SENTENCE PARSING IN DUTCH:
THE IMPORTANCE OF LEXICAL INFLUENCES

Marc BRYSBAERT[1]
Catholic University Leuven

Don C. MITCHELL
University of Exeter, U.K.

According to one of the major theories of sentence parsing, initial syntactic choices are made on the basis of processing strategies that apply universally to all languages of the world. In a study using a particular sentence structure in Dutch, Flores d'Arcais (1990) has claimed to provide cross-linguistic support for one such strategy (late closure), a conclusion subsequently endorsed by Frazier (1993). However, prior evidence with equivalent structures in English has shown that they are subject to lexical influences, with the implication that the crucial observations may not generalize to different classes of verbs. The present study demonstrates that comparable lexical effects occur in Dutch - effectively undermining the claim that parsing biases in material of this kind can be used to support the hypothesis that late closure is a universal strategy.

Text reading involves several levels of processing going from word recognition to the integration of ideas that are presented in separate paragraphs. Inspired by the modularity idea that currently dominates large parts of cognitive psychology (e.g., Fodor, 1983), each level of processing is thought to be largely autonomous. Within this framework, recent years have witnessed an increased interest in the existence of a syntactic parser as a bridge between word recognition and text comprehension (see Chapters 10-16 of Balota, Flores d'Arcais, & Rayner (1990) for a recent state-of-the-art; although the idea of an autonomous syntactic parser is much older in psycholinguistics, see e.g. Forster & Ryder, 1971; Garrett, 1975). The parser must explain how a string of serially presented words is analyzed into its underlying representation. For research on agrammatic aphasic patients (e.g., Caplan, Baker, & Dehaut, 1985; Caramazza & Zurif, 1976) has quite convincingly shown that understanding of the individual words does not suffice to assign the appropriate relationships between the people or objects referred to in a sentence.

Although one might expect that the explicit syntactic cues in a sentence (such as punctuation, inflection of verbs, and case, gender, and number

markings of words) are one of the major sources of information for the syntactic parser (Mitchell & Holmes, 1985), relatively little attention has been paid to these variables, possibly because most studies have been done in English where inflections and markings play a rather minor role (Mitchell, Cuetos, & Zagar, 1990). In contrast, much research has dealt with the order of the words in a sentence. Most languages have relatively strict rules of where words with a certain syntactic role can be placed in a sentence (though there are large inter-language differences; Finnish and Russian, for instance, are rather word-order free). This suggests that the sequence of words may entail important information about the underlying representation. Investigation of that aspect received a strong impetus when it was discovered that specific, perfectly legal word orderings led to substantial processing difficulties, as is shown in the following three examples:[2]

(1)   John hit the girl with a book with a bat (Rayner, Carlson, & Frazier, 1983).
(2)   Since Jay always jogs a mile seems like a short distance (Frazier & Rayner, 1982).
(3)   The horse raced past the barn fell (Bever, 1970; Rayner et al., 1983).

So, it looked as if readers and listeners committed themselves to just one structural analysis not only at points where the interpretation was straightforward but also at points in the sentence when two or more alternative interpretations were possible; a phenomenon called *garden-pathing* (e.g., Frazier & Rayner, 1982). Two main principles seemed to govern these preferences: minimal attachment and late closure (Frazier, 1978, 1987). Minimal attachment states that initial syntactic decisions favour the syntactic structure with the smallest number of nodes; that is, the

---

[2]The difficulty in Sentence (1) is due to the fact that the prepositional phrase „with a book" can either refer to the girl (i.e., the girl is holding a book) or to the hitting (i.e., a book is used to hit with). The final phrase of the sentence „with a bat" forces the former interpretation, which for most people is not the preferred one so that it gives rise to processing difficulties. The problem of Sentence (2) is situated in the noun phrase „a mile" which can either be the object of the verb of the first clause (i.e., Jay always jogs a mile), or the subject of a new clause (i.e., a mile is a short distance). Readers usually prefer the first representation. The ambiguity of Sentence (3), finally, has to do with the verb „raced" which can either be a past simple tense or a past participle. In the former case, the verb is likely to be the verb of the clause introduced by the subject „horse" (i.e., the horse raced); in the latter case, it introduces a modification of the noun „horse" (i.e., the horse that was raced). Again, the first interpretation is the preferred one.

structure that allows the incoming information to be attached to the phrasal representation of the sentence without requiring a new node in the syntactic tree. Figure 1 shows how the principle of minimal attachment can explain the preference to initially attach the prepositional phrase „with a book" in sentence (1) to the verb phrase „hit the girl" rather than to the noun phrase „the girl". Late closure refers to the fact that, if minimal attachment does not prohibit it, new incoming information is preferentially attached to the phrase or clause postulated most recently. Thus, in the sentence:

(4)   John saw Ann running on the beach.

Late closure predicts that the clause „running on the beach" will be attached to „Ann" rather than to „John".
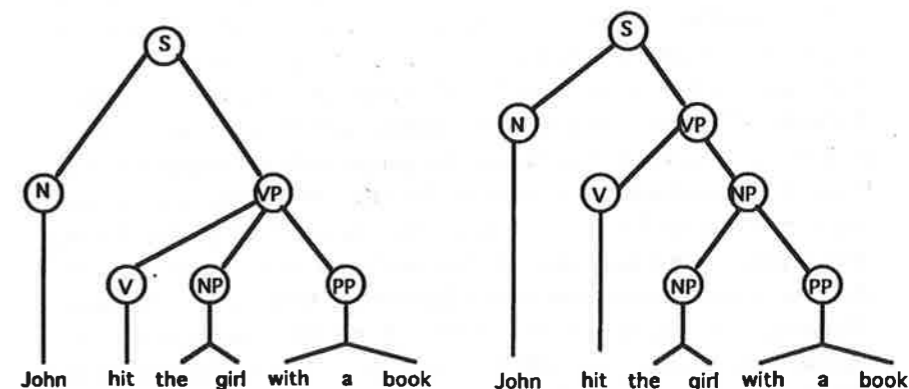

Figure 1

Working on the assumption that minimal attachment and late closure are related to the need to avoid overloading the listener's immediate memory in the course of sentence processing, Frazier (1987) proposed that both strategies operate universally across all languages.

Given the wide-ranging scope of this claim, one might have expected Frazier to have been able to cite empirical support from a number of different languages. In fact, her evidence in support of minimal attachment was restricted to observations in just three languages, and in the case of late closure she offered no cross-linguistic support at all. The present paper will focus on the generality of late closure.

Since Frazier (1987) expressed her conjecture there has been a considerable amount of cross-linguistic work on late closure. However, much of this has been restricted to a single kind of linguistic structure and it is not clear whether the conclusions can be generalized to other forms. The structure in question is one in which a modifier such as a relative clause has to be attached to one of two or more sites within a complex noun phrase (NP) as in (5).

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

With materials of this kind, the late closure strategy dictates that the modifier should initially be attached to the most recent noun phrase (i.e., „actress") and, moreover, if the strategy is truly universal then this pattern of preference should occur in all languages. In fact, Cuetos and Mitchell (1988) found that in Spanish equivalents of this sentence the preference is for attachment to the first noun phrase (i.e., „servant"), a finding that has been corroborated by Carreiras (1992; Carreiras & Clifton, 1993), Mitchell & Cuetos (1991), and several others. Subsequent studies have extended the evidence against late closure to other languages such as French (Zagar & Pynte, 1992) and Dutch (Brysbaert & Mitchell, 1993), while other studies apparently provided some support for late closure in English (Clifton, 1988; Frazier, 1990) and Italian (de Vincenzi & Job, 1993). Taken together, these studies have prompted marked refinements in the theoretical treatment of parsing strategies (cf. Frazier, 1990; Frazier & Clifton, in preparation (as cited by Carreiras & Clifton, 1993); Gibson et al., 1994; de Vincenzi & Job, 1993). However, even on the most generous interpretation it would be difficult to argue that they provide unequivocal support for the universality of the late closure strategy.

Evidence from other structures is much more limited. However, Flores d'Arcais (1990) and Frazier (1993) have recently used processing data in Dutch and English from structures like (6a,b) to claim support for the generality of the late closure strategy.

(6a)   Jan zag Anneke lopend op het strand. (Dutch)
(6b)   John saw Ann running on the beach. (English)

As with the complex NP structures considered above, the final clause can be attached to either of two sites (in this example the proper nouns „Jan/John" or „Anneke/Ann"). Late closure dictates that it should be the second

person mentioned that is performing the action (in this case „running on the beach"). In support of this Flores d'Arcais (1990) reported two studies using materials like (7a,b). (One of the studies used eye-tracking and the other was based on word-by-word reading.)

(7a)   Jan zag Anneke lopend op het strand; ze was moe.
            (John saw Ann running on the beach; she was tired)

(7b)   Jan zag Anneke lopend op het strand; hij was moe.
            (John saw Ann running on the beach; he was tired.)

In these materials, pronoun gender is manipulated in the appended „test" clause and the time taken to process this clause is assumed to vary according to the plausibility of this statement given the preferred interpretation of the first part of the sentence. So, in this example „she was tired" would be a plausible consequence, and hence read quickly, if it was „Anneke/Ann" who was interpreted as „running on the beach", whereas „he was tired" would be processed more rapidly if the „running" clause had been attached to „Jan/John". In both of the studies outlined by Flores d'Arcais (1990) the results showed faster reading in sentences like (7a) than those like (7b). This suggests that the ambiguous clause is preferentially linked to the more recent of the two potential attachment sites. Flores d'Arcais (1990) interpreted this as evidence in support of late closure in Dutch - a conclusion which was subsequently endorsed by Frazier, 1993; p. 89).

If this conclusion is correct, it would provide at least modest extension of the scope of late closure. However, there are reasons for doubting the generality of the finding. In particular there is evidence that, at least in English, the attachment preference in sentences of this form is strongly influenced by detailed lexical features of the first verb. For example Mitchell and Holmes (1985) used questionnaire and self-paced reading tasks to show that biases of this kind can be eliminated by changing the verb. These studies were based on materials like (8a,b).

(8a)   The groundsman chased the girl waving a stick (in his hand).
(8b)   The groundsman noticed the girl waving a stick (in his hand).

The questionnaire study used the sentences without the final phrase. Subjects overwhelmingly judged the „groundsman" to be the person

„waving the stick" in (8a), whereas this interpretation was reversed in (8b). In the on-line study the reading time for the final phrase (now included) was reliably longer in (8b) than in (8a). These findings indicate that attachment preferences can be altered by replacing one verb with another and numerous other studies using related sentence forms have shown comparable effects of specific lexical information (e.g., Garvey & Caramazza, 1974; McKoon, Green & Ratcliff, 1993; Taraban and McClelland, 1988; Vonk, 1984, 1985).

This raises severe problems for the interpretation of the Flores d'Arcais study. If comparable verb effects occur in Dutch, then the fact that a sample of sentences produced a reliable bias in favour of N2 preference (i.e., preference to attach the modifier to the second noun of the sentence) cannot be taken as evidence in favour of late closure: in these circumstances, it is all too possible that a different set of sentences would have produced the opposite effect. Indeed, the interpretative difficulties are even more fundamental than this. Frazier's (1987, 1989) theoretical handling of verb effects is based on the assumption that syntactic analysis occurs in at least two phases, and that the influences of detailed lexical information are restricted to the second. In the first stage attachments and other structural decisions are made on the basis of the universal parsing strategies (e.g., late closure and minimal attachment). In the second stage these preliminary analyses are „filtered" (and sometimes recomputed) on the basis of detailed lexical information. Thus, according to Frazier's own theoretical position the initial influence of general parsing strategies can very quickly become contaminated by the subsequent action of lexical effects. Given that the Flores d'Arcais materials, like (7a,b) above, tested for bias effects at a relatively late stage in processing (in a new clause, and following a punctuation mark) it seems highly unlikely that these can be regarded as tapping into the first stage of processing within Frazier's theoretical framework. In view of this observation, it is surprising that Frazier (1993) was prepared to treat this evidence as having a bearing on the operation of the late closure strategy. A more likely interpretation is that the Flores d'Arcais (1990) findings are the result of verb-specific filtering effects and that they have no implications at all for the generality of the late closure strategy.

However, the above arguments presuppose that there are verb-specific effects in Dutch, just as there are in English - an assumption which may not be safe to make, given earlier failures to generalise psycholinguistic findings across languages. If, contrary to this, there is no such variation in

Dutch, then it could conceivably be argued that the Flores d'Arcais findings reflect the influence of general parsing strategies alone. In this case there may be a stronger basis for taking them as evidence that late closure occurs in languages other than English. To assess the case for late closure in these particular structures in Dutch it is therefore important to determine whether the Flores d'Arcais findings are subject to change when different verbs are used in the first position. This is tackled here in four studies using materials like (9a,b) as well as the original sentences (i.e., 7a,b).

(9a)   Jan achtervolgde Anneke lopend op het strand; ze was moe.
                (John chased Ann running on the beach; she was tired)
(9b)   Jan achtervolgde Anneke lopend op het strand; hij was moe.
                (John chased Ann running on the beach; he was tired.)

If the advantage of the (a) form changes as a function of the main verb, then this would undermine the argument that late closure is implicated in this task. The first three studies were self-paced reading experiments with different forms of segmentation and the last study was an eye-tracking study. The reason why we have data on four different presentation modes is that the sentences were part of a larger study in which the effects of different presentation modes were investigated.

METHOD

Subjects. Twenty-four subjects participated in each experiment. They were undergraduate students and research assistants from the Katholieke Universiteit Leuven. All were native Dutch speakers and had normal or corrected-to-normal vision. None of the subjects was aware of the research hypothesis.

Stimulus material. The test sentences consisted of four sentences translated from Mitchell and Holmes (1985).[3] They are listed in Appendix 1. Each sentence had four versions obtained by an orthogonal variation of (i) whether the verb induced N2 (i.e., object) or N1 (i.e., subject) attachment, and (ii) whether the disambiguating part of the sentence was in line with

---

[3] We could not make use of the sentences of Flores d'Arcais (1990), because they have never been published, except for the example sentences (7a) and (7b).

object (N2) or subject (N1) attachment. The ordering of the versions in Appendix 1 and the Results sections, therefore, is N2/N2 (cf. 7a), N2/N1 (7b), N1/N2 (9a), and N1/N1 (9b). The disambiguating part of the sentence was slightly different than the one used by Flores d'Arcais (1990) because the latter could be criticized of introducing an unnecessarily long delay between the ambiguous part and the disambiguating section (see above). Each subject saw one version of a sentence; the versions were distributed over subjects according to a latin-square design, so that every version of a sentence was seen by six subjects in an experiment. The test sentences were embedded in 116 filler sentences that were either first sentences of Dutch (translations of) novels and detectives (N = 48) or sentences that addressed a number of divergent psycholinguistic questions (N = 72). Twenty-five of the filler items were immediately followed by a question related to the content of the sentence that could be answered by 'yes' or 'no' (e.g., sentence: „De Turkse en Marokkaanse winkels in het zuiden van de stad waren tot lang na acht uur open" [The Turkish and Moroccan shops in the south of the city remained open till late after eight o'clock]; question: „Lagen de Turkse en Marokkaanse winkels in het noorden van de stad?" [Were the Turkish and Moroccan shops in the north of the city?]). Purpose of the questions was to ensure that subjects read the sentences in order to understand them correctly.

Procedure. Subjects were seated in front of a 12" CRT monitor connected to a microcomputer. Stimuli were presented on text line 10 of the 80x25 character space of the screen (and on line 12 for the first sentence which consisted of two lines of text). The experiment was divided in three blocks: one practice block of 15 sentences and two test blocks of 60 sentences.

In the self-paced reading experiments, a trial started with one or two lines of dots indicating the structure of the sentence. The 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. In the first experiment the keypress revealed the complete sentence; in the second experiment only the first word appeared -the second and successive words being displayed in succession with later key-presses. Finally, in the third experiment subjects paced through the sentences in a series of phrases (with precise segmentations given in Appendix 1). In the two segmented conditions the presentation was non-cumulative. That is, each display was removed from the screen and replaced

by dots as the next display went up.

In the eye-tracking study, 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 (Crane & Steele, 1985) which has a spatial resolution of 10 min of arc. Only the right eye was tracked, although vision happened binocular. Horizontal and vertical eye position was sampled every millisecond. In this experiment, no dots were presented before the sentence appeared. Subjects were calibrated before each of the three blocks, with additional checks at the end of the session or after 20 sentences to ensure that the subjects had not moved their head.

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. The order of sentences was different for each subject and obtained with the permutation algorithm outlined in Brysbaert (1991). If a sentence 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. The subject had to indicate his/her 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 between 2.0 (phrase-by-phrase) and 2.6 mistakes (word-by-word), which is about 10 percent. There was no significant difference between the four experiments.

RESULTS

Table 1 displays the reading times (in milliseconds) for all four experiments. Where possible a distinction has been made between the beginning of the sentence and the disambiguating part. Note that the reading times for these two parts do not add up to the total reading times listed in the last column. This is due to fact that the total reading time was defined as the time span between the keypress of the subject that brought the first information on the screen, and the keypress that made the last information disappear. The reading times for the two parts of the sentence, however, were defined as the sum of all fixation durations; that is, without the time lost for keypresses in the self-paced reading experiment and the time lost for saccades in the eye-tracking study. As saccadic movements in reading last between 30 and 70 ms, the difference is quite substantial in the

Table 1. *Reading Times (in ms) as a Function of Sentence Type and Presentation Condition*

	Beginning	Disambig. segment	Total
Self-paced, sentences			
Version 1	-	-	4,314
Version 2	-	-	5,304
Version 3	-	-	5,817
Version 4	-	-	5,124
Self-paced, words			
Version 1	4,513	1,155	6,187
Version 2	4,396	2,136	6,654
Version 3	4,603	1,868	6,593
Version 4	4,407	1,845	6,371
Self-paced, phrases			
Version 1	3,222	963	4,243
Version 2	3,102	1,296	4,450
Version 3	3,020	1,334	4,408
Version 4	3,429	1,193	4,675
Eye-tracking			
Version 1	2,312	983	4,092
Version 2	2,824	997	4,705
Version 3	2,621	969	4,393
Version 4	1,821	956	4,300

eye-tracking study.

Because the results of all four studies were well in line with one another (see Table 1) and because the number of stimulