepositional phrase to be integrated into a single structure (which, of course will happen to turn out to be incorrect in (8), though not in (9)). Notice, however, that the highest NP-node in (8a) is a potentially unnecessary node. If the VP-node in (8) and (9) is postulated before the PP *van Holland* is encountered, then Minimal Attachment alone predicts the preference for the PP to be attached to the VP. If the VP-node is not yet represented when the PP is encountered, but the S-node is, a VP-attachment preference would still be expected in a system incorporating Minimal Attachment. In general, given two equally minimal attachments, the processor will choose an attachment consistent with its current phrase-marker, over one requiring a revision of its current analysis, viz, the addition of a NP-node between the already connected NP and S node in (8a). However, if neither the VP-node nor the S-node has been postulated (e.g., projected from their heads), then there is no reasons to expect the VP attachment to be preferred. Hence, this analysis conflicts with the predictions of the Minimal Attachment strategy implicated in the processing of English. In short, there is a real question concerning whether the processing principles identified for English will accurately characterize the processing of even a closely related language like Dutch.

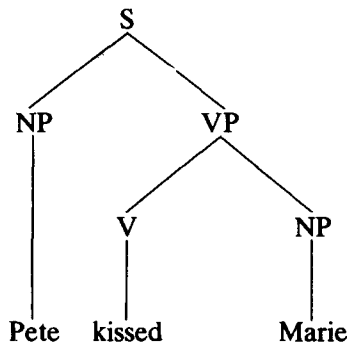
2.1 *Experiment* 1: *Constituent structure ambiguities*

Experiment 1 was designed to test the assignment of phrase-structure, specifically, the predictions of the Minimal Attachment strategy in Dutch. We will begin, however, by considering English sentences to illustrate the basic predictions of Minimal Attachment. Then we will turn to the Dutch structures and show that the same predictions hold, though the structures in Dutch are slightly more complicated.

In (10) Minimal Attachment predicts that *Marie* will be analyzed as the

direct object of *kissed*, as shown in (10a). When the ambiguous phrase *and her sister* is encountered, this representation must be revised. According to Minimal Attachment, the ambiguous phrase will be taken to be part of a conjoined noun phrase, as indicated in (10b), rather than part of a conjoined sentence, shown in (10c), since the former analysis requires fewer syntactic nodes to be postulated.[2]

(10)a.



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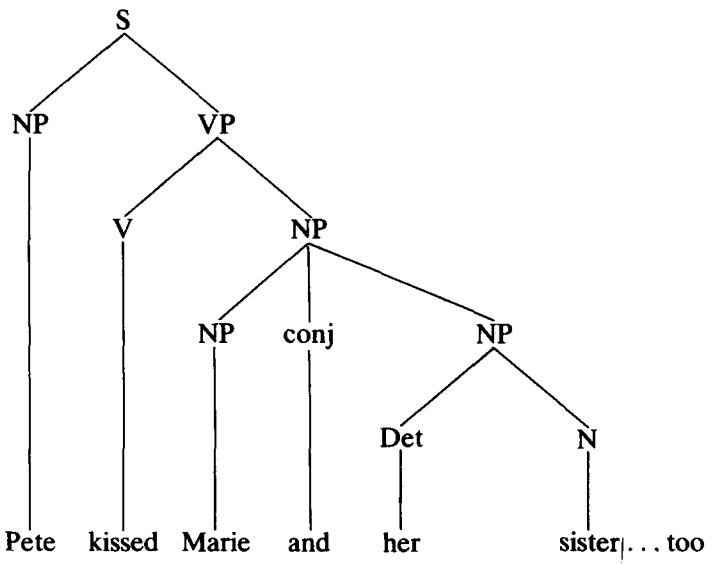
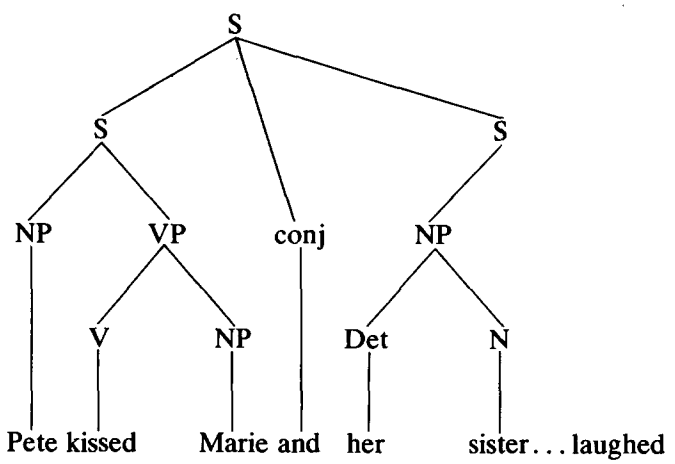


[2] This prediction rests on the assumption that the processor identifies the first S-node postulated as a root S in a language like English (see Frazier and Rayner, to appear, for suggestive evidence this S is not immediately labelled a root S is consistently left-branching languages like Japanese). Hence, adding an S 'over the top' of the highest S, as is necessary for sentential subjects or conjoined clauses, constitutes a revision in the initial analysis of the sentence, not just an addition to the current phrase marker. See Frazier (1979) for discussion of this distinction and for evidence about processing conjunctions in English. One might assume that the attachment of *and* is accomplished only when the

c.



The Minimal Attachment analysis (10a) will be consistent with the remainder of the sentence in (10b), but not the remainder in (10c). To reiterate, the representation in (10a) will have to be revised (i.e., a new NP node will be added) when the word *and* is encountered in both (10b) and (10c). However in (10c) Minimal Attachment predicts that a second revision of analysis will be necessary when the final word *laughed* is encountered. Hence, prior disambiguation of the ambiguous noun phrase *her sister* should facilitate the processing of a Nonminimal Attachment structure like (10c) more than it facilitates the Minimal Attachment structure (10b).

We turn now to the situation in Dutch. The following examples illustrate all the possibilities, as indicated by the labels.

(11)a. Piet kuste Marie en **haar zusje** ook.
Pete kissed Marie and her sister too
(*Minimal Attachment-ambiguous*)

b. Piet kuste Marie en **haar zusje** lachte.
Pete kissed Marie en her sister laughed
(*Nonminimal-ambiguous*)

c. Annie zag **haar zusje** ook
Annie saw her sister too
(*Minimal Attachment-unambiguous*)

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following word has been received. Notice that this will prevent the processor from attempting a conjoined NP analysis in sentences with conjoined VPs, as in (i) where *and* is followed by a categorially unambiguous verb.

(i) John saw the snake and screamed.

The alternative is to assume (as in English) that the lower of two minimal attachments is preferred (see Kimball, 1974; and discussion of Late Closure in Frazier, 1979).

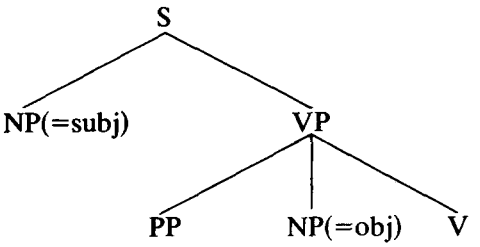
d. Annie zag dat **haar zusje** lachte.
Annie saw that her sister laughed
(*Nonminimal-unambiguous*)

The complementizer **dat** 'that' is obligatory in Dutch. (Note that there is a homophonous demonstrative **dat**, but the existence of this form could at most inflate the reading time for (11d), thereby reducing the predicted difference between (11b) and (11d) potentially eliminating – rather than contributing to – the predicted outcome.) Hence, in a sequence like **zag dat NP** 'saw that NP' the NP may only be interpreted as the (surface) subject of a clause; and, in a sequence like **zag NP** 'saw NP', the NP may only be interpreted as the simple direct object of the verb. In (11c) and (11d) the words following the 'ambiguous' phrase **haar zusje** are identical to the words that follow this phrase in their respective ambiguous counterparts, (11a) and (11b). Thus, in terms of reading times for the final words in (11), we expect that the differences between (11b) and its unambiguous counterpart (11d) should be greater than the differences between (11a) and its unambiguous counterpart (11c), since disambiguating (11b) should prevent two revisions of analysis: the minor revision after **en** is encountered and the major revision after **lachte** is encountered. Indeed, revising the second misanalysis in (11b) should be rather costly, since assigning the NP-conjunction analysis is not only syntactically incorrect but leads to inappropriate grammatical relations (unlike the misanalysis of **Marie** illustrated in (11a)).

In order to show in detail how it is that the Minimal Attachment Hypothesis predicts these differences, we turn to the structure of Dutch sentences like those in (11). The basic structure of a Dutch clause is illustrated in (12a). As we saw earlier, this is the structure of all subordinate clauses in the language. However, to satisfy the Verb-second constraint, the tensed verb must be raised to the beginning of the clause, as illustrated in (12b), as proposed in den Besten (1983) for example. The initial constituent of the clause is adjoined (in what might be considered topic position), as illustrated in (12c). It is this obligatory 'topic' which guarantees that the verb appears in second position. The initial constituent may correspond to a subject (as in (i) in (12c)), an object (ii) or a prepositional phrase (iii), for example.[3]

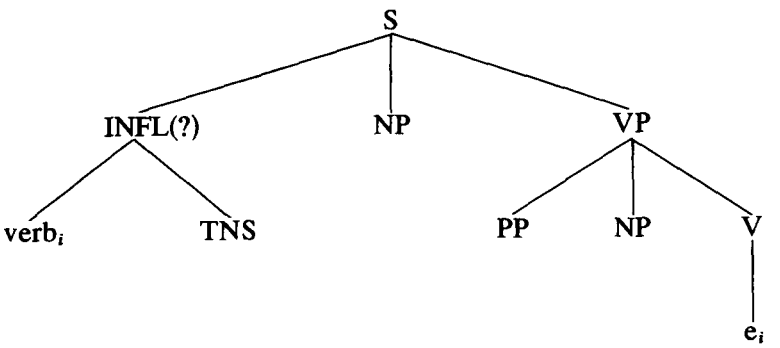
[3] Jansen (1978) estimates that a full 50% of Dutch sentences begin with nonsubject constituents. The structures given here are really only schematic and are intended to be compatible with an entire family of linguistic analyses. They differ in detail but share the crucial feature that the verb second appearance of root clauses results from adjunction (or substitution) of a constituent to a clause which is verb-initial.

(12)a. basic clause



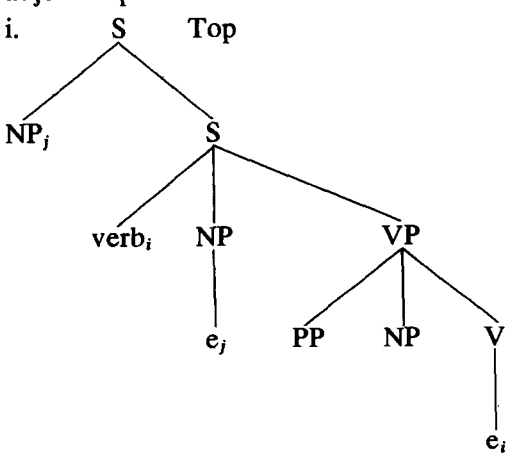
Jan met dit mes een kip snijdt
John with this knife a chicken cut

b. INFL-initial rootclause (to satisfy verb second constraint)



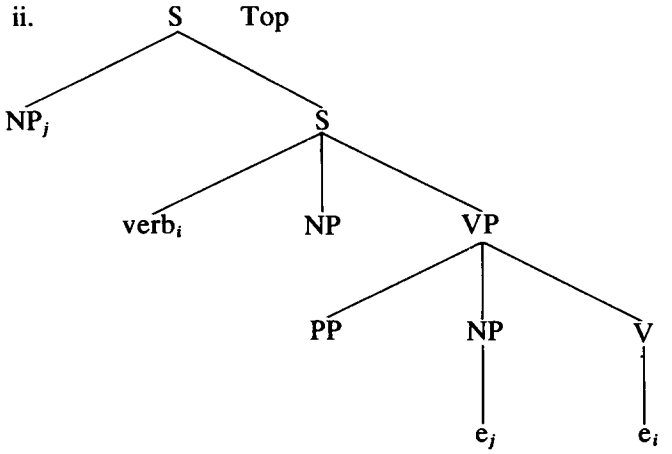
c. adjoin 'topic'

i.



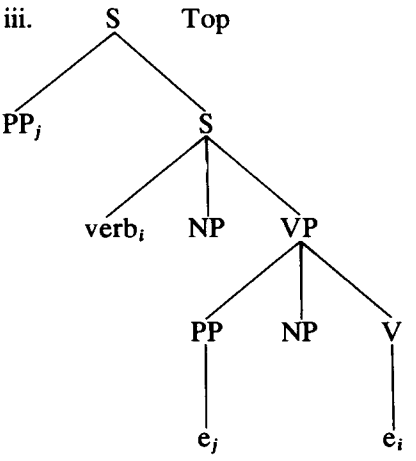
Jan snijdt met dit mes een kip
John cut with this knife a chicken

ii.



Een kip snijdt Jan met dis mes
a chicken cut John with this knife

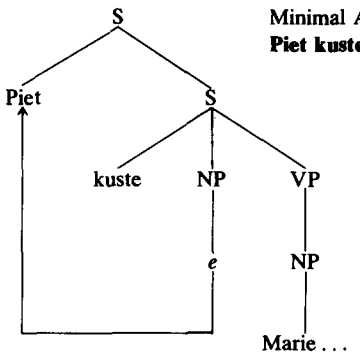
iii.



Met dit mes snijdt Jan een kip
with this knife cut John a chicken

We may now consider (11a). When the processor encounters the word **Piet**, this must be taken to be in 'topic' position, since Dutch sentences may not begin with subordinate clauses which are not marked by an overt subordinating conjunction. And the following verb must be adjoined to the clause, as illustrated in (13).

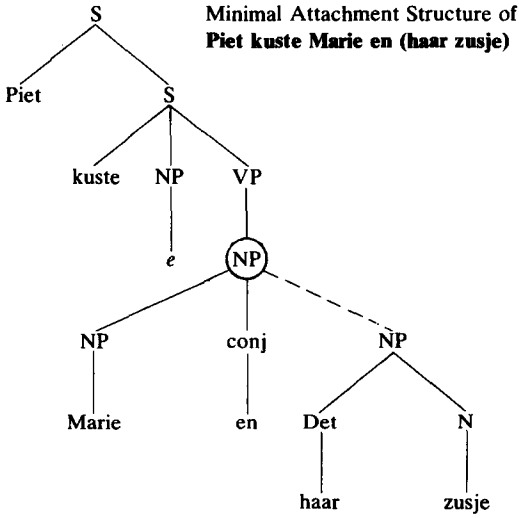
(13)



Minimal Attachment Structure of **Piet kuste Marie. . .**

We will assume that **Piet** is taken to correspond to the 'subject' of the clause (i.e., to the "kisser", not the "kissee"). Native speakers consistently report that this interpretation of the sentence is preferred (as opposed to one where the initial NP is interpreted as the 'object' or patient). Thus, an empty subject must be postulated and related to the phrase in 'topic' position. According to Minimal Attachment, **Marie** will now be analyzed as a direct object, i.e., a daughter of the VP, as illustrated in (13).[4] When **en** 'and' is encountered, the phrase marker in (14) should be constructed.

(14)

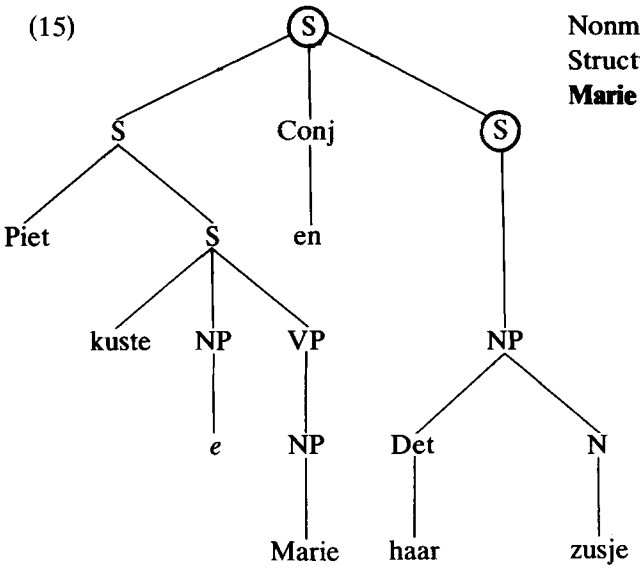


Minimal Attachment Structure of **Piet kuste Marie en (haar zusje)**

[4] The question of precisely when the empty category corresponding to the raised verb is postulated is interesting and relevant to a detailed account of the precise computational steps involved in the processing of sentences with conjoined phrases. In the present experiment, the conjunction *en* was included in the same frame as the direct object noun phrase and thus it is most likely that the postulation of the empty verb was delayed until the second conjunct was encountered.

This, of course, will prove to be consistent with the remainder of (11a), but not with (11b), the phrase marker in (14) will have to be revised, as indicated in (15).

(15)



Nonminimal Attachment Structure of **Piet kuste Marie en (haar zusje)**

The additional nodes required to revise (13) for the NP conjunction analysis (14) and the S conjunction analysis (15) are circled; as the reader may verify, the S conjunction analysis requires the postulation of more nodes for reasons parallel to those in the simpler English example illustrated above.

In short, Minimal Attachment predicts that (11b) will initially be misanalyzed because **en haar zusje** 'and her sister' will incorrectly be assigned the structure in (14). Disambiguating the syntactic role of **haar zusje** as in (11c and d) should thus facilitate (11b) considerably. The effect of disambiguating (11a) should be minimal by comparison, since **en haar zusje** will initially be assigned the correct direct object analysis, even in the ambiguous sentence form (11a) (though a minor revision – insertion of an NP node – will be required in the ambiguous form).

Twelve sentences like (11) were constructed, with four versions of each. The ambiguous phrase was identical across all four versions of a sentence. The word or words following the ambiguous phrase were identical for the two Minimal Attachment versions of a sentence (e.g., (11a) and (11c)) and for the two Nonminimal versions (e.g., (11b) and (11d)). The average length of the material following the ambiguous phrase was eight characters for both the Minimal and Noniminmal

Attachment versions. All experimental sentences are presented in Appendix 1.

The sentences were divided into three frames: the first included all material preceding the ambiguous NP; the second frame included only the ambiguous NP (which was identical across all four versions); and, the final frame included all items following the ambiguous NP (which was identical for the two Minimal and for the two Nonminimal versions).

Sixty-six filler sentences were also constructed. These sentences were of various forms to preclude the possibility of subjects developing an experiment-specific strategy based on superficial properties of sentences predictable only in the experimental setting. Thus, the filler sentences differed from each other quite radically in terms of their length and structural complexity. Roughly half of the filler sentences were followed by questions. The sentences were divided into either two or three frames for visual presentation. The frames varied in length from one to nine words per frame. This was done to prevent subjects from developing experiment-specific structural preferences, based on expectations about the length of frames. Filler sentences were divided into frames in a fairly arbitrary fashion, insuring only that breaks did not violate the internal constituent structure of simple phrases (e.g., separating a determiner and noun).

The sentences were individually randomized for each subject and presented visually, frame-by-frame, under control of a Micromax computer. Each frame began at the left margin of a CRT screen, centered vertically on the screen. The first frame of each sentence was preceded by a row of "X"s which remained on the screen for 500 msec. After 60 msec. the first frame of a sentence appeared on the screen. When a subject finished reading a frame, he or she indicated this by pressing a response key. Response times were automatically recorded; responses longer than 3900 msec. were recorded as 0 (missing) responses. The next frame of the sentence would then appear. For sentences followed by a question, the question would automatically appear after a subject responded to the sentence-final frame. The oral response to the question was recorded on audio tape. After a 500 msec. delay, the next trial would begin.

Forty native speakers of Dutch (mostly students at the Catholic University of Nijmegen) were paid to participate in the experiment. They were instructed to read each sentence as quickly as possible without sacrificing comprehension. They were warned that half the sentences would be followed by a question.

The sentences were divided into four lists: each list contained all the

filler sentences and an equal number of each experimental sentence types. No list contained more than one version of a single sentence.

2.2 *Results*

The results of Experiment 1 are presented in Table 1 (after excluding the 4 responses over 3900 msec.).[5] The predicted interaction between ambiguity and attachment-type was significant ($p < 0.001$). Disambiguation benefited Nonminimal Attachment forms more than the Minimal Attachment sentence forms.

The final frame of the ambiguous form (1596 msec.) took longer to read than the final frame of the unambiguous form (1141 msec.) for the Nonminimal Attachment sentences ($P < 0.001$ by subjects, $P < 0.003$, by items). The final frame of the ambiguous Minimal Attachment sentences (1222 msec.) took longer to read than the final frame of the unambiguous form (1082 msec.), ($P < 0.001$ by subjects; $P < 0.001$ by items).

The results of Experiment 1 thus confirm the predictions of Minimal Attachment in all respects. Disambiguation facilitated processing of the Nonminimal Attachment form to a greater extent than it facilitated the Minimal Attachment form, as shown by the thoroughly significant interaction of ambiguity and attachment-type.

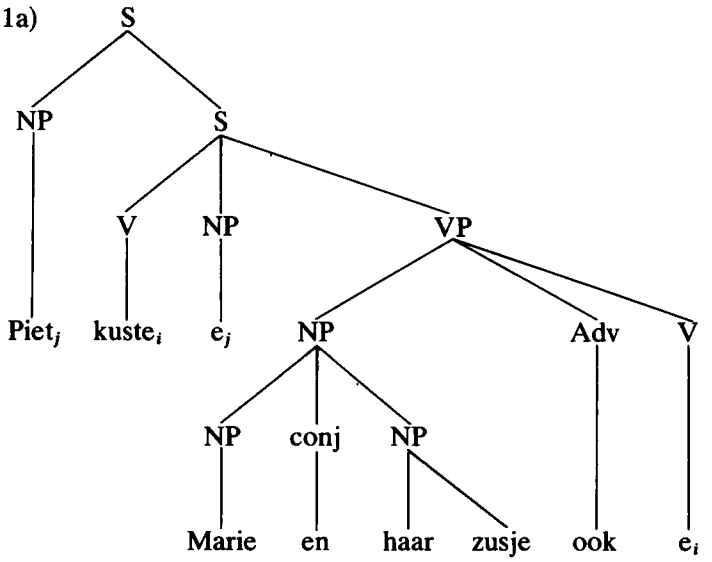
There is, however, a possible alternative interpretation of the results which must be considered. Examine the complete representation of the experimental sentences, provided in (16)–(19). Notice in particular the difference in the structural complexity of the final clauses of the two versions of the Nonminimal Attachment sentences, (17) and (19).

TABLE 1
Experiment I

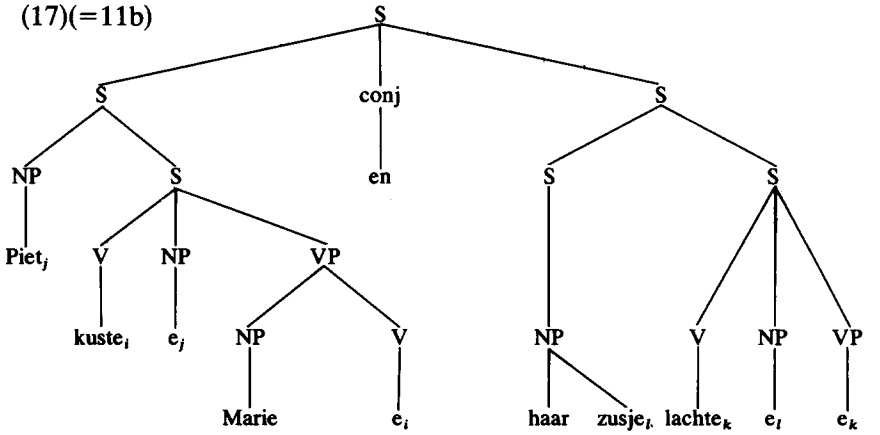
	Reading Time for Final Frame in Msecs.	
	Ambiguous	Unambiguous
Minimal Attachment	1222	1082
Nonminimal Attachment	1596	1141

[5] Due to an experimenter error, the Minimal Attachment versions of one sentence were divided into only two frames and thus had to be omitted from analysis; the score for this sentence was replaced by each subject's mean for that condition.

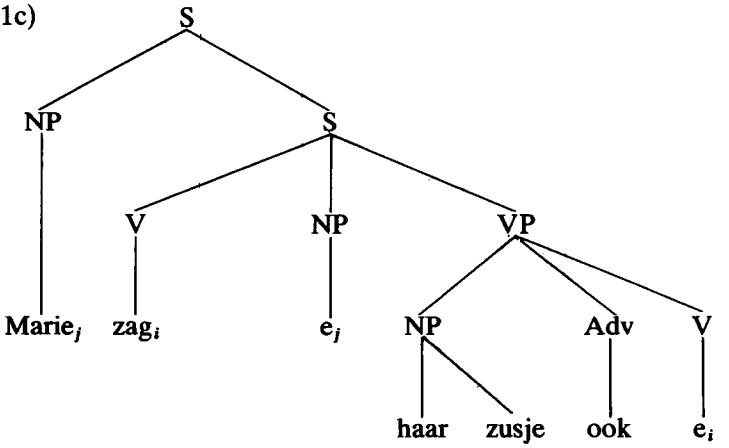
(16)(=11a)



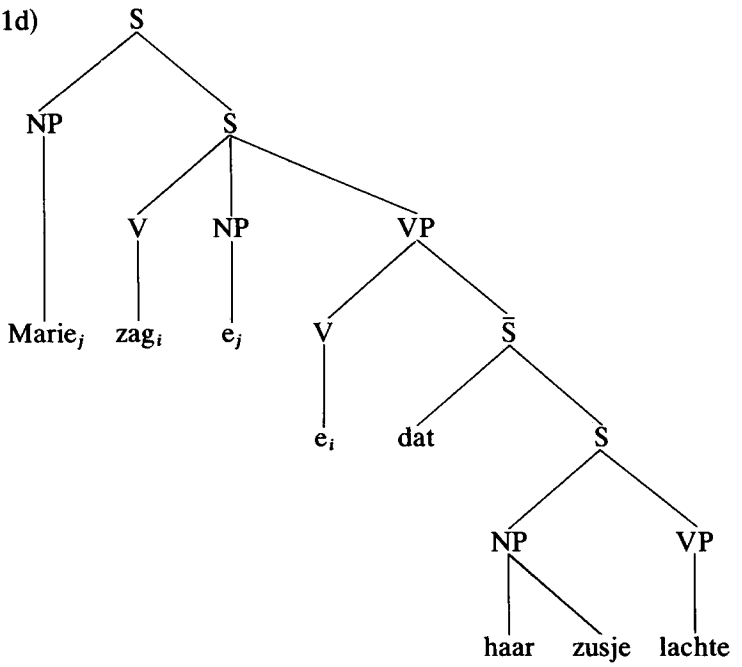
(17)(=11b)



(18)(=11c)



(19)(=11d)



Might this difference in complexity alone account for the experimental results? At first blush, it would appear so.

Though structural complexity differences might contribute to the magnitude of the effect in Experiment 1, there is strong reason to doubt that this factor by itself could account for the results. First, if it is not Minimal Attachment which is governing the analysis of the sentences, we must ask what other principle is. Clearly it is not Nonminimal Attachment, since this makes exactly the wrong predictions. And, if we assume that syntactic analysis of the ambiguous sentence forms is delayed, we immediately encounter problems. We will see that the assumption is incompatible with the results of Experiment 2, for example. It also conflicts with the fact (already mentioned) that native Dutch speakers always take the first NP (e.g. **Piet**) of sentences like these[6] to be the 'subject' (kisser), not the 'object' (kissee) of the verb in the first clause (**kuste**); despite the fact that this is not forced by the grammar of Dutch. If perceivers were delaying syntactic analysis, we would expect them to at least occasionally notice the (semantically) equally plausible reading where the second noun phrase is the subject. In short, we would have to explain why perceivers are delaying decisions about certain ambiguities, but not others. (In fact, based on the English data, we would expect just

[6] I am restricting attention to the relevant situation where both arguments are animate, as in the experimental sentences.

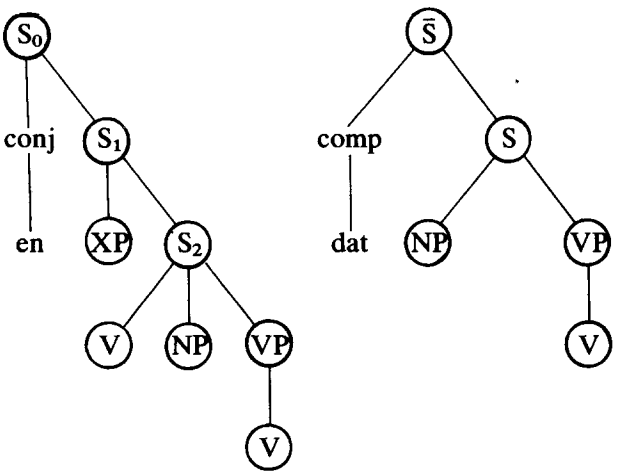
the opposite pattern to the one we would need to postulate, i.e., if there are any delayed syntactic decisions, they seem to involve analysis of empty categories, not lexical phrases.[7])

There remains one possibility. Perhaps the processor computes both the NP-conjunction and the S-conjunction analysis when it encounters the conjunction **en**; when it receives the final (disambiguating) word, it simply attaches the word into the appropriate representation, resulting in NP conjunction for (16) and S conjunction for (17). But clearly this cannot be right. In both the ambiguous (17) and unambiguous (19) Nonminimal Attachment sentences, the processor would only need to attach the verb **lachte** to the VP; there would be no reason at all to expect this operation to take on average nearly half a second longer (450 msec.) in (17) than in (19). So the first argument against an alternative interpretation of Experiment 1 is that no alternative readily accounts for the data.

Nevertheless, imagine for a moment that Minimal Attachment is not implicated in the processing of the above sentences: thus there is no incorrect analysis (with subsequent restructuring) of (17); and, the difference in reading time for the final word in (17) vs. (19) is thus entirely due to differences in the structural complexity of the final clauses of these sentences. Could the observed effect be due to correct structure building per se?

The structure of the final clauses is illustrated in (20).

(20)a. Conjoined Clause (=17) b. Subordinate Clause (=19)



[7] While there are many indications that syntactic analysis of lexical phrases occurs virtually immediately (Frazier and Rayner, 1982) there is currently less evidence concerning the

Notice first that the postulation of the circled nodes in (20) is unambiguously warranted as soon as the conjunction is received (remember that we are assuming that **en** is taken to be a sentential conjunction). These nodes constitute obligatory predictions in Dutch: a clause must have a subject and predicate, accounting for the lowest S and the nodes it dominates; and, since conjoined clauses are subject to the verb-second constraint, S_1 in (20a) and the node it dominates is also obligatory and predictable. Thus, apart from the identity (not the existence) of the *XP* in (20a), all of the 'extra' nodes in (20a), which are responsible for its complexity relative to (20b), are predictable *in advance*, given the occurrence of a sentential conjunction (**en**).

It is clear that concentrations of syntactic nodes unambiguously warranted by the input string (as in unambiguous sentential subjects in English) do contribute to processing complexity, though typically the effects are not nearly so large as those resulting from failure to postulate ambiguously warranted nodes (see discussion in Frazier, 1985). What is not known at present is whether concentrations of unambiguously warranted nodes which are predictable in advance have observable effects on sentence processing complexity. And that, as we have just seen, is the sort of case we are considering here. Thus, even if we ignore the problem of how subjects know to take **en** as a sentential conjunction in (17), it is not obvious that the structural complexity hypothesis will account for the difference in the complexity associated with the final frame of (17) versus (19), not to mention the magnitude of the difference. Moreover, there are known to be facilitation effects in the processing of parallel syntactic structures, especially conjoined clauses (Frazier et al., 1985). Since the additional nodes in (17), those not present in (19), are parallel to those in the first clause, we might actually expect (17) to enjoy a processing advantage not found in (19), perhaps offsetting or neutralizing any potential complexity of these nodes.[8] In sum, on closer inspection, the

precise timing of various processes involved in the syntactic analysis of empty categories. Much of the presently available evidence on the processing of empty categories derives from intuitional studies and/or end of sentence measures of processing complexity. Preliminary evidence certainly favors the view that analysis of empty categories occurs very rapidly (Tanenhaus, Carlson and Seidenberg, 1985; Stowe, 1986) but many unsolved issues remain.

[8] Frazier, et al. (1985) argue that in highly parallel conjoined sentences in English the processor may immediately construct an S-structure representation of an input, without first attaching phrases into a representation reflecting their surface structure position in the input string. If so, then for reasons entirely parallel to those given for English, we might expect Dutch perceivers to directly construct a canonical (S-structure) representation of the second of two conjoined clauses without necessarily representing the clause-initial constituent in its 'adjoined' or 'raised' position.

hypothesis that it is solely the structural complexity of the correct analysis of the ambiguous Nonminimal Attachment sentences which is responsible for the extreme difficulty associated with their final frame is simply not very compelling.

We turn now to one final argument in favor of the Minimal Attachment interpretation of the results, namely, evidence that this strategy is operative in the analysis of other ambiguities in the language. Consider the example in (21) (which is comparable to sentence (8), discussed above).

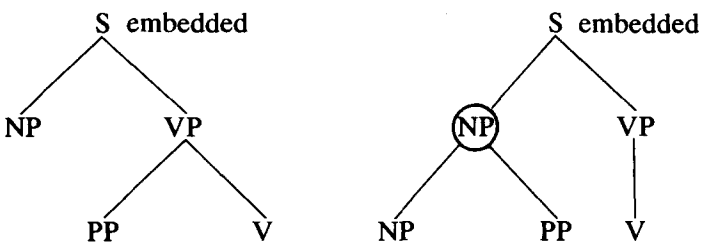
(21)a. Ik weet dat de man **in Holland investeert**
I know that the man in Holland invests

I know that the man invests in Holland.

b. Ik weet dat de man in Spanje **in Holland investeert**
I know that the man in Spain in Holland invests

I know that the man in Spain invests in Holland.

(22)a. Minimal Attachment b. Nonminimal Attachment



When the processor encounters the prepositional phrase immediately following the noun phrase **de man** in (21), Minimal Attachment predicts that the prepositional phrase will be attached as a constituent of the VP because the alternative attachment requires the postulation of a potentially unnecessary NP-node (circled in (22b)). In (21b) this decision will prove to be incorrect, and thus reading times for the underlined phrase in (21) are predicted to be longer in (21b) than in (21a). This sentence was actually included as one of the filler sentences in Experiment 1 to see if it would be feasible to use this structure in a later study. Half of the subjects saw (21a); half saw (21b). The boldface phrase constituted the final frame of each sentence and **Ik weet dat de man** constituted the initial frame in both sentences. The prepositional phrase **in Spanje** in (21b) was included in a separate frame. The mean reading time for the

final frame of (21b) (1796 msec.) was substantially slower than for (21a) (1697 msec.),[9] confirming the predictions of Minimal Attachment.

Further, relying on intuitive evidence from native Dutch speakers, it is clear that (23b) is preferred continuation of a fragment like (23a).

(23)a. De leraar heeft het kind het katje . . .
the teacher has the child the kitten

b. De leraar heeft het kind het katje laten-zien.
the teacher has the child the kitten let-see

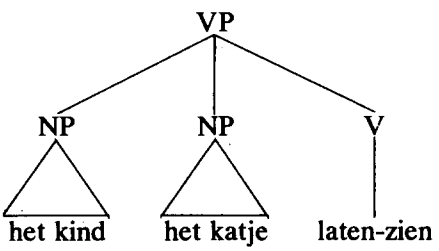
The teacher showed the child the kitten.

c. De leraar heeft het kind het katje zien helpen.
the teacher has the child the kitten see help'

The teacher saw the child help the kitten.

Laten-zien is a lexicalized compound verb meaning 'show', which may be analyzed as a distransitive verb with two arguments in its complement, as illustrated in (24).

(24)



By contrast, **zien helpen** is not one lexicalized form but two distinct verbs. If we assume that **zien helpen** is not analyzed as a compound verb, i.e., turned into a ditransitive on par with **laten-zien**, the preference for (23b) again follows Minimal Attachment since whatever the structure of (23c),[10] if **zien helpen** is not ditransitive, (23c) will involve the additional syntactic nodes implicated by the clausal structure of the complement of **zien**, i.e., 'the child helped the kitten'. And, of course, these additional nodes will be potentially unnecessary nodes during the analysis of the

[9] In the absence of a fully-controlled study, this finding is naturally not conclusive, but merely suggestive. I should note, however, that the grand mean for these two groups of subjects actually goes in the opposite direction of the finding reported, arguing at least that the result is not due to accidental differences in the two subject populations.

[10] See Bach, Brown, and Marslen-Wilson (1986) for discussion of these structures and of the processing complexity they present in Dutch and in German.

NPs (**het kind, het katje**), given the existence of the simpler structure in (23b). One might object that obviously the language processor will not construct entire clauses when there is no evidence in the input which requires it to do so. But this, of course, is precisely the point: the human language processor does not assign potentially unnecessary structure (clausal or otherwise).

We have just seen informal evidence that Minimal Attachment applies in Dutch in structures other than those tested in Experiment 1. Given this, it would be necessary to complicate a theory of syntactic processing in Dutch to prevent Minimal Attachment from applying in particular structures, e.g., (16) and (17). Thus in all respects, the assumption that Minimal Attachment applies in Dutch seems to result in the best (simplest) account of the available data.

This conclusion in turn provides one argument aginst the view that phrasal nodes are projected only when their heads are encountered. In an example like (21) Minimal Attachment correctly predicts the actual preference (for the PP to attach to VP) only if the embedded VP and S nodes have already been postulated when the PP is processed, which is to say before the head of VP or S has been encountered. If these nodes had not yet been postulated, then we might have expected the processor to favor attachment of the PP to the preceding NP, since this attachment would at least permit the PP to be immediately structured together with another phrase. By taking the NP attachment, the processor could avoid holding two isolated phrases in memory until subsequent analysis turned up the heads of potential mother nodes which might dominate the NP and PP. In short, Minimal Attachment seems to make the right predictions in Dutch but only if we assume phrasal nodes are postulated as soon as they are required: when they are needed to attach, grammatically, an input item into the constituent structure representation of preceding items.

3. Parsing Embedded Structures

We turn now to an experiment designed to further explore possible delays of analysis in head-final structures, specifically, Dutch relative clauses. If phrasal nodes are not postulated until their heads are encountered, then the VP- and S-nodes of a relative clause will not be present until the end of the clause, when V and INFL are encountered. Assuming 'subject' is the NP immediately dominated by S and 'direct object' is the NP immediately dominated by VP, we would not expect the parser to determine whether the head of the relative (or the relative pronoun)

should be analyzed as the daughter of S (subject) or daughter of VP (object) before the corresponding S or VP has been postulated. In short, delays in postulating phrasal nodes should result in delays in determining the relation between those nodes and other phrases (the relative pronoun in the present example).

The experiment also explores several proposals concerning the identification of 'gaps' (phonetically empty positions in a phrase marker) such as the empty object of *see* in (25).

(25) What did John see *e*?

The relevant literature on relative clauses and gap-identification procedures will be discussed in the course of laying out the predictions for Experiment 2.

3.1. *Relative Clauses and Gap-Identification*

Consider an ambiguous Dutch relative clause, like (26). Dutch is unlike an SVO language such as English or French in that the position of the verb will not disambiguate the grammatical function of the noun phrases in a relative clause since such clauses are verb final. In Dutch, the subject and verb agree in number. However, because the noun phrases in (26) are both singular, the number marking on the verb will not help to disambiguate the role of the noun phrases.

(26) Ik schreef aan de vriend die mijn tante heeft bezocht.
I wrote to the friend who my aunt have-SG visited

a. de vriend die [*e* mijn tante heeft bezocht] (*Subject Relative*)
the friend who has visited my aunt

b. de vriend die [mijn tante *e* heeft bezocht] (*Object Relative*)
the friend who my aunt has visited

By contrast to (26), the noun phrases in (27) and (28) exhibit distinct number markings.

(27) de vriend die [*e* mijn tantes heeft
the friend who my aunts have-SG
bezocht] (*Subject Relative*)
visited

the friend who has visited my aunts

(28) de vriend die [mijn tantes hebben bezocht]
the friend who my aunts have-PL visited
(Object Relative)

The friend who my aunts have visited

If, in processing, the analysis of verb final clauses is delayed until the verb is encountered, there is no reason to expect any systematic preference for the subject (26a) versus object (26b) interpretation of (26), at least in cases where the two analyses are equally plausible on semantic or pragmatic grounds. The processor should simply delay attachment of the noun phrases in (26) into a constituent structure representation until the verb is encountered. At this point, the processor should arbitrarily choose one structure or the other in ambiguous clauses like (26), and should choose just the correct analysis in unambiguous cases like (27) and (28). Thus, if we were to present sentences like (26) to subjects and then question the grammatical function of the noun phrases in the relative clause, we would expect roughly an equal number of subject relative and object relative responses. This delay hypothesis further predicts that there should be no systematic difference in the processing times for unambiguous subject relatives versus unambiguous object relatives, since in each case only the correct analysis should be constructed.

In contrast to the delay hypothesis, we might consider the predictions of various principles proposed to account for the processing of English. The basic approach of most treatments of the processing of English sentences with 'gaps' (empty categories) and 'fillers' (phrases controlling the interpretation of gaps) has been based on the insight that sentences with filler-gap – or 'transformational' – dependencies may be processed by the same routines used for sentences without such dependencies (see, for example, Jackendoff and Culicover, 1971; Wanner and Maratsos, 1978). Fodor (1978, 1979) discusses this proposal (henceforth, the Gap-As-Second-Resort Principle or GASP) and notes that it predicts that the language processor will check the input lexical string to see if it contains a phrase of the predicted category, before it postulates a gap. Hence, given two adjacent phrases of the same syntactic category, extraction of the second should always be more acceptable than extraction of the first. Fodor calls this the "XX Extraction" principle and presents English examples like (29), and structurally comparable French examples, to support this prediction.

(29) Which patient did the nurse bring the doctor?
a. Which patient did the nurse bring the doctor *e*?
b. ?Which patient did the nurse bring *e* the doctor?

In (29), if the processor expects an NP to follow the verb, it should check the lexical string to see if in fact an NP follows the verb. Since one does, this should be analyzed as a constituent of the verb phrase. Given that *bring* may be used with a double object construction, the processor may expect another NP to occur. Again it will check the input string to see if there is an NP. Since no NP occurs in this position, it will postulate a gap, which may then be related to the question-constituent at the beginning of the sentence. Hence, (29a), where *the doctor* is interpreted as the indirect object of *bring*, is correctly predicted to be the preferred interpretation of (29).

Checking the lexical string before postulating a gap seems like a very sensible principle for the processor to follow and it correctly predicts the existence of the XX Extraction preferences discussed by Fodor. Assuming the structures in (26)–(28), this strategy clearly predicts that Dutch perceivers should prefer the object relative interpretation of relative clauses. Once the processor encounters the relative pronoun **die** it will expect a clause to follow and presumably it will expect this clause to contain a subject noun phrase. According to GASP it will check the lexical string to see if a noun phrase does in fact occur. Since a noun phrase does occur, this will be taken to be the subject. The result is that the pattern in (30a) should be preferred to the pattern in (30b).

(30)a. NP *e*
b. *e* NP

Thus, in ambiguous relative clauses subjects should tend to report the object relative interpretation which results from (30a). In unambiguous relatives where the number marking on the verb is inconsistent with this initial interpretation, (30a) should be revised to (30b). Assuming this revision takes some non-negligible amount of time, unambiguous subject relatives are predicted to take longer to process than unambiguous object relatives. Of course, if the processor delays analysis of head-final constructions, as suggested by the delay hypothesis discussed earlier, then there is no reason to expect GASP (XX Extraction) principles to apply in either the ambiguous or unambiguous clauses even if these principles do correctly characterize the processing of head-initial structures.

There is yet another possibility to be considered. In English and French, it has been shown that subject relatives take less time to process than object relatives (e.g., Ford, 1983; Frauenfelder, et al., 1980). As noted at the outset the processing problems that relative clauses pose in these languages are different from those posed by Dutch, since the SVO order of clauses will disambiguate the function of the noun phrases: if the relative pronoun is followed by a verb, the clause may only be a subject relative, as in (31a); if it is followed by a noun phrase, this phrase must be the subject of the relative clause, as in (31b), resulting in an object relative.

(31)a. the girl who left
b. the girl who the man left

It is still not entirely clear why subject relatives are easier to process than object relatives in such languages. One hypothesis is that the complexity of object relatives is due to the fact that the head of the relative must remain unstructured, perhaps held in a special memory buffer, dubbed "HOLD" by Wanner and Maratsos (1978), for longer than is necessary for subject relatives (though see Ford, 1983). While this 'HOLD hypothesis' has never itself been interpreted as a decision principle governing what option the processor should pursue at choice points in the syntactic analysis of a string, one can easily imagine that the identification of a filler increases the probability of the processor postulating a gap. In other words, we may turn this into a decision principle, as in (32).

(32) *Active Filler Hypothesis*[11]
Empty HOLD as soon as possible.

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[11] I have formulated the Active Filler Strategy in terms of HOLD only to simplify the exposition. I strongly suspect the real generalization is that the processor ranks *e* above lexical NP in the immediate domain (e.g., immediate S) of a non-argument filler. In other words, having identified a ('moved') phrase in non-argument position, the processor assumes the existence of an $\bar{A}-A$ dependency (presumably because this ('short') movement is the unmarked dependency within and across languages).

If the processor arrives at the end of the immediate domain, e.g., crosses an S, then the $\bar{A}-A$ hypothesis will be disconfirmed, assuming 'long' extraction involves an $\bar{A}-\bar{A}$ dependency in all but the immediate clause of the gap. This would explain the contrast between (35) and (36) below, for example. If correct, this implies the existence of two distinct gap filling systems (within a language): a filler-driven system operative in the immediate domain of an $\bar{A}$-filler, and a gap driven system which executes a (backwards) search for an appropriate filler whenever an obligatory or lexically preferred gap is detected (see discussion of the most recent filler strategy in Frazier, et al., 1983). If the proposed statement of the Active Filler Strategy is correct, the gap driven system will operate or be effective only in the case of NP movement and 'long' extraction.

It should be immediately apparent that this principle conflicts with the judgements indicated in (29). However, we will treat the hypothesis as viable, and will delay discussion of this problem.

The Active Filler Hypothesis predicts that the structure in (30b) should be preferred to (30a) in any construction in which an obligatory filler precedes a gap. In particular, it predicts the existence of a preference for subject relative clauses in Dutch. Specifically, Dutch perceivers should tend to report the subject relative interpretation of ambiguous relatives. Further, they should initially assign the subject relative analysis to temporarily ambiguous relatives, resulting in a subsequent revision of analysis in unambiguous object relatives. Thus, unambiguous object relatives should take longer to comprehend than unambiguous subject relatives, again assuming that revisions of analysis take some non-negligible amount of time and assuming that the processor is not delaying analysis of verb-final structures.

3.2. *Experiment* 2

To test the predictions of the Delay Hypothesis (no asymmetry), the Gap-As-Second-Resort Principle (Object relative preference) and the Active Filler Hypothesis (Subject relative preference), materials were prepared for a frame-by-frame self-paced reading study. Twenty four experimental sentences were constructed. Twelve of these sentences contained ambiguous relative clauses in sentence final position, as in (33a). The head of the relative clause and the noun phrase within the relative always had human referents. Each sentence was followed by a question of the form **Wie** *verb* **wie**?, as indicated in (33b).

(33)a. Jan houdt niet van de Amerikaanse die de Nederlander
John liked not the American who the Dutchperson
wil uitnodigen.
wants to invite

b. Wie wil wie uitnodigen?
Who wants who invite

Who wants to invite who?

The remaining twelve sentences contained unambiguous relative clauses in sentence final position. To avoid drawing attention to these sentences, only half of them were followed by a question (again, of the form **wie** *verb* **wie**?); and, of these questions, only half questioned the relations in the relative clause. Each sentence appeared in two versions: in one, the verb

agreed in number with the head of the relative clause, as in (34a); in the other, the verb agreed in number with the noun phrase in the relative clause, as in (34b). In half of the sentences, the head of the relative was a singular noun; in half, it was plural.

(34)a. Karl hielp de mijnwerkers die de boswachter vonden.
Karl helped the mineworkers who the forester found-PL

Karl helped the mineworkers who found the forester.

b. Karl hielp de mijnwerkers die de boswachter vond.
Karl helped the mineworkers who the forester found-SG

Karl helped the mineworkers who the forester found.

Thus, subject relatives and object relatives were equally likely to occur with singular verbs and plural verbs. The only difference between the two versions of a sentence was whether the verb occurred in the singular or plural form. All sentences appear in Appendix II.

The experimental sentences were divided into two frames: one frame included the relative clause and the head of the relative; the other frame included all preceding portions of the sentence. Two test lists were constructed. Each contained six unambiguous subject relatives and six unambiguous object relatives, with the constraint that two versions of a sentence never appear in a single list. Each list contained an equal number of subject relatives and object relatives with plural (and singular) verbs. Both lists contained all ambiguous relative clause sentences and all filler sentences. In all other respects, Experiment 2 was identical to Experiment 1 – in fact they were run together.

3.2. *Results*

The mean Response Time for the final frame of the experimental sentences (consisting of the relative clause plus its head) is presented in Table 2.[12] Unambiguous object relatives took longer to read (2440 ms) than unambiguous subject relatives (2328 ms). Statistically, this effect did not quite reach significance ($P < 0.07$ by subjects, $p < 0.06$ by items).

Turning to the question data, subjects were very accurate overall (96% correct for distractor items). In the ambiguous relative clause sentences, there was a clear preference for the subject relative inter-

[12] On 7.8% of the trials, subjects did not respond within the preestablished 3900 msec. cut-off point. The missing responses were distributed equally between subject and object relatives and thus were replaced by the condition mean.

TABLE 2
Experiment II

Reading time for Final Frame in Msecs.	
Unambiguous Subject Relatives	2328
Unambiguous Object Relatives	2440
Answers for Ambiguous Relatives	
Head of Relative = Subject	74% (346 responses)
NP in Relative = Subject	26% (120 responses)

pretation: 74% of all responses identified the head of the relative clause as the subject. The preference for the subject relative interpretation held for every single sentence. (The proportion of subject relative responses for each ambiguous sentence is presented in Appendix II, following the sentence.)

The question-answering data clearly and unambiguously indicates a preference for subject relative clauses. It is thus puzzling that the reading time advantage for subject relatives did not quite reach significance. Though the unambiguous relatives were not systematically questioned, the answers to the subset of relevant questions is revealing. In unambiguous object relatives, the head of the relative was incorrectly identified as the subject of the relative clause verb 31% of the time (compared with only 3.7% incorrect identification in unambiguous subject relatives). Apparently subjects in the experiment assigned a subject relative clause analysis to (at least some) unambiguous object relatives and often, roughly a third of the time, failed to revise this incorrect analysis. This, of course, offers an explanation for why the reading time analysis did not reach significance. We would expect reading times for unambiguous object relatives to be longer than for unambiguous subject relatives only in those cases where subjects actually did revise an incorrect subject relative analysis and compute the correct object relative analysis.

These data are obviously incompatible with the predictions of GASP and are clearly compatible with the Active Filler Hypothesis, which predicted precisely this pattern of response. The question, however, is whether the data truly exclude the Delay Hypothesis.

One might argue, for example, that the overwhelming preference for the subject relative interpretation of the ambiguous relatives does *not* reflect an initial commitment to the subject relative analysis. Rather, the processor might delay assigning an analysis in hope that disambiguating information will occur. When no such information arrives, the processor computes the simpler or less complex analysis. But this, of course, is the

question: why should the subject relative analysis be easier than the object relative analysis, if the processor is delaying its analysis? We cannot invoke the HOLD hypothesis here, since under that hypothesis the head of the relative would be held unstructured until the end of the clause, regardless of whether the processor then assigned a subject or an object interpretation. Further, it is simply unclear why the processor would delay assigning an analysis until disambiguating information had been encountered, and then ignore that information when it arrived, as indicated by the incorrect responses to the unambiguous object relatives.

To reiterate, the Delay Hypothesis does not account for these data, because it offers no explanation for the preference for subject relative interpretations of the ambiguous clauses, or for the response time advantage of the unambiguous subject relatives or the erroneous analysis assigned to unambiguous object relatives.

4. Implications

Below we will examine the implications of our findings for a theory of human language processing.

4.1. *Constituent structure*

The finding (Experiment 1) that temporarily ambiguous conjoined structures are processed faster if they conform to the minimal attachment analysis of the ambiguous string, as in the case of NP-conjunction, than if they do not, as in S-conjunction, was taken as evidence that Minimal Attachment governs the constituent structure analysis of Dutch. The conclusion that Minimal Attachment is operative in Dutch is of interest in itself, because it constitutes preliminary evidence supporting the cross language validity of a model of sentence processing developed to account for English. Minimal Attachment also provides a window into the timing of node-postulation, since its predictions concerning the preferred analysis of an ambiguous phrase depend on which particular nodes are already present in the phrase marker constructed in response to preceding items in the input sentence. If it were assumed that phrasal nodes are not postulated until their heads are encountered, then we would be left without an explanation for certain preference data (e.g., (21)) which otherwise follow straightforwardly from Minimal Attachment.

The Head Projection Hypothesis (which predicts that phrasal nodes are not postulated until their heads are encountered) was not adopted in

our account of Dutch due to these preference data and due to the results of Experiment 2, especially the garden-path effects observed in the unambiguous object relatives. If the present evidence is correct, then the Head Projection Hypothesis does not apply in Dutch and thus cannot be universally valid. The Head Projection Hypothesis is based on a grammatical principle (that the features of a mother node are determined by its head) which is widely accepted as being universal. Thus if the Head Projection Hypothesis is not also universal, it is clearly loses its appeal as a potential processing principle even for a particular language where it is consistent with the data.

Undoubtedly it is desirable to obtain more evidence on the processing of head-final constructions, particularly in languages containing only head-final phrases. Nevertheless, the inability here to turn up any evidence at all in favor of delays in the analysis of head-final phrases at the very least encourages the view that immediate constituent structure analysis based on purely structural principles is universal. It also poses a challenge for any attempt to incorporate the Lexical Proposal Hypothesis (which also predicted delayed analysis of head-final phrases) into a universal theory of language processing.

4.2 *Gap-filling*

The outcome of Experiment 2 disconfirmed the predictions of GASP, supporting instead the predictions of the (contradictory) Active Filler Strategy (AFS). As noted above, GASP has been incorporated into most general accounts of gap-filling in English. Hence, incorporating AFS into a theory of human language processing is problematic, because of the accepted account of the English data. Similarly, maintaining GASP is no longer straightforward, given the evidence for AFS presented here.

In principle, the processing systems for Dutch and English might differ. Both GASP and AFS might belong in a theory of human language processing. If so, we must discover how the parsing system adopts AFS under some circumstances, e.g., given Dutch input, but develops GASP under others, e.g., given English input. The adoption of a filler-driven system (i.e., a system in which AFS operates) might, for example, be tied to the verb-second characteristic of Dutch or to its consequence, namely, that all root sentences begin with a filler (i.e., a displaced constituent).

It is logically possible that the language processing system is paramaterized. Fixing some grammatical parameter may also determine the value of some parameter in the processing system. A related possibility is that appropriate processing principles may be adopted as a result of

experience with a particular language. Due to the success rate of a given principle in a particular language that principle could be adopted. However, given how very little we know at present about the processing of filler-gap dependencies, another possibility is that the current characterization of gap-filling in English or Dutch is simply mistaken. If so, it may be possible to preserve a fully universal and invariant theory of human sentence processing in which the only difference between the processing system of these (and hopefully any) two languages is the particular grammar exploited during the parsing process.

Turning first to see if we should revise the account of Dutch, we see that something like the AFS must be assumed, independent of the above evidence concerning relative clauses. As mentioned in passing in the introduction to Experiment 1, the initial NP in NP-V-NP sequences is preferentially interpreted as corresponding to the 'subject' argument (e.g., the agent of an agent-patient verb), at least when both NPs are animate. In an informal survey of native Dutch speakers' intuitions, this was true for every nonlinguist questioned. Similarly, there is a preference to interpret the initial NP as corresponding to the 'subject' argument in simple constituent questions of the form '**Wie** 'who'-V-NP?' (Read, Kraak and Boves, 1980) though the strength of the preference depended on the prosodic properties of the question.[13] To account for these preferences, it is necessary to assume the operation of either the AFS or something very much like it. Certainly assuming GASP (the gap-driven system proposed for English) would produce precisely the wrong results, incorrectly predicting a preference to interpret the initial NP as direct object (or patient) in each of these structures.

Turning now to English, there is some indication that the standard account of the filler-gap processing system must be revised, quite apart from the conflict between GASP and AFS. As pointed out in Frazier (1985), GASP and the XX Extraction preference cannot be assumed to be fully general, even in English, due to examples like (35).

(35) Who did Fred tell Mary left the country?
  a. tell Mary *e*
  b. tell *e* Mary

[13] Surprisingly, in my informal survey of native Dutch speakers' intuitions, constituent questions containing an auxiliary did not exhibit a strong preference for the initial constituent to be interpreted as subject. In trying to reconcile this with the study of Read, et al. (1980) I realized that the questions in that study never contained auxiliaries. I am currently trying to determine whether in fact the presence of an auxiliary matters, and, if so, why.

GASP and the XX Extraction Principle predict that there should be a strong preference to interpret *who* as the subject of the embedded clause, as illustrated in (35a). This prediction is not confirmed by intuitions; indeed, there seems to be a fairly clear preference for (35b). It should be noted, however, that the preference for (35b) seems to hold only in cases where the gap may occur in the same (immediate) clause that introduce the filler. Thus the preference for the '*e* NP' pattern does not seem to be present in example (36), (pointed out to me by Edwin Williams) where there does not appear to be any systematic preference. (Note that the absence of a preference in (36) is not a problem for the statement of the AFS given in note 13).

(36)a. Who did Fred desperately want to tell Mary left the country?
b. I don't remember who the CIA decided to warn the Ambassador left?

Once again this runs counter to the prediction of GASP. And, in various recent experimental studies (cf. Crain and Fodor, 1985; Stowe, 1986) it has been demonstrated that readers prefer an empty category, rather than a lexical phrase, to follow a verb like *force* or *persuade* in a string like (38).

(38) Who did you persuade...?

This is not only evidence against GASP, but seems to require the assumption that empty categories are ranked above lexical noun phrases as required by the AFS.

In short, GASP simply cannot be maintained in English in the general case. Further, the XX preferences originally used to motivate the principle are now open to alternative explanations (see Woolford, 1986).[14] Additional investigation of gap-filling routines is clearly needed in both Dutch and English to securely establish the Active Filler Strategy, in particular its generality. But it is encouraging that the one potential example we have seen of a language-specific parsing routine (the use of GASP in English, but not Dutch) cannot be maintained, even if we restrict out attention to generalizations within one language.

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[14] Woolford (1986) proposes a universal mapping convention governing the distribution of empty categories, constraining the mapping of lexical items onto the terminal positions in a phrase marker. In a right-branching language like English, the mapping process operates from left-to-right, resulting in the configuration 'NP *e*' within any mapping domain (essentially any maximal projection, excluding VP). In left-branching languages, the mapping process operates from right-to-left, resulting in the configuration '*e* NP'.

APPENDIX I

Attachment sentences:

1a. Piet kuste Marie en / haar zusje / ook.
b. Piet kuste Marie en / haar zusje / lachte.
c. Annie zag / haar zusje / ook.
d. Annie zag dat / haar zusje / lachte.
2a. De gast praatte alleen met je ouders en / je oom / gisteren.
b. De gast praatte alleen met je ouders en / je oom / klaagde.
c. Ik hoorde / je oom / gisteren.
d. Ik hoorde dat / je oom / klaagde.
3a. Ik zag de man en / de vrouwen samen.
b. Ik zag de man en / de vrouw schreeuwde.
c. Ik zag / de vrouwen / samen.
d. Ik zag dat / de vrouw / schreeuwde.
4a. De vreemdeling verstaat de kleermaker en / de winkelbediende / vandaag.
b. De vreemdeling verstaat de kleermaker en / de winkelbediende / grijnsde.
c. De vreemdeling verstaat / de winkelbediende / vandaag.
d. De vreemdeling wist dat / de winkelbediende / grijnsde.
5a. De meid poetst de keuken maar / de slaapkamer / zelden.
b. De meid poetst de keuken maar / de slaapkamer / bleef vuil.
c. De meid poetst / de slaapkamer / zelden.
d. De meid wist dat / de slaapkamer / vuil bleef.
6a. De bibliothecaris bestelde de boeken en / de tijdschriften / bijna dagelijks.
b. De bibliothecaris bestelde de boeken en / de tijdschriften / waren vergeten.
c. De bibliothecaris bestelde / de tijdschriften / bijna dagelijks.
d. De bibliothecaris dacht dat / de tijdschriften / waren vergeten.
7a. Henk vroeg de studente en / de secretaresse / te helpen.
b. Henk vroeg de studente en / de secretaresse / hielp ook.
c. Henk vroeg / de secretaresse / te helpen.
d. Henk wist dat / de secretaresse / ook hielp.
8a. Jan hielp het kind en / de jongen / met opstapelen.
b. Jan hielp het kind en / de jongen / hielp het meisje.
c. Jan hielp / de jongen / met opstapelen.
d. Ik geloof dat / de jongen / het meisje hielp.
9a. Sylvia begon vandaag in een nieuwe roman en / haar studie boek / te lezen.
b. Sylvia begon vandaag in een nieuwe roman en / haar studie boek / bleef liggen.
c. Sylvia begon vandaag / haar studie boek / te lezen.
d. Sylvia zag dat / haar studie boek / bleef liggen.
10a. Leo onderwees het meisje en / de jongen / gisteren.
b. Leo onderwees het meisje en / de jongen / speelde.
c. Leo onderwees / de jongen / gisteren.
d. Leo dacht dat / de jongen / speelde.
11a. Inge serveerde de erwtensoep en / de Quiche Lorraine / bij 't middageten.
b. Inge serveerde de erwtensoep en / de Quiche Lorraine / mislukte.
c. Inge serveerde / de Quiche Lorraine / bij 't middageten.
d. Inge zag dat / de Quiche Lorraine / mislukte.
12a. Karl vond de agent en / de vreemdeling / eindelijk.
b. Karl vond de agent en / de vreemdeling / keek.
c. Karl vond / de vreemdeling / eindelijk.
d. De agent wist alleen dat / de vreemdeling / keek.

APPENDIX II

A. *Ambiguous relative clauses*:
(Proportion of 'Head=Subject' Responses in Parentheses)

1. Jan houdt niet van / de Amerikaanse die de Nederlander wil uitnodigen. Wie wil wie uitnodigen? (31/37)
2. De onderwijzeres hoorde / de gasten die de kinderen stoorden. Wie stoorde wie? (32/40)
3. Mijnheer Carver hielp / de matroos die de man heeft gestoken. Wie heeft wie gestoken? (32/38)
4. Niemand praatte met / de atleten die de toeschouwers hadden uitgescholden. Wie schold wie uit? (21/37)
5. Daar is / de man die mijn zuster heeft geholpen. Wie hielp wie? (38/40)
6. Ik schreef aan / de vriend die mijn tante heeft bezocht. Wie heeft wie bezocht? (36/38)
7. Pieter zag / de vreemdeling die de kelner niet kon verstaan. Wie kon wie niet verstaan? (28/39)
8. Hier is / de vrouw die de kleermaker heeft vergeten. Wie heeft wie vergeten? (24/36)
9. Wij lachten om / de meisjes die de kerels volgden. Wie volgde wie? (32/40)
10. Daar gaat / de studente die mijn onderwijzer niet kent. Wie kent wie niet? (24/40)
11. Hier komt / de persoon die de winkelbediende zoekt. Wie zoekt wie? (27/39)
12. Daar staat / de typiste die de professor verwacht. Wie verwacht wie? (21/40)

B. *Unambiguous relative clauses*:
(a = subject relative; b = object relative)

13a. Wij kennen / de meisjes die de jongen zoeken. Wie zoekt wie?
b. Wij kennen / de meisjes die de jongen zoekt. Wie zoekt wie?
14a. Daar is / de secretaresse die de redacteuren kent. Wie kent wie?
b. Daar is / de secretaresse die de redacteuren kennen. Wie kent wie?
15a. Karl hielp / de mijnwerkers die de boswachter vonden. Wie vond wie?
b. Karl hielp / de mijnwerkers die de boswachter vond. Wie vond wie?
16a. Marie zag / de vrienden die mijn zuster thuis brachten. Wie zag wie?
b. Marie zag / de vrienden die mijn zuster thuis bracht. Wie zag wie?
17a. Ian praatte over / de wasvrouw die de schoonmaakster huurde. Wie praatte over wie?
b. Ian praatte over / de wasvrouw die de schoonmaakster huurden. Wie praatte over wie?
18a. De ouden van dagen herinneren zich / de Spanjaard die alle Nederlandse meisjes bemint. Wie herinnert zich wie?
b. De ouden van dagen herinneren zich / de Spanjaard die alle Nederlandse meisjes beminnen. Wie herinnert zich wie?
19a. Iedereen negeerde / de vrouwen die mijn broer hielpen. Wie hielp wie?
b. Iedereen negeerde / de vrouwen die mijn broer hielp. Wie hielp wie?
20a. Mijn moeder vond / de vriend die mijn zusjes in de kast verborg. Wie verborg wie?
b. Mijn moeder vond / de vriend did mijn zusjes in de kast verborgen. Wie verborg wie?
21a. Ik zag / de bedelaars die Marie iets vroegen. Wie vroeg wie?
b. Ik zag / de bedelaars die Marie iets vroeg. Wie vroeg wie?
22a. Hier is / de grote man die de kinderen aanbad. Wie aanbad wie?
b. Hier is / de grote man die de kinderen aanbaden. Wie aanbad wie?

23a. Daar zaten / de arbeiders die de chef haten. Wie haat wie?
b. Daar zaten / de arbeiders die de chef haat. Wie haat wie?
24a. De vader luisterde altijd naar / de jurist die zijn dochters raadpleegde. Wie raadpleegde wie?
b. De vader luisterde altijd naar / de jurist die zijn dochters raadpleegden. Wie raadpleegde wie?

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