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Modifier Attachment in Sentence Parsing: Evidence from Dutch

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Current theories of parsing suggest a wide variety of mechanisms by which modifiers, such as relative clauses, may be related to constituents that offer more than one potential attachment site. Some, like the tuning hypothesis, are based on the premise that people's parsing performance is shaped by prior exposure to language. Others (e.g. garden-path theory and construal theory) play down any potential role of past linguistic experience, stressing instead the varying influences of structural characteristics of the sentence in question. The two views encourage differing expectations about cross-linguistic variation in parsing preference. A questionnaire study and two on-line experiments were carried out to investigate attachment preferences in Dutch. The results pose a number of problems for the majority of the existing parsing models and are clearly inconsistent with some of the traditional theories. In contrast, the findings are compatible with models incorporating parsing mechanisms that are tuned by language experience. The results highlight the need for further corpus studies to subject these accounts to more searching scrutiny.

There has recently been a good deal of discussion about whether human parsing is based on universal procedures that operate over all the different languages of the world or whether certain aspects of processing are restricted either to individual languages or to subclasses of the full range of languages (Bates & MacWhinney, 1987; Carreiras & Clifton, 1993; Cuetos & Mitchell, 1988; Cuetos, Mitchell, & Corley, in press; De Vincenzi & Job, 1993; Frazier, 1978, 1987; Frazier & Clifton, 1996; Gibson, Pearlmutter, Canseco-Gonzales, & Hickok, 1996; Gilboy, Sopena, Clifton, & Frazier, 1995; Hemforth,

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Konieczny, & Scheepers, 1994; Inoue & Fodor, 1995; Mazuka & Lust, 1990; Mitchell, Cuetos, & Zagar, 1990).

The dominant view is probably that there is a single universal parsing mechanism—a device that takes full account of the grammatical features of the language under analysis but, apart from this, displays no variation from language to language. This position is adopted explicitly by a number of authors (e.g. Crocker, 1992; Frazier, 1987; Inoue & Fodor, 1995; Kimball, 1973) and implicitly by many others (e.g. Gorrell, 1994, 1995; Pritchett, 1992).

In contrast with this view, a smaller number of investigators have proposed that at least some aspects of the parsing process may change from language to language—or even from individual to individual (Bates & MacWhinney, 1987; Cuetos & Mitchell, 1988; Cuetos et al., in press; Frazier & Rayner, 1988; Gibson et al., in press; Just & Carpenter, 1992; Mazuka & Lust, 1990; Mitchell, 1994; Mitchell & Cuetos, 1991a).

Much of the discussion of these issues has centred on the nature of the strategies people use to parse sentences like (1):

(1) Someone shot the servant of the actress who was on the balcony.

The crucial feature of this sentence is that it includes a complex noun phrase (NP) followed by a relative clause (RC): ". . . who was . . .". In this particular case, the complex NP is made up of a simple NP followed by a prepositional phrase (PP) (i.e. the complex is of the form NP–PP). In materials incorporating NP–PP–RC sequences of this kind (henceforth NP–PP–RC sentences), the relative clause ("who was . . . ") can be attached at more than one point within the preceding complex. It can be attached either "high" to "servant" (henceforth sometimes referred to as N1 for Noun1 attachment) or "low" to "actress" (N2 attachment). (The terms "high" and "low" refer to positions in the phrase-marker of the complex noun phrase.) Comparable sentences with equivalent ambiguities occur in numerous languages other than English.

One of the major goals of theories of parsing has been to explain how readers and listeners resolve ambiguities of this kind (among many others). Using the simplest working assumptions, universal theories presumably predict that the mechanisms will be the same across all languages. However, against this expectation, several studies have shown that there is clear cross-linguistic variation in the way people process sentences of the kind illustrated above. In particular, readers' parsing strategies sometimes lead to the relative clause being attached high (to N1), sometimes low, and in certain cases there appears to be no special preference for either of the potential attachment sites. Cuetos and Mitchell (1988) administered a questionnaire simply asking subjects "Who was on the balcony?"—or its equivalent—for a sample of sentences. In English there was a reliable preference for low attachment (to "actress"), whereas in a Spanish form of the questionnaire subjects were more likely to opt for high attachment (to "*criado*" = "servant"). A series of on-line studies using subject-paced reading confirmed that this high-attachment bias in Spanish exerts its influence before the end of the sentence. These experiments were based on materials such as (2a, b), among others:

(2a) *Alguien disparó contra el criado de la actriz/que estaba en el balcón/con su marido.* [Someone shot the (male) servant of the actress who was on the balcony with her husband.]

(2b) *Alguien disparó contra la criada de la actriz/que estaba en el balcón/con su marido.* [Someone shot the (female) servant of the actress who was on the balcony with her husband.]

The final phrase (''*con su marido*'') indicates that the person on the balcony must be female, forcing low attachment (to ''*actriz*'') in (2a). If the relative clause is attached to N1 (''*criado*'') as this phrase is read, as the questionnaire data suggest, then some readjustment will be needed to detach the clause from the N1 site and re-attach it to N2. The reading time for this phrase would therefore be expected to be longer than that for the corresponding display in (2b), where both potential heads are feminine and no revision is called for. This was precisely the result that was obtained, and the findings (for Spanish) have since been replicated and extended in several ways (Carreiras, 1992; Carreiras & Clifton, 1993; Mitchell et al., 1990; Mitchell & Cuetos, 1991a, 1991b).

In contrast with the clear high-attachment preference in Spanish, the findings for English are somewhat mixed. The original, questionnaire-based support for low-attachment preference reported by Cuetos and Mitchell (1988) has been replicated in two further studies by Mitchell and Cuetos (1991a) and in several other unpublished questionnaire studies conducted in England (Martin Corley, personal communication—but see Clifton, 1988, for a contrary finding). The low-attachment (N2) bias is apparently confirmed as an on-line effect in a subject-paced reading experiment reported by Clifton (1988; see also Frazier, 1990). Using materials like (3a, b), these investigators found that the latter portions of sentences forcing low attachment (e.g. 3a) were read more rapidly than were the corresponding parts of sentences forcing high attachment (e.g. 3b).

(3a) The doctor called in/the son of the pretty nurse who hurt herself.

(3b) The doctor called in/the son of the pretty nurse who hurt himself.

However, in contrast with this finding, Carreiras and Clifton (1993) found no reliable preference for either high or low attachment in English equivalents of their Spanish sentences—a result that is consistent with several on-line studies conducted in Exeter by Martin Corley and one of the present authors (DCM).

Ultimately it will be essential to establish whether English sentence processing leads to equibiased attachment or a preference for low attachment. However, in either case there appears to be clear evidence that the pattern of processing is different from the form demonstrated repeatedly in Spanish. Since the earlier studies, these patterns of preference have been examined in several other languages. The majority of these studies show a high-attachment bias (French: Zagar & Pynte, 1992; German: Hemforth et al., 1994; Vera Kempe and Ralph Radach, personal communication; and Russian: Vera Kempe and Ralph Radach, personal communication). However, De Vincenzi and Job (1993) have presented evidence that although Italian readers show a clear high-attachment preference within complex noun phrases incorporating the preposition ''*dalla*'', ''*dello*'' and ''*del*'' (i.e.

Italian equivalents of "of") in questionnaire studies, the biases may be different with other prepositions (e.g. "*con*" = "with") or even with "of" materials in on-line studies. In particular, they reported findings that they take as evidence of initial low-attachment biases in Italian.

Although several accounts of ambiguity resolution have been proposed in recent years (see the General Discussion), none of them has succeeded in predicting the pattern of attachment preferences that prevailed in the languages scrutinized above. Nor do most of them provide a satisfactory basis for correct predictions about attachment preferences in new languages. In an effort to clarify some of the issues in research of this kind, the present paper focuses on attachment biases in Dutch. The Dutch language presents several features that could potentially throw fresh light on the problem. Like English and German, but unlike all other languages examined to date, Dutch is pre-nominal in the sense that adjectives typically precede the nouns they modify. Certain accounts of relative clause attachment assign a crucial role to adjective-noun order (see General Discussion for details). Data from a previously untested pre-nominal language provide an opportunity to test the generality of such accounts. As can be seen in Experiments 2 and 3, the Dutch language also offers a device that may make it possible to evaluate attachment preferences on the very first word of a relative clause. To the extent that such opportunities are not available in most languages, this may provide a particularly good chance to probe early attachment preferences. Finally, Dutch (again like English and German) is a language that has more than one way of expressing genitive or possessive relationships. In this sense it differs from the Romance languages examined most closely up to now. As it has been suggested that differences of this kind may underpin cross-linguistic differences (see General Discussion for further details), this offers a further motive for investigating Dutch attachment preferences.

Before proceeding to examine the Dutch findings in detail, it should be noted that there are questionnaire data in German indicating that readers prefer to attach relative clauses to the first host site (Hemforth et al., 1994; Kempe & Radach, personal communication). In view of the fact that Dutch seems to have patterns more or less similar both to German and to English (see above), but readers of English do not seem to share the attachment preferences found in readers of German, it would be instructive to determine which of these two languages Dutch resembles more closely in terms of attachment bias (both off- and on-line). The answer to this question offers the prospect of identifying leads that may eventually enable us to isolate some of the factors that contribute to cross-linguistic variation in preferences of this kind.

EXPERIMENT 1

As far as we are aware, there is no prior evidence on the attachment preference in Dutch NP–PP–RC sentences. The closest comparison available seems to be unpublished evidence on N–V–N-Modifier such as (4) described by Flores d'Arcais (1990, p. 353):

(4) *Jan zag Anneke lopend op het strand.*
[John saw Anneke running on the beach.]

With materials of this kind Flores d'Arcais (1990) argues that the modifier is intially attached low (see also Frazier, 1993). However, this bias has been shown to vary according to the property of the first verb (Brysbaert & Mitchell, 1994). If the verb "*zag*" [saw] is replaced by "*achtervolgde*" [chased], as in (5), subjects prefer high attachment to low attachment.

(5) *Jan achtervolgde Anneke lopend op het strand.*
[John chased Anneke running on the beach.]

Thus it is unlikely that the attachments within N–V–N structures can be used to draw inferences about the NP–PP–RC structures of interest here.

The present experiment tackles the issue directly by using a Dutch translation of the questionnaire originally presented to English and Spanish readers by Cuetos and Mitchell (1988).

Method

The original English questionnaire was translated into Dutch and checked in detail by three native speakers.

As in the earlier studies, each sentence was followed by a question designed to tap the reader's preferred attachment of the ambiguous relative clause, as in (6):

(6) *Iemand schoot op de knecht van de actrice die op het balkon zat.*
[Someone shot the servant of the actress who was on the balcony.]
Wie zat op het balkon? . . .
[Who was on the balcony? . . .]

Subjects were simply asked to write in a single word—either "*knecht*" or "*actrice*"—identifying one of the two people supposed (in their judgement) to be on the balcony. There were 24 test sentences, interspersed with 26 filler sentences representing a variety of other, unrelated kinds of ambiguity. Of the 24 test sentences, 11 were examples in which both of the potential attachment sites were human nouns (e.g. "the servant of the actress"), whereas in the remaining 13 sentences the first noun was non-human and the second noun was human (e.g. "the book of the girl"). This slight imbalance was an unintended feature of the original questionnaire used by Cuetos and Mitchell (1988) and was retained to keep the comparison as close as possible. The order of the sentences was also the same as in the original English and Spanish questionnaires.

The questionnaire was administered to subjects in groups of approximately 20. The subjects were 107 first-year undergraduates attending the Katholieke Universiteit Leuven.

Results

The results of 7 subjects were discarded because they gave one or more answers indicating that they understood the critical clauses to have been attached to heads other than to the two noun-sites within the complex noun phrase. For the human/human materials, subjects selected NP1 attachments for a mean of 6.2 out of the 11 sentences, and NP2 for

the remainder. For the non-human materials, the subjects selected NP1 attachments for a mean of 8.7 out of the 13 sentences, and NP2 attachments for the remainder.

The data were converted to percentages of high-attachment preferences for the different materials and subjected to *t*-tests with subjects and materials as random effects. The overall high-attachment preference (62.1%) was significantly different from 50% in one-sample *t*-tests, $t_1(99) = 6.13$, $p < .01$, $t_2(23) = 3.09$, $p < .01$. A related samples *t*-test over subjects provided some evidence that the effect for non-human/human materials (66.9%) was more marked than that for human/human materials (56.4%), $t_1(197) = 3.34$, $p < .01$). However, because of the small number of sentences, this difference was not reliable in the materials analysis, $t_2(21) = 1.41$, n.s. Analysed separately, the high-attachment bias was reliable for the non-human/human sentences, $t_1(99) = 7.84$, $p < .01$; $t_2(12) = 2.88$, $p < .05$. The corresponding effect for human/human materials was reliable on the subjects analysis, $t_1(99) = 2.75$, $p < .01$, but not on the materials analysis, $t_2(10) = 1.36$, n.s.

To test whether there are individual differences between preferences shown by different subjects, the entire data set was entered into a 100×24 matrix, with entries registered as 1 whenever a subject opted for high attachment for a given sentence and 0 otherwise.

This data set was submitted to an analysis of variance (ANOVA) with materials treated as a random variable (as in a normal materials analysis) and the 100 subjects treated as 100 different levels of a random-effects treatment.

The results of this analysis showed that there were highly reliable differences between the scores for different subjects (implying that there were differences in their individual tendencies to attach high from one sentence to the next). The subjects-as-treatments effect in the analysis yielded an *F*-ratio of $F(99, 2277) = 5.47$, $p < .01$. This analysis shows that some subjects consistently produced higher scores (i.e. higher probabilities of N1 attachment) than others, and that this tendency was statistically reliable to the extent that re-examining these effects over the 24 sentences indicated that the 100 "treatments" incorporated reliable differences.

To examine the individual differences in greater detail, we conducted a HICLAS analysis (De Boeck & Rosenberg, 1988). This deals with input in the form of Boolean variables and allows one to establish a simultaneous (hierarchical) classification of both materials and subjects. This provides an indication of how the sentences are related to one another and how subjects, in turn, relate to this structure. The analysis gave a satisfactory goodness-of-fit of .67 at rank 1 (i.e. the simplest classification) and showed that 3 sentences and 17 subjects were unlikely to yield high attachment. The 21 other sentences and 83 subjects were given a classification as high attachment preference. The goodness of fit was only slightly improved if a more complex classification was used in which the sentence and the subject pool were further subdivided to get a more accurate picture (e.g. rank 2 gave a goodness-of-fit of .72). Because the questionnaire was administered in a fixed format (i.e. each subject received the same sequence of sentences), it is not clear whether the low-attachment preference for three sentences was due to the formulation of the sentence or to their position in the questionnaire. However, the results provide strong indication that there are reliable individual differences in the attachment strategies adopted by different subjects.

Discussion

The results provide a strong indication that, in Dutch, when a relative clause has to be attached to a site within a complex noun phrase, readers generally prefer to link it with the noun phrase mentioned first within the structure (i.e. applying the terminology used in this paper, they show a preference for high (or N1) attachment). This bias was more marked when the noun phrase occupying the N1 site was non-human, but remained reliable in the subjects' analysis when both alternatives were human. It seems clear, then, that there is an N1 preference in the particular sentences used in this (cross-linguistic) questionnaire. It may be worth noting, however, that the N1 preferences in Dutch (56% for human/human heads, and 67% for non-human/human heads) are less marked than those in Spanish (72% for human/human, and 78% for non-human/human), although they are based on exactly the same questionnaire. This point will be futher elaborated in the General Discussion.

The high-attachment preference revealed here contrasts starkly with the low-attachment preference reported by Flores d'Arcais (1990) for materials in which a relative clause had to be linked to structures other than complex noun phrases. This strongly suggests that any generalization about attachment preferences has to be qualified by reference to the linguistic structure of the host constituent (i.e. the constituent into which the relative clause is being attached).

The results seem to show some evidence that attachment patterns are influenced by head type (human versus non-human) and also that there may be individual differences in the directions and strengths of biases shown by different readers. These findings suggest that semantic or pragmatic factors may be involved in determining attachment preferences, and that resolution procedures may vary from individual to individual. A detailed examination of these issues is given in the General Discussion.

In parsing studies it is often found that attachment preferences established late in a sentence or after the end of a sentence are different from those obtained on-line shortly after the point of ambiguity (e.g. Rayner, Carlson, & Frazier, 1983; De Vincenzi & Job, 1993). This raises the question of whether the high-attachment preference in Dutch manifests itself while the sentence is still being processed.

EXPERIMENT 2

In order to test whether the high-attachment bias predominates during early phases of the analysis of the relative clause, it is necessary to probe the modifier attachment preferences at points before the end of the sentence. In the past this has usually been done by using subject-paced reading techniques to compare the reading times for strings of words that disambiguate in favour of either N1 or N2 attachment (e.g. Carreiras, 1992, Carreiras & Clifton, 1993; Cuetos & Mitchell, 1988; De Vincenzi & Job, 1993; Frazier, 1990; Mitchell & Cuetos, 1991a, 1991b; Mitchell et al., 1990). Where displays are read faster when compatible with one attachment rather than the other, this has been taken as evidence that the attachment bias is in place at the point of testing. Using materials of the kind shown in Example (7), the Dutch language offers the prospect of examining attachment biases very early as well as fairly late in the relative clause. The early probe data involve disambiguating

the relative clause from the very first word on—a feature that has not been exploited in previous studies of this kind and which could therefore yield results of particular interest.

(7a) *De gangsters/schoten/op de zoon/van de actrice/die/op het balkon/zat/met zijn arm/in het gips.*
[The terrorists shot the son of the actress who was on the balcony with his arm in a cast.]

(7b) *De gangsters/schoten/op de zoon/van de actrice/die/op het balkon/zat/met haar arm/in het gips.*
[The terrorists shot the son of the actress who was on the balcony with her arm in a cast.]

(7c) *De gangsters/schoten/op het zoontje/van de actrice/dat/op het balkon/zat/met zijn arm/in het gips.*
[The terrorists shot the little son of the actress who was on the balcony with his arm in a cast.]

(7d) *De gangsters/schoten/op het zoontje/van de actrice/die/op het balkon/zat/met haar arm/in het gips.*
[The terrorists shot the little son of the actress who was on the balcony with her arm in a cast.]

In Dutch there are two forms of the relative pronoun: "*dat*" and "*die*". The "*dat*" form is used to attach the relative clause to a singular neuter head NP, whereas the alternative form is used for all other types of head. Singular neuter heads are marked overtly by the use of a specific definite article form—"*het*". In all other cases, the definite article "*de*" is used. In (7a) and (7b), the relative clause "*die op het . . .*" can be attached either to N1 ("*zoon*") or N2 ("*actrice*"), and the ambiguity remains until the phrase "*met zijn/haar arm*" indicates whether the head should be masculine or feminine. These two forms of the sentence closely parallel the materials used in the Spanish and English studies discussed earlier.

In (7c), the use of the relative pronoun "*dat*" indicates unambiguously that the relative clause must be attached to N1 (i.e. the singular neuter head "*het zoontje*"). Equally, the use of the "*die*" form in (7d) forces N2 attachment to "*de actrice*". In each case the later, gender-specific phrase "*met zijn/haar arm*" merely provides information to keep it consistent with the existing commitment.

Following the logic of the Cuetos and Mitchell study, if readers show a high-attachment bias, as the off-line data suggest, then the relative clause should be linked to N1 (i.e. the masculine head "*zoon*" ["son"]). In this case the disambiguating phrase "*met haar arm*" (in 7b) would signal an attachment error, triggering reanalysis and allowing the parser to switch the relative clause from N1 to N2. In contrast, the corresponding phrase in (7a) ("*met zijn arm*") should be entirely compatible with the prevailing attachment and should be processed without reanalysis. Hence N1 preference predicts that the latency for the disambiguating portion of (7b) should be longer that that for the corresponding segment of (7a).

Such a finding would establish that the high-attachment bias is in place well before the end of the sentence (and correspondingly the reverse effect would point to low-attachment bias at this point). The materials in (7c) and (7d) may be used to see whether comparable effects occur at the very beginning of the relative clause. If high assignment by the "*dat*" pronoun in (7c) is faster than low assignment in (7d), then this would suggest that the attachment is already in place at this point. The current experiment was designed to examine early and late attachment by using materials of this kind.

One important problem needs to be addressed before embarking on the study, however. In studies of the kind just outlined, latency differences may not be determined by attachment bias alone. Where sentences are artificially broken into segments, there is clear evidence that reading latencies can be affected by the pattern of segmentation (e.g. Kennedy, Murray, Jennings, & Reid, 1989; Mitchell, 1987). Clifton (personal communication, 1988) raised the possibility that the original Cuetos and Mitchell findings may have reflected segmentation artefacts rather than offering evidence for high-attachment bias. More recently, Carreiras and Clifton (1993) have raised a similar objection to the studies in Italian conducted by De Vincenzi and Job (1993). Mitchell and Cuetos countered the earlier criticisms by showing that the pattern of results was essentially unchanged when subdivisions prior to the relative clause were eliminated (Cuetos & Mitchell, 1988, Experiment 4) and even when the unsegmented display was extended to include the first four or five words of the relative clause (Mitchell & Cuetos, 1991b, Experiment 3). However, none of these studies examined the segmentation artefacts that might occur when the complex NP itself is subdivided into different displays (as in the De Vincenzi & Job, 1993, study). Indeed, it seems quite reasonable to suppose that the status of the two potential attachment sites may be affected if the experimental task is set up so that one is removed from the screen before the other appears.

Segmentation effects of this kind were examined in the present study by partitioning the materials in two ways—one in which the experimental sentences are unsegmented (and in which N1 and N2 obviously appear in the same display), and one in which N1 and N2 appear in different displays. In the latter condition, material was presented phrase-by-phrase, segmented as indicated by the oblique slashes in (7a,b,c,d).

Method

Stimulus Material

The test sentences consisted of 20 groups of 4 sentences (see Appendix 1), which allowed an orthogonal variation of (a) reference to the first or the second noun of the complex head, and (b) immediate or delayed disambiguation of the relative clause. Of the 20 groups of sentences, 8 had complex heads of the type human/human (e.g. "the son of the actress"), 8 other groups were of the type non-human/human (e.g. "the book of the girl"), and 4 of the type human/non-human (e.g. "the main character of the film"). Test sentences were combined with 100 filler sentences, which were either first sentences of Dutch novels and detective stories ($n = 48$) or sentences that addressed other unrelated psycholinguistic questions ($n = 52$). Of the filler sentences, 25 were followed by a question that addressed the content of the sentence and could be answered by "yes" or "no" (e.g. "*Voor de poort van het klooster Mariabronn vlak bij de weg stond een kastanjeboom*" [In front of the gate of the abbey Mariabronn near the road stood a chestnut tree]; question: "*Lager een weg voor de poort van het*

klooster?'' [Was there a road in front of the gate of the abbey?]). The purpose of the questions was to ensure that subjects read the sentences in order to understand them.

Procedure

Subjects were seated in front of a 14″ CRT monitor connected to a microcomputer. There were no head restraints. Stimuli were presented on text lines 10 and 12, and the experiment was divided in three blocks: one practice block of 15 sentences and two test blocks of 60 sentences. In all conditions, a trial started with one or two lines of dots indicating the structure of the sentence. These dot patterns were obtained by converting each letter of the sentence into a dot. Subjects had to press the space bar of the computer keyboard to change the dots to the desired text fragment. For 24 of the subjects, this key-press revealed the complete sentence. For 24 other subjects, it provided just the first phrase, the second and successive phrase being displayed in succession with later key-presses (the precise segmentations are given in Appendix 1). The presentation was non-cumulative—that is, each display was removed from the screen and replaced by dots as the next display went up. The number of mistakes on the 25 comprehension questions did not differ between the two conditions (sentences: $M = 2.3$; phrases: $M = 2.0$, $F < 1$).

At the end of the experimental session, all subjects completed the questionnaire used in Experiment 1.

Subjects

The 48 subjects were undergraduate psychology students from the Katholieke Universiteit Leuven, who took part in the experiment as partial fulfilment of course requirements. All subjects were naive with respect to the hypothesis tested and were native Dutch speakers.

Results

Table 1 shows the sum of the reading times for all components of the sentence in the two segmentation conditions. As analyses failed to show reliable effects due to head type in the present and the following experiment, this variable is no longer mentioned in the rest of the paper.

An ANOVA with one between-subjects variable (presentation mode) and two within-subjects variables (position of disambiguation, and attachment site) revealed a reliable effect of attachment site (N1 = 7.349, N2 = 7.658) in the subjects analysis, $F_1(1, 46) =$

TABLE 1
Sentence Reading Times[a] as a Function of Presentation Mode, Position of Disambiguation, and Attachment Site in Experiment 2

Position of Disambiguation	*Attachment Site*	*Full Sentence*	*Phrase-by-phrase*
delayed	N1	7.722	7.064
delayed	N2	7.778	7.307
immediate	N1	7.350	7.260
immediate	N2	8.210	7.336

[a] In sec.

9.75, $p < .01$, and an effect approaching significance in the materials analysis, $F_2(1, 19) = 3.32$, $p < .09$. The only other effect that reached any degree of significance was the three-way interaction, $F_1(1, 46) = 5.89$, $p < .05$; $F_2(1, 19) = 3.05$, $p < .10$. This interaction was due to the fact that the difference between N1 and N2 attachment was greater for sentences with immediate disambiguation when the complete sentence was presented, whereas the difference was greater for the delayed disambiguation when sentences were presented phrase by phrase. Planned comparisons showed that only the difference between N2 attachments with full sentence presentation and immediate disambiguation and N1 attachments with full sentence presentation and immediate disambiguation was significant, $F_1(1, 46) = 21.55$, $p < .01$, $F_2(1, 19) = 6.54$, $p < .05$.

In a further analysis the constituent latencies of the phrase-by-phrase data were subjected to more detailed scrutiny by looking at the latencies for 7 different regions of the sentences (see Table 2). The regions were defined as follows: (1) the phrases constituting the head of the main clause, (2) NP1 of the complex head, (3) NP2, (4) the relative pronoun, (5) the phrases constituting the ambiguous part of the relative clause (at least for those sentences with delayed disambiguation), (6) the region that in all sentence types had a disambiguating value, and (7) the remainder of the relative clause (see Appendix 1 for the exact borders of the seven regions and their relationship to the phrases of the sentences).

ANOVAs with three repeated measures (position of disambiguation, attachment, and region) revealed only one significant main effect: that of region, $F_1(6, 138) = 87.23$, $p < .01$; $F_2(6, 114) = 12.62$, $p < .01$. This finding is of little theoretical interest, given that the regions varied markedly in the numbers of words displayed. No other effect reached significance in either the subjects or the materials analysis. A closer examination using planned comparisons, however, revealed that N2 attachment induced longer reading times for the final two (disambiguating) regions of the sentences with delayed disambiguation (Regions 6 and 7, combined: $F_1(1, 23) = 4.57$, $p < .05$; $F_2(1, 19) = 4.36$, $p < .06$), albeit only approaching significance in the by-items analysis. No similar effect was present in the sentences with immediate disambiguation, although there was a tendency towards initial facilitation of N2 attachment (in Regions 5 and 6), followed by a reverse effect in

TABLE 2
Reading Times[a] for the Different Regions in the Sentences of the Phrase-by-phrase Presentation Mode, as a Function of Delayed versus Immediate Position of Disambiguation and Attachment Site in Experiment 2

	1 Head	*2 NP1*	*3 NP2*	*4 RP*	*5 Amb.*	*6 Disamb.*	*7 Remainder*
D–N1	1392	746	904	583	1241	873	1217
D–N2	1424	817	897	550	1236	986	1288
I–N1	1375	847	887	589	1309	960	1184
I–N2	1387	838	946	615	1221	893	1328

[a] In msec.

Note: D = delayed; I = immediate.

Region 7. The tendency towards initial facilitation was not significant, however (Regions 4, 5, and 6 combined: $F_1(1, 23) = 2.55$, $p > .10$; $F_2(1, 19) = 1.61$, $p > .20$).

Discussion

Overall, the results confirm that the high-attachment bias obtained in the earlier questionnaire study also shows up in the latency data of a more on-line task. Sentences forcing low attachment took longer to read than did those forcing high attachment (cf. the main effect of attachment site in the combined analysis). The finding, however, is complicated by a three-way interaction between presentation mode (full sentence or phrase-by-phrase), position of the disambiguation (immediate or delayed), and attachment (high or low). The preference for high attachment is significant only in sentences with immediate disambiguation and complete sentence presentation. It is not clear whether the absence of a significant high-attachment preference in the delayed condition of the full sentence presentation is a genuine effect or simply due to random fluctuation. This is especially true because it is not replicated in the next experiment.

On the other hand, the absence of clear attachment preferences in the phrase-by-phrase presentation conditions is compatible with De Vincenzi and Job's (1993) finding that there is less evidence for early closure in sentences with the complex head presented in two different displays. Two comments should be added, however. First, in our study there was no evidence for a reversal of the preference towards late closure, as there was in De Vincenzi and Job's (in the sentences with delayed disambiguation, there was even reliable evidence against late closure if the analysis was restricted to the final two regions). This may point to differences between Dutch and Italian in the degree of high-attachment preference, or to the fact that more than a quarter of De Vincenzi and Job's sentences of the late closure type were misunderstood (a much higher error rate than occurs in most studies of this kind—including the present one—see Procedure section). Second, and more important, the lack of high-attachment preference for sentences that are disambiguated early in the relative clause is not repeated in the full sentence presentation condition. In that condition, sentences with immediate evidence for late closure were the sentences that took the longest time to read (see Table 1). This is quite surprising, given the fact that sentences with disambiguation at the relative pronoun can hardly lead to a prolonged garden path.

EXPERIMENT 3

The interpretation of Experiment 2 was complicated by the fact that there were slightly different patterns of data when the materials were segmented in different ways. To obtain more precise information about moment-to-moment attachment preferences, it is necessary to use an on-line task that does not involve partitioning the stimulus materials into different displays. The present study uses eye-tracking procedures to examine local processing effects with exactly the same materials as those used in Experiment 2.

Method

Subjects

Subjects were 30 graduate students and research assistants from the Katholieke Universiteit Leuven. All were native Dutch speakers and had normal or corrected-to-normal vision. Before the sentence reading experiment, all subjects had taken part in two other experiments with the eye-tracking system, so that they were quite experienced with the equipment. None of the subjects was aware of the research hypothesis. Because not all subjects had reliable eye-movement measurements (see Procedure Section), data from only 24 subjects were taken into account for statistical analyses.

Stimulus Material

The materials were identical to those used in the previous experiment.

Procedure

Subjects were seated at a distance of 75 cm from a 14″ CRT monitor, with the line of sight of the right eye orthogonal to the central screen position. The head was immobilized by means of a head rest and a bite bar with dental impression compound. Eye movements were monitored with a Generation-V dual-Purkinje-image eye-tracker (as described in Crane & Steele, 1985), which has a spatial accuracy of 10 min of arc. Only the right eye was tracked, although vision was binocular. Horizontal and vertical eye position were sampled every millisecond. The experiment was divided into three sessions, each of which started with a calibration procedure. In this procedure the subject fixated a series of diagonally aligned calibration points, which were presented one at a time in a subject-paced manner. After successful completion of the calibration routine, a calibration check was run. This check consisted of five "+" signs aligned on the 12th line of the 80 × 25 character space of a screen presented in text mode. The plus signs were placed on character positions 10, 25, 50, 65, and 70. The subject had to fixate each sign and press on a button (as in the normal calibration routine). Upon pressing the button, the subject was given feedback about the eye position calculated by the eye-tracker. This was done by displaying a "×" sign. Ideally, the "×" sign had to fall on the "+" sign. A deviation of maximally two letter positions to the left or right and one letter position up or down was allowed, however. As soon as the calibration check was successfully finished, the sentences were presented one at a time on a self-paced basis. Sentences were presented on the 10th text line if they were one-line sentences and on the 10th and the 12th line if they were two-line sentences. Subjects were asked to read the sentences in order to understand the content. They were told not to learn the sentences by heart, just to read them. At the end of a session or after 20 sentences, a new calibration check was run to ensure that the subject's head had not moved. The subject had to remain motionless during the whole experimental session, which lasted between 5 and 15 min, depending on the reading speed of the subject.

The first experimental session consisted of 15 practice sentences, all of which were first sentences of novels. They were presented to introduce the calibration checks and the task to the subjects (the calibration procedure was already known from previous experiments). The second and the third sessions contained 60 sentences and four calibration checks each. The sentences were obtained by making a random permutation of the 20 test sentences and the 100 filler sentences and by dividing the sequence into two halves. Every subject received a different randomization and saw only one of the four possible versions of a test sentence (according to a Latin square design). If a filler item was encountered that had a question following it, upon the subject's keypress indicating the end of the

sentence, the sentence disappeared and the question was presented on the 16th text line. Subjects had to answer by pressing a button with the right (YES) or the left (NO) hand. Feedback was given by the presentation of a "wrong!" message if necessary. Subjects made, on the average, 2.6 mistakes, which is about 10 percent. Subjects who did not pass the calibration checks were discarded from the analyses. This was the case for six subjects (i.e. 20% of the sample tested). After the experiment, subjects filled in the Cuetos and Mitchell (1988) questionnaire.

Results

The mean total reading time for the different types of sentences is given in the first column of Table 3. Split-plot ANOVAs with two repeated measures (position of disambiguation, and attachment) and one group factor (the Latin-square group in the analysis over subjects, and the group of six subjects who read a particular version of the sentences in the analysis over materials) revealed that the difference between high and low attachment was significant, $F_1(1, 20) = 13.74$, $p < .01$; $F_2(1, 16) = 19.63$, $p < .01$. In the F_2 analysis there was also a significant Group × Attachment Preference interaction, $F_2(3, 16) = 30.28$, $p < .01$, due to the fact that the four groups of subjects differed in their overall reading speed. Further analyses of the reading times of Experiment 3 combined with those of the full sentence condition of Experiment 2 failed to show a significant interaction between position of disambiguation and attachment preference, or a significant three-way interaction between study, position of disambiguation, and attachment preference, suggesting that the absence of a clear early closure effect in the sentences with delayed disambiguation in Experiment 2 was due to random fluctuation. However, Experiment 3 confirmed the more difficult nature of the sentences with immediate disambiguation by returning a marginally significant main effect of position of disambiguation, $F_1(1, 20) = 3.88$, $p < .07$, $F_2(1, 16) = 4.11$, $p < .06$. This effect did not interact with that of attachment preference, F_1, $F_2 < 1$.

The eye-tracking data were analysed in relation to the seven regions defined in Experiment 2. In a first analysis, we looked at a dependent variable that would tell us where processing difficulties start. Previous research (Brysbaert, 1994) had indicated that

TABLE 3

Sentence Reading Time, Cumulative Region Reading Time, and Re-reading Time as a Function of Delayed versus Immediate Position of Disambiguation and Attachment Site in Experiment 3

		Cumulative Region Reading Times[b]							
	Sentence Reading Time[a]	*1 Head*	*2 N1*	*3 N2*	*4 RP*	*5 Amb.*	*6 Disamb.*	*7 Remainder*	*Re-reading Time*[b]
D–N1	6.731	778	574	592	110	815	657	903	997
D–N2	7.581	855	573	631	108	965	701	988	1363
I–N1	7.133	765	563	717	110	970	653	915	1081
I–N2	8.023	770	696	626	88	885	689	1123	1561

[a]In sec. [b]In msec.

Note: D = delayed; I = immediate. The sum of the reading times does not equal the sentence reading times because the times for saccades and eye blinks are not included in the present figures.

one of the most informative variables in this respect is the cumulative region reading time (CRRT). This variable is simply defined as the sum of the fixations between the moment when the eyes first cross the front border of the region and the moment when they first cross the back border. The variable differs from first-pass reading time (FPRT) because regressions arising from a region are added to the CRRT of that region but not to the FPRT. CRRT is preferred to FPRT[1] because it is assumed that regressions are an indication of processing difficulties at the region from which they originate and, therefore, should be added to the reading time of that region. Analyses have indicated that this variable agrees more with findings of self-paced reading tasks than FPRT (both in the present experiment and in Brysbaert, 1994). A further distinction was made when the subject started to re-read the sentence towards the end (i.e. either from Region 7 or from Region 6 when Region 7 consisted of a single word). This re-reading time (starting from the moment when the subject returned from the end of the sentence to the main clause) was not added to the CRRT of the last region but was considered as a separate variable. Table 3 shows the results of this analysis.

A cursory examination of the delayed disambiguation data shows that a major part of the time cost for sentences with forced late closure is devoted to re-reading the sentence. The rest is (not surprisingly) distributed over the regions surrounding the disambiguating information. (The fact that some of the effect is found in the preceding region indicates that there must have been some previewing effect, possibly facilitated by the fact that the disambiguating information was often on the second line of text and may occasionally have been picked up during a saccade arrest in the return sweep.) Planned comparisons showed that re-reading was the only part that differed reliably between high and low attachment in both the subjects and the materials analysis, $F_1(1, 23) = 4.42$, $p < .05$; $F_2(1, 16) = 4.19$, $p < .06$, if the Latin-square group is included in the design (see earlier). The combined effect in Regions 5, 6, and 7 also showed some differences, however, $F_1(1, 23) = 6.46$, $p < .05$; $F_2(1, 16) = 3.23$, $p < .10$.

Surprisingly, almost exactly the same picture emerges in the "immediate" conditions in which the relative pronoun type had been expected to determine the attachment. The processing problems in sentences with forced late closure appear to start not when the

[1] Although we favour the use of CRRT above FPRT to find out where in the sentence processing difficulties start, for comparison purposes it may be interesting to have the latter index as well. This is defined as the time interval between the first entrance of the critical region and the first exit, either to the left or to the right side. In addition, zero values (i.e. region skipping) are treated as a separate variable. This is especially important for Region 4 (the relative pronoun), for which the skipping rates amounted to 67% for D1, 70% for D2, 65% for I1, and 66% for I2 (F_1, $F_2 < 1$). FPRTs for the different regions and conditions are:

	1	2	3	4	5	6	7
D–N1	796	474	541	263	763	651	829
D–N2	854	519	543	278	822	683	888
I–N1	776	494	587	252	812	620	783
I–N2	791	536	577	238	776	617	953

In line with the CRRT analysis, conditions that forced N2 attachment gave rise to enhanced reading times in Regions 6 and 7 (planned comparison R6 + R7, D + I: $F_1(1, 23) = 6.36$, $p < .05$; $F_2(1, 16) = 3.67$, $p < .08$). There were no other reliable differences.

relative pronoun is first encountered but, rather, when the second disambiguating region is encountered. Planned comparisons showed a significant difference in re-reading time, $F_1(1, 23) = 7.25$, $p < .01$; $F_2(1, 16) = 6.32$, $p < .05$, and a tendency in the same direction in the reading time data for the last region, $F_1(1, 23) = 3.90$, $p < .10$; $F_2(1, 16) = 4.09$, $p < .07$. In addition, there was some tendency for relative pronouns forcing late closure to be processed more rapidly than those forcing early closure. However, this effect was not reliable. The difference for Region 4 plus Region 5 was not significant in the analysis over subjects, $F_1(1, 23) = 2.07$, $p > .10$; $F_2(1, 16) = 4.93$, $p < .05$, and the difference in Region 3 (which would be an indication of a preview effect), was preceded by a larger difference in the opposite direction in Region 2, implying that it might be partly due to processing spill-over from earlier portions of the sentence.

To establish how long the subjects looked at the different regions, total reading time per region was calculated and tabulated (see Table 4).

Although reading times for all regions were longer for forced low attachment than for forced high attachment, planned comparisons showed that only those of the first two regions and of the last two regions differed reliably, Region 1–head of the main clause: $F_1(1, 23) = 4.71$, $p < .05$; $F_2(1, 16) = 5.08$, $p < .05$; Region 2–N1: $F_1(1, 23) = 8.35$, $p < .01$; $F_2(1, 16) = 6.08$, $p < .05$; Region 6–disambiguating region: $F_1(1, 23) = 12.67$, $p < .01$; $F_2(1, 16) = 6.79$, $p < .05$; Region 7–remainder of the relative clause, significant only by subjects: $F_1(1, 23) = 7.66$, $p < .05$; $F_2(1, 16) = 3.19$, $p < .10$. There were no reliable differences in overall pattern between sentences with immediate and delayed disambiguation.

One final analysis concentrated on the data obtained in the questionnaires completed in Experiment 1 and repeated after the on-line studies in both the current experiment and in Experiment 2. The results indicated that even though the questionnaires themselves were identical, the strengths of the high-attachment biases varied as a function of the experimental session that had gone before. The overall percentages of high-attachment biases were as follows: Experiment 1, 62.1%; Experiment 2 (unsegmented), 51.0%; Experiment 2 (phrase-by-phrase), 60.9%; and Experiment 3, 55.6%. A one-way ANOVA of these percentage values by subjects provided evidence that the differences approach significance, $F(3, 168) = 2.60$, $p < .06$.

TABLE 4
Total Reading Time per Region[a] as Function of Delayed versus Immediate Position of Disambiguation and Attachment Site[b] in Experiment 3

	1 Head	*2 N1*	*3 N2*	*4 RP*	*5 Amb.*	*6 Disamb.*	*7 Remainder*
D–N1	1076	682	777	144	969	832	953
D–N2	1225	747	811	188	1126	990	1098
I–N1	1040	757	827	184	1077	886	1006
I–N2	1159	871	872	171	1142	1001	1229

[a]In msec. [b] N_1, N_2.
Note: D = delayed; I = immediate.

Discussion

Experiment 3 replicates the condition with full sentence presentation in Experiment 2 and shows (a) that sentences in which late closure is forced are more difficult to process than are those in which early closure is imposed, and (2) that this effect is evident in sentences that have a disambiguating relative pronoun, as well as those in which the pronoun is compatible with both of the alternative interpretations. The finding that high-attachment preference is obtained in sentences with a disambiguating pronoun at first sight suggests that the preference is established as soon as the complex head is processed. However, detailed examination of the eye-tracking data does not support this suggestion. The processing difficulties in sentences with disambiguating relative pronouns did not start in the immediate vicinity of the pronoun itself. Instead, they became evident at the point where the material was disambiguated for the second time (i.e. from Region 6 on—see Table 3). In fact, if anything, there was a tendency towards a reversed (N2-favouring) effect in the vicinity of the relative pronoun.

Three interpretations of these findings suggest themselves. The first is based on the premise that the initial advantage in processing N2-attached relative pronouns is a real effect, and takes this as evidence for a transition from low to high attachment during the processing of the relative clause. A difficulty for this interpretation is that it provides no explanation why the transition takes place *in the presence of conflicting information.* To be viable, this account would have to explain why readers switch their preferred attachment from N2 to N1 in the face of clear-cut evidence (in the form of the relative pronoun) that the earlier analysis was correct.

The other two interpretations assume that there is no genuine attachment bias in the vicinity of the relative pronoun. The first possibility is that the relative clause is initially associated with the whole complex NP (without any preference) and that the final attachment is left to other operations implemented a little later in the clause. As with the previous suggestion, this account would have to explain why the postulated late-acting processes would act to shift the attachment from low to high even in cases where there is explicit prior syntactic evidence for low attachment.

The third interpretation is based on the observation that during first-pass reading sentences with a disambiguating relative pronoun do not seem to be processed differently from sentences with an uninformative relative pronoun. This may indicate that the information involved in the relative pronoun is not picked up during fluent reading, either because it is not conspicuous enough (i.e. the difference between "*die*" and "*dat*" is too subtle) or because people adopt processing strategies that ignore gender information (cf. gender errors are common in many real-life settings). If the information conveyed by the relative pronoun is missed or ignored, then it clearly cannot be used to resolve the ambiguity—in which case one would expect the processing profile to be essentially the same as that for sentences with delayed disambiguation. On this account, the only thing left for the reader to do after misinterpreting the sentence would be to locate the neglected information in the second-pass reading. This would provide an explanation for the fact that, overall, sentences with immediate disambiguation tended to take longer to read than sentences with delayed disambiguation. It should be noted, however, that separate analyses on instances in which the relative pronoun was skipped

and those in which it was not skipped failed to yield any difference, so that the failure to use the information conveyed by the relative pronoun can hardly be explained by perceptual processes.

The results of post-experimental questionnaires in each condition suggested that the late off-line biases first demonstrated in Experiment 1 may not be entirely fixed or stable as properties of sentence processing. The virtually reliable evidence that questionnaire biases change as a function of the preceding experimental session strongly suggest that at least certain aspects of the ambiguity-resolving procedure are altered in some way by the subject's recent experience. What seems to happen is that subjects confronted with experimental conditions that elicit a reliable N1 bias (i.e. full sentence presentation) are less likely to give N1 answers in the subsequent questionnaire (i.e. a negative spill-over effect). An interpretation of this finding may be that the processing difficulties encountered for the N2 sentences tend to reduce the pre-experimental imbalance of attachment preferences. The possible implications of these findings are explored in the General Discussion.

GENERAL DISCUSSION

The current experiments provide evidence that in Dutch genitive structures of the form (NP–PP–RC) there is a bias in favour of attaching the relative clause high (to the first potential host-site) rather than low (to the noun phrase immediately preceding the clause). The bias shows up both in off-line (questionnaire) tasks and in on-line tasks where the potential hosts are not presented in different displays. The off-line influences appeared to vary across individuals and apparently change as a function of what the reader has been doing in the preceding half-hour. These findings add to the body of cross-linguistic evidence on attachment preferences and offer some prospect of clarifying the mechanisms underlying such biases.

For much of the remaining discussion we shall use these findings to evaluate a range of different theoretical explanations that have been put forward to explain NP–PP–RC attachment effects. (For a more comprehensive review of these accounts see Cuetos et al., in press.) These frameworks include accounts in which there is a singular commitment to one attachment (e.g. Frazier, 1987), a singular attachment that is later reversed by a subsequent set of operations (e.g. Frazier, 1990), and accounts in which opposing tendencies compete against one another to determine the resulting attachment (e.g. Cuetos & Mitchell, 1988; Gibson et al., in press). They also include models in which there is no initial commitment to one attachment rather than another (e.g. Frazier & Clifton, in press) and proposals that maintain that structural decisions are made by mechanisms that are shaped by the statistical properties of the language under analysis (e.g. Mitchell & Cuetos, 1991a, 1991b).

Until recently, perhaps the most widely accepted account of attachment phenomena of this general kind was the "garden-path" model developed by Frazier and colleagues (Frazier, 1978, 1987; Frazier & Rayner, 1982; Rayner et al., 1983). According to this account, people handle structural ambiguity by committing themselves entirely to one of the various alternative interpretations of the ambiguous constituent. At a later stage of processing, this reading may be subject to revision based on analysis in a device not

involved in the first phase of processing (cf. Rayner et al., 1983). Crucially, the model proposes that the initial choice is made on the basis of syntactic considerations alone, whereas the re-assessment in the second phase may be made on the basis of a variety of sources of information including syntactic features not used in Phase 1 (Frazier, 1989; Mitchell, 1989), verb-thematic information (Rayner et al., 1983), discourse context (Ferreira & Clifton, 1986), and various other sources of information (see Frazier, 1990; Mitchell, 1994). The initial choice is governed by a range of different decision-making strategies, each applying in specific circumstances (see Frazier, 1987, for a review). However for attaching relative clauses to complex NPs, the most relevant is a strategy known as late closure: "If grammatically permissible, attach new items into the clause or phrase currently being processed (i.e. the phrase or clause postulated most recently)" (Frazier, 1987, p. 562). Applied to the NP–PP–RC materials, this implies that on encountering the relative clause, the parser should initially attach the constituent to the most recent potential head (i.e. N2) (for detailed arguments see Cuetos & Mitchell, 1988; de Vincenzi & Job, 1993; Frazier, 1990).

The present data are incompatible with this account in that they show no reliable low-attachment tendencies at any point in the sentence. Along with comparable findings in earlier studies and in other languages, these data pose problems for traditional statements of the garden-path model. As a result of these difficulties, the model has recently been refined in a way that enables it to account for certain high-attachment biases (cf. Frazier, 1990; De Vincenzi & Job, 1993). Whereas the original model made no specific statement about whether the initial (low) attachment would be retained, cancelled, or reversed, the refined version argued for a reversal—postulating that this was engineered by a set of discourse mechanisms operating in the second phase of processing (see Frazier, 1990, for details, and Cuetos et al., in press, for an overview).

Certain aspects of the present data are easier to reconcile with this updated version of the model. The definitive evidence for high-attachment bias is confined to points in the sentence at which discourse reanalysis could potentially have exerted an influence. On this account, the failure to show an earlier low-attachment bias would presumably have to be attributed to some kind of insensitivity of the experimental measures employed here. However, this type of model offers no explanation of the finding that the late-acting "reanalysis" effects apparently exert their influence even in sentences that have earlier been disambiguated by the use of one particular form of the relative pronoun. Overall, then, the results are not encouraging for the refined-garden-path account, especially when taken together with other evidence against this model (for further details see Cuetos et al., in press; and see Mitchell & Cuetos, 1991a, 1991b; Mitchell et al., 1990, for extensive arguments against the garden-path account in Spanish).

According to a second class of models of modifier attachment (the Competition models), relative clause attachment choice is seen as being the outcome of conflicting tendencies associated with rivalry between two or more strategies. Thus, instead of assuming that a single strategy (like late closure) always automatically prevails, the proposal here is that such biases are sometimes overridden by the effects of competing local (or special-purpose) strategies. For example, in a version of the model put forward by Cuetos and Mitchell (1988), the "local" influence was assumed to be an adjective-straddling strategy that emerges only in post-nominal languages. Cuetos and Mitchell

outlined reasons for assuming that this particular special-purpose strategy would not exert an influence in pre-nominal languages, implying that a late closure (N2) bias should show up in such languages. A more recent proposal of this general kind was put forward by Gibson et al. (in press). In this case, the special-purpose strategy was posited to be the tendency to attach modifiers to the potential host that is closest to the most recent predicate (a bias the authors termed the "predicate proximity principle"). Acting at the same time (they assumed) is a more general tendency to attach constitutents to the most recent of two or more competing hosts (the Recency principle). Gibson et al. (in press) went on to provide a detailed model spelling out how the competing tendencies may be weighed against one another to reach the eventual attachment decision. In general terms, the model proposes that there is a cost associated with attaching to increasingly distant host-sites and a different numerical cost associated with linking modifiers to NPs other than the one that is closest to the predicate. A simple arithmetical calculation is used to rank the total cost associated with selecting each of the competing sites, and this is used to predict the order of preferred attachments. In NP–PP complexes, the first noun phrase is closer to the predicate than the second, whereas recency favours N2 over N1. The outcome depends on the value of a parameter that determines the strength of the predicate proximity principle—a parameter that is assumed to vary from language to language.

The present results appear to rule out the straddling version of the Competition model, and they place some constraints on the way in which the Gibson et al. model might operate. Specifically, our evidence for an N1-bias in Dutch (a pre-nominal language) is incompatible with the proposal that high attachment is restricted to languages in which adjectives predominantly follow nouns, undermining the case for the particular special purpose modifier-straddling strategy proposed by Cuetos and Mitchell (1988). In contrast with this version of the competition model, however, the predicate proximity/recency model could handle the current results merely by assuming that the Proximity parameter for Dutch is high enough to ensure that N1-attachment prevails in this language. Working within this particular framework, then, the results place constraints on the value of this particular parameter. A future challenge for this model will be to explain how this parameter might be set in different languages. In the absence of clear proposals on this matter, it remains impossible to predict which of the two preferences will prevail in as-yet-untested languages.

Yet another account of NP–PP–RC attachment has been outlined as part of Frazier and Clifton's recent Construal theory (Frazier & Clifton, in press; see also Carreiras & Clifton, 1993; and Gilboy et al., 1995). This theory is essentially a fairly radical extension of the garden-path model—motivated, in part, by the empirical failures of the earlier formulations. Frazier and Clifton suggest that the traditional garden-path account applies only to what they call "primary relations" (which include the arguments or obligatory constituents of the main predicate and its dependents). In other cases (and this specifically includes the attachment of relative clauses), the new constituent is simply "associated" with quite a broad domain (in our case the *whole* complex NP). This general "association" process does not favour any one site at the expense of the others. Rather, the specific decision is made by a second, broader process referred to as "construal". This uses all available information, including discourse and other non-structural information, to

decide where to attach the constituent. So, the proposal is basically that the garden-path theory does not apply to NP–PP–RC sentences (because relative clauses are not "primary relations"). Instead, the attachment is determined by other (currently underspecified) processes. In formulations to date (e.g. Carreiras & Clifton, 1993; Frazier & Clifton, in press; Gilboy et al., 1995), these additional processes may include semantic factors, Gricean conversational maxims, discourse principles (such as Frazier's, 1990, "relativized relevance" principle), and perhaps other influences as well (e.g. prosodic effects: Gilboy & Sopena, in press).

The present findings are certainly compatible with the proposition that RC attachment should show no particular bias during the early putative "association" stage of processing. However, the current lack of detail on the "construal" process makes it impossible to specify in advance what the final attachment bias will be in any particular language. It has been argued that discourse principles such as "relativized relevance" might create pressure in favour of high attachment (see De Vincenzi & Job, 1993; Frazier, 1990), and if this were the only influence in play, N1-preference would be expected to prevail in all languages. To explain the lack of bias (or perhaps opposing bias) in English, the theory needs to postulate the existence of a counterforce. Up to now, the only clear candidate seems to have been Gricean conversational maxims, which may exert an influence in some languages but not in others (see Frazier, 1990). In the following paragraphs we suggest a way in which this proposal might be elaborated to predict the attachment outcome in a language like Dutch.

According to Frazier (1990), the reason English shows a greater tendency in favour of N2-attachment than Spanish may be related to the fact that English has more than one linguistic device for expressing genitive relationships. A genitive connection between two noun phrases can be expressed either in the form of a Saxon genitive (e.g. "the actor's daughter") or in the form of a Norman genitive (i.e. "the daughter of the actor"). A speaker or writer who wishes to modify one of the two nouns can do this completely unambiguously in one case ("daughter" in the present example) by electing to use a modifying constituent immediately after the Saxon version of the genitive. (In a sentence including the string, "the actor's daughter who was on the balcony", it is only the "daughter" that can be the agent of the relative clause). Given that there is a clear way of expressing a relationship of this kind, the writer would be violating Grice's maxims of manner such as "be perspicuous" and "avoid ambiguity" (Grice, 1975, p. 46) in using the Norman form here to modify "daughter" (or its equivalent). Hence, in conforming to Grice's maxims, a writer would tend to use the Norman form (followed by a relative) exclusively for the purpose of modifying the *alternative* host (i.e. "actor", in this example). Following the same conventions, a reader would presumably interpret a relative clause following either type of genitive as being attached to the second noun (i.e. "daughter" in Saxon genitives and "actor" in the Norman form). It should be stressed that this bias in favour of low attachment to Norman genitives depends crucially on the existence of alternative (and unambiguous) genitive devices in the language. In languages that have only a single genitive form (such as Spanish), a writer's "choice" of this form clearly cannot convey attachment information in the way it might where there are alternatives.

We are now in a position to use these arguments to spell out what might have been expected to happen in Dutch. For a start, Dutch is similar to English in that it has more than one genitive form; in fact, it has three, as illustrated in (8a,b,c):

(8a) Norman genitive: "*de hoed van vader*" ["the hat of father"]
(8b) Saxon genitive: "*vaders hoed*" ["father's hat"]
(8c) Antecedent + possessive pronoun form: "*vader zijn hoed*" ["father his hat"]

As in English, the Norman form is ambiguous in providing a host for a relative clause following the genitive noun phrase (i.e. a relative clause following "*de hoed van vader*" in (8a) could, in principle, be attached to either "*hoed*" or "*vader*"). In contrast with this, the relative clause in (8b) and (8c) should be attached unambiguously to "*hoed*" in each case.[2] Following the argument outlined above, we can therefore infer that the Gricean conversational maxims of manner would tend to favour low N2-attachment in Dutch Norman genitives, just as they do in English. On the basis of this extension of the argument, then, a possible prediction of construal theory may be that Dutch readers should show attachment preferences that are comparable with those in English. That is, in contrast with Spanish and French, the theory can be viewed as suggesting that Dutch readers should end up being biased in favour of low-attachment in structures of this kind—exactly the opposite of the pattern demonstrated in this study.

Of course, the results of these studies cannot be taken as discrediting construal theory as a whole. Gricean effects of the kind outlined above are just some of many factors that might influence the outcome of the construal process. There may be other important differences between Dutch and English, or there may be reasons why the maxim of perspicuity has a different influence on the interpretation of Saxon and Norman genitives in the two languages. However, what the present results do show is that one possible specification of construal theory remains incapable of accounting for the data. Thus, the Dutch findings contribute to our understanding of modifier attachment by indicating that within construal accounts the explanation of cross-linguistic differences in attachment bias must appeal to something other than the mere existence of alternative devices for conveying RC-attachment to complex NPs. In doing this, they highlight the fact that current formulations of construal theory offer no fully adequate account of cross-linguistic differences in attachment preferences.

The final type of account that we consider in the light of the Dutch data is a class of models in which parsing biases are based on statistical shaping effects. There are various such models in the literature, but the only ones that have specifically addressed the problem of NP–PP–RC ambiguity are those incorporating some form of the tuning hypothesis (cf. Cuetos et al., in press; Mitchell, 1994; Mitchell & Cuetos, 1991a, 1991b). Basically such models can be regarded as variants of the garden-path model.

[2] These observations have been verified independently in a grammaticality judgement task carried out by 12 subjects who did not participate in the experiments reported here. NP–PP–RC sentences were judged to have very low acceptibility on a 5-point rating scale when the semantic contents of the relative clause indicated N1-attachment in examples like (8b) and (8c). In all other cases, the sentences were judged to be "acceptable" or "highly acceptable".

However, instead of positing that the initial parsing choice is determined by linguistic principles such as late closure, the proposal is that the first reading is determined by actuarial considerations. Specifically, the suggestion is that on encountering any structural ambiguity, the parser initially selects the syntactic analysis that has worked most frequently in the past. This involves mechanisms for keeping records of prior contacts with linguistic ambiguities, as well as their outcomes, and these mechanisms may be connectionist in nature. However, the proposal makes no commitment on issues of this kind. It merely suggests that faced with an attachment ambiguity, readers and listeners will simply make the choice that has predominated in the corpus of material to which they have been exposed in the past. The assumption is that the statistics for N1 versus N2 attachment vary from language to language, with N2 attachment predominating in some languages (as in English) and N1 attachment prevailing in others (such as Spanish, French, etc.). Once the initial attachment has been made, the model is assumed to run in essentially the same way as the traditional garden-path model.

The preliminary corpus data from Spanish and English are compatible with this model (see Cuetos et al., in press). With Dutch, however, it is not yet possible to offer a full evaluation of the proposal, because as far as we are aware there are not as yet any published summaries of the modifier attachment biases in this language. It is hoped that the publication of the present findings may do something to encourage the exploration of these statistical questions.

In the absence of such data, we can only speculate about the viability of the tuning hypothesis in Dutch. For what it is worth, we anticipate that the data will in fact turn out to be compatible with the hypothesis—that is, that N1-preference will turn out to predominate in Dutch corpora. The grounds for this conjecture are twofold. First, in the standard Dutch grammar (*Wolters' Algemene Nederlandse Spraakkunst*, abbreviated as *ANS*, by Geerts et al., 1984) compiled by a combined team of Belgian and Dutch authorities, we found nine examples of how to write "correct" NP–PP–RC Dutch sentences. Of these, all but one were clearly intended to convey interpretations in which the relative clause was attached high. (Four sample sentences are listed in Appendix 2). This imbalance of examples strongly suggests that high attachment may predominate in more general use of the language.

The second reason for expecting high attachment is based on arguments prompted in part by Frazier's (1990) observations about the use of Saxon and Norman genitives to express possessive relationships in a language. Assume that across all the possessive structures of a language, modifiers are predominantly attached to the "possessee"—as the corpus data indicate they are in Spanish. In languages with more than one genitive form, this overall attachment bias will be distributed over the different forms, and the bias associated with one particular form (the Norman genitive) will vary depending on the bias and absolute frequency of the alternative forms. Where the alternatives are unambiguous (100% "possessee" attachment), as they are in English and Dutch, the bias within the Norman form will depend primarily on the frequency with which the alternative forms are used in the language. The Saxon genitive is quite common in English, and on the current argument we take this to be the reason that "possessee" attachments are left in the minority in the non-Saxon form (yielding an N2 dominance in the Norman corpus data). In Dutch, however, the use of the non-Norman forms is much more restricted. Apart

from a number of archaic expressions, (8b) is mainly used with proper names (e.g. *Amsterdams haven* ["Amsterdam's port"]) and with family relatives (e.g. *tantes koekjes* ["aunt's cookies"]; *ANS*, p. 53). Construction (8c) is more frequent, but mainly in spoken language (*ANS*, pp . 208–209; Koelmans, 1975). On the basis of these observations we infer that the (Norman) bias in Dutch will be shifted away from N1 dominance less than it is in English, and we think (though this is total conjecture) that the shift may be small enough to leave the Dutch Norman corpus bias favouring N1 attachment. The fact that the Dutch non-Norman genitive forms nevertheless exist and may exert some influence on the N1 bias in NP–PP–RC structures is compatible with the finding that the N1 preferences for the questionnaire appear to be smaller in Dutch than in Spanish (see Experiment 1).

Clearly the tuning hypothesis can only be evaluated properly when definitive corpus data become available. However, the purpose of these observations is to point out that there are grounds for believing that the current evidence for high overall attachment bias in Dutch will turn out to be compatible with the hypothesis.

Before moving on to other issues, it may be worth considering one aspect of the present data that does not appear to be immediately compatible with the tuning hypothesis. If it is really true that the statistical evidence in Dutch supports high attachment, and if this information is used to determine the very earliest attachment preferences, then it could well be argued that the hypothesis is undermined by the failure to find any evidence of N1 attachment at the beginnings of relative clauses. Indeed, the argument might be made more emphatic by drawing attention to the trends (albeit non-significant) in the opposite direction. However, although these findings certainly fall short of actively supporting the hypothesis, we do not view them as compromising the account in any serious way. For a start, immediate or short-lived garden-path effects are known to be much smaller than misreadings that survive for several words, and there is no guarantee that the reversal of such a briefly established preference would be stable enough to be statistically reliable. As for the tendency for processing to be faster when the relative pronoun shares the gender of the most recent noun phrase, we would argue that to the extent that this is a genuine phenomenon, the explanation for the facilitation may lie in the effects of low-level lexical (or gender) priming and not in parsing biases running counter to the tuning hypothesis.

We now turn briefly to the evidence that attachment biases change as a function of what the reader has been doing beforehand (Experiments 2 and 3) and the fact that there seem to be individual differences in bias (Experiment 1). These observations are compatible with the spirit of the tuning hypothesis in the sense that this account emphasizes the possibility that parsing preferences may be altered by the individual's own linguistic experiences. As such experiences are likely to vary from time to time and from individual to individual, changes of the kind reported above are not unexpected within this type of framework. In contrast, none of the other accounts considered above offers any direct explanation for these findings. The results rest uneasily with accounts that interpret attachment bias exclusively in terms of linguistic factors such as discourse considerations (relativized relevance), or predicate proximity, or in terms of Gricean conversational maxims. At the very least we can conclude that all of these accounts will have to be

extended radically or refined in various ways before they can account for the data presented here.

Finally, we turn to some of the methodological issues raised by these experiments. The results of the self-paced reading studies show that the pattern of attachment data appears to change according to the way in which the materials are segmented in the task. This suggests that it is not safe to draw conclusions about possible variations in attachment bias where segmentation is a factor that changes between studies or conditions. One implication of this is that in drawing conclusions about differences between languages, it is crucial to ensure that segmentation is not a factor that varies between the different studies (cf. De Vincenzi & Job, in press).

To summarize the outcomes of this study, then, the data provide further evidence against the traditional-garden-path model, and they argue against the modifier-straddling version of the competition model. The findings draw attention to the fact that many of the other accounts of modifier attachment are incomplete and underspecified. The evidence that high attachment prevails in Dutch could not have been predicted given current formulations of construal theory, and neither this model nor the refined-garden-path account offers immediate explanations for individual differences in attachment preferences, or for the fact that such effects appear to be subject to change over the course of an experimental session. A fully comprehensive account would provide the basis for modelling these effects with some precision. Most of the findings are broadly compatible with the linguistic tuning model and with the predicate proximity/recency model of Gibson et al. (in press). However, as with the other models, few of the specific findings could have been predicted in advance, and the results highlight the need to conduct corpus and other studies to provide the basis for parameter and bias setting. Overall, the phenomena associated with modifier attachment indicate that there are substantial aspects of syntactic analysis for which we do not have anything even approaching an adequate theoretical account. It seems likely that future cross-linguistic investigations of these issues will provide a strong stimulus for developing and refining the theoretical understanding that still eludes us.

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APPENDIX 1

Sentences Used In Experiments 2 and 3

The first eight sentences have a NP–PP structure of the type human/human, the following eight of the type non-human/human, and the final four of the type human/non-human. The "/" and "*" signs mark the borders of the phrases presented one at a time in the relevant condition of Experiment 2. The "*" signs additionally mark the borders used to define the seven regions used for the calculations of Tables 2, 3, and 4. The order of the sentences within a block is always delayed–N1, delayed–N2, immediate–N1, immediate–N2. The line breaks are the same as those of Experiments 2 and 3.

1. De gangsters/schoten*op de zoon*van de actrice*die*op het balkon/zat*
   met zijn arm*in het gips.
   De gangsters/schoten*op de zoon*van de actrice*die*op het balkon/zat*
   met haar arm* in het gips.
   De gangsters/schoten*op het zoontje*van de actrice*dat*op het balkon/zat*
   met zijn arm*in het gips.
   De gangsters/schoten*op het zoontje*van de actrice*die*op het balkon/zat*
   met haar arm*in het gips.

2. Jan en Mieke/ontmoetten*de vriendin*van de leraar*die*in Duitsland*
   aan haar ogen*geopereerd was.
   Jan en Mieke/ontmoetten*de vriendin*van de leraar*die*in Duitsland*
   aan zijn ogen*geopereerd was.
   Jan en Mieke/ontmoetten*het vriendinnetje*van de leraar*dat*in Duitsland*
   aan haar ogen*geopereerd was.
   Jan en Mieke/ontmoetten*het vriendinnetje*van de leraar*die*in Duitsland*
   aan zijn ogen*geopereerd was.

3. De omstaanders/troostten*de vrouw*van de gewonde*die*bloed*
   aan haar handen*had.
   De omstaanders/troostten*de vrouw*van de gewonde*die*bloed*
   aan zijn handen*had.
   De omstaanders/troostten*de vrouw*van het slachtoffer*die*bloed*
   aan haar handen*had.
   De omstaanders/troostten*de vrouw*van het slachtoffer*dat*bloed*
   aan zijn handen*had.

4. De studenten/staarden*naar het broertje*van het kamermeisje*dat*opvallende
   ringen*in zijn oren*had.
   De studenten/staarden*naar het broertje*van het kamermeisje*dat*opvallende
   ringen*in haar oren*had.
   De studenten/staarden*naar de broer*van het kamermeisje*die*opvallende
   ringen*in zijn oren*had.

De studenten/staarden*naar de broer*van het kamermeisje*dat*opvallende ringen*in haar oren*had.

5. De kinderen/schrijven/brieven*naar de zus*van de zanger*die*in de kerk* an haar stoel*gevallen was.
   De kinderen/schrijven/brieven*naar de zus*van de zanger*die*in de kerk* van zijn stoel*gevallen was.
   De kinderen/schrijven/brieven*naar het zusje*van de zanger*dat*in de kerk* van haar stoel*gevallen was.
   De kinderen/schrijven/brieven*naar het zusje*van de zanger*die*in de kerk* van zijn stoel*gevallen was.

6. De journalisten/ondervroegen*de dochter*van de kolonel*die*een blauwe plek*op haar voorhoofd*had.
   De journalisten/ondervroegen*de dochter*van de kolonel*die*een blauwe plek*op zijn voorhoofd*had.
   De journalisten/ondervroegen*het dochtertje*van de kolonel*dat*een blauwe plek*op haar voorhoofd*had.
   De journalisten/ondervroegen*het dochtertje*van de kolonel*die*een blauwe plek*op zijn voorhoofd*had.

7. De jongens/plaagden*de nicht*van de secretaris*die*in het park/liep/ met een hoed*op haar hoofd*en/een gele tas/in haar handen.
   De jongens/plaagen*de nicht*van de secretaris*die*in het park/liep/ met een hoed*op zijn hoofd*en/een gele tas/in zijn handen.
   De jongens/plaagden*het nichtje*van de secretaris*dat*in het park/liep/ met een hoed*op haar hoofd*en/een gele tas/in haar handen.
   De jongens/plaagden*het nichtje*van de secretaris*die*in het park/liep/ met een hoed*op zijn hoofd*en/een gele tas/in zijn handen.

8. Vanmiddag/zagen/we*de zoon*van de verpleegster*die*bij ons thuis*zijn neus*opgehaald had/voor de hond.
   Vanmiddag/zagen/we*de zoon*van de verpleegster*die*bij ons thuis*haar neus*opgehaald had/voor de hond.
   Vanmiddag/zagen/we*het zoontje*van de verpleegster*dat*bij ons thuis*zijn neus*opgehaald had/voor de hond.
   Vanmiddag/zagen/we*het zoontje*van de verpleegster*die*bij ons thuis*haar neus*opgehaald had/voor de hond.

9. De kinderen/keken*naar het boek*van het meisje*dat*in de woonkamer/lag/ met een scheur*in de kaft*en/een inktvlek/op het eerste blad.
   De kinderen/keken*naar het boek*van het meisje*dat*in de woonkamer/lag/ met een scheur*in haar broek*en/een inktvlek/op haar jas.
   De kinderen/keken*naar het boek*van de jongen*dat*in de woonkamer/lag/ met een scheur*in de kaft*en/een inktvlek/op het eerste blad.

De kinderen/keken*naar het boek*van de jongen*die*in de woonkamer/lag/
met een scheur*in zijn broek*en/een inktvlek/op zijn jas.

10. De dieven/loerden*naar de koffer*van de toerist*die*bij de brievenbus/
stond/en*niet op slot*was.
De dieven/loerden*naar de koffer*van de toerist*die*bij de brievenbus/
stond/en*zijn ticket*zocht.
De dieven/loerden*naar het koffertje*van de toerist*dat*bij de brievenbus/
stond/en*niet op slot*was.
De dieven/loerden*naar het koffertje*van de toerist*die*bij de brievenbus/
stond/en*zijn ticket*zocht.

11. De toeristen/fotografeerden*de ezel*van de boer*die*bij de put/stond/en*
met zijn staart*naar de vliegen/sloeg.
De toeristen/fotografeerden*de ezel*van de boer*die*bij de put/stond/en*
met zijn zakdoek*naar de vliegen/sloeg.
De toeristen/fotografeerden*het paard*van de boer*dat*bij de put/stond/en*
met zijn staart*naar de vliegen/sloeg.
De toeristen/fotografeerden*het paard*van de boer*die*bij de put/stond/en*
met zijn zakdoek*naar de vliegen/sloeg.

12. Mijn ouders/bezochten*de verblijfplaatsen*van de soldaten*die*bij de
rivier*liggen/en/dringend/geverfd*moeten worden.
Mijn ouders/bezochten*de verblijfplaatsen*van de soldaten*die*bij de
rivier*liggen/en/gekscherend/naar de meisjes*fluiten.
Mijn ouders/bezochten*de verblijfplaatsen*van het legerpeloton*die*bij de
rivier*liggen/en/dringend/geverfd*moeten worden.
Mijn ouders/bezochten*de verblijfplaatsen*van het legerpeloton*dat*bij de
rivier*ligt/en/gekscherend/naar de meisjes*fluit.

13. De vrouwen/keken*naar het speelgoed*van het kindje*dat*op het bed/lag/en*
stuk/getrokken*was.
De vrouwen/keken*naar het speelgoed*van het kindje*dat*op het bed/lag/en*
huilend/om zijn mama*riep.
De vrouwen/keken*naar de teddybeer*van het kindje*die*op het bed/lag/en*
stuk/getrokken*was.
De vrouwen/keken*naar de teddybeer*van het kindje*dat*op het bed/lag/en*
huilend/om zijn mama*riep.

14. De mensen/keken*naar de bagage*van de wanderlaar*die*onder de boom/stond*
met een rood lintje/aan het handvat*en/een sticker/op de voorkant.
De mensen/keken*naar de bagage*van de wanderlaar*die*onder de boom/stond*
met een gouden ringetje/in zijn oor*en/een sticker/op zijn arm.
De mensen/keken*naar het reisgoed*van de wanderlaar*dat*onder de boom/stond*
met een rood lintje/aan het handvat*en/een sticker/op de voorkant.

De mensen/keken*naar het reisgoed*van de wanderlaar*die*onder de boom/stond*
met een gouden ringetje/in zijn oor*en/een sticker/op zijn arm.

15. De kleuters/streelden*de kat*van de Franse vrouw*die*bij de fontein/zat*
te snorren/en/met haar poot/over haar neus/wreef.
De kleuters/streelden*de kat*van de Franse vrouw*die*bij de fontein/zat*
te lezen*en/met haar hand/over haar haar/streek.
De kleuters/streelden*de kat*van het Franse fotomodel*die*bij de fontein/zat*
te snorren*en/met haar poot/over haar neus/wreef.
De kleuters/streelden*de kat*van het Franse fotomodel*dat*bij de fontein/zat*
te lezen*en/met haar hand/over haar haar/streek.

16. De gekken/sloegen*de hond*van de buur*die*in de tuin*
een bot/zat*af te kluiven.
De gekken/sloegen*de hond*van de buur*die*in de tuin*
een krant/zat*te lezen.
De gekken/sloegen*het hondje*van de buur*dat*in de tuin*
een bot/zat*af te kluiven.
De gekken/sloegen*het hondje*van de buur*die*in de tuin*
een krant/zat*te lezen.

17. Wij/bewonderden*de hoofdrolspeler*van de film*die*deze
week*geïnterviewd werd*op de televisie.
Wij/bewonderden*de hoofdrolspeler*van de film*die*deze
week*uitgezonden werd*op de televisie.
Wij/bewonderden*de hoofdrolspeler*van het toneelstuk*die*deze
week*geïnterviewd werd*op de televisie.
Wij/bewonderden*de hoofdrolspeler*van het toneelstuk*dat*deze
week*uitgezonden werd*op de televisie.

18. De kostschoolmeisjes/lazen*over de eigenares*van de molen*die*in
het dorp*gewoond had*voor de eerste wereldoorlog.
De kostschoolmeisjes/lazen*over de eigenares*van de molen*die*in
het dorp*gebouwd werd*voor de eerste wereldoorlog.
De kostschoolmeisjes/lazen*over de eigenares*van het kasteel*die*in
het dorp*gewoond had*voor de eerste wereldoorlog.
De kostschoolmeisjes/lazen*over de eigenares*van het kasteel*dat*in
het dorp*gebouwd werd*voor de eerste wereldoorlog.

19. De dorpsvrouwen/praten*over de bewaker*van de kerk*die*gisteren/
na acht uur*neergeslagen werd*door onbekenden.
De dorpsvrouwen/praten*over de bewaker*van de kerk*die*gisteren/
na acht uur*leeggeplunderd werd*door onbekenden.
De dorpsvrouwen/praten*over de bewaker*van het museum*die*gisteren/
na acht uur*neergeslagen werd*door onbekenden.

De dorpsvrouwen/praten*over de bewaker*van het museum*dat*gisteren/
na acht uur*leeggeplunderd werd*door onbekenden.

20. Alle mannen/zijn verliefd*op de verkoopster*van de lingerie*die*tijdens
de feestdagen*flauwgevallen is*in de winkel.
Alle mannen/zijn verliefd*op de verkoopster*van de lingerie*die*tijdens
de feestdagen*afgeprisd is*in de winkel.
Alle mannen/zijn verliefd*op de verkoopster*van het ondergoed*die*tijdens
de feestdagen*flauwgevallen is*in de winkel.
Alle mannen/zijn verliefd*op de verkoopster*van het ondergoed*dat*tijdens
de feestdagen*afgeprijsd is*in de winkel.

APPENDIX 2

High and Low-attachment Examples

Examples from the Dutch Grammar: *Wolters' Algemene Nederlandse Spraakkunst* (Geerts et al., 1984).

Three high-attachment examples:

De antieke klok van mijn tante, die duizend gulden waard was, . . . (p. 239)
[The antique clock of my aunt, that was worth thousand guilders, . . .]

Ik lees alle boeken van Wojnowitsj die in het Nederlands vertaald zijn. (p. 245)
[I read all books of Wojnowitsh that are translated into Dutch]

De eigenaar van de fabriek, die gearresteerd is. (p. 713)
[The owner of the factory, who is arrested]

The single low-attachment example:

Het beeld van de held die hij dacht te zijn, . . . (p. 246)
[The image of the hero who he thought to be, . . .]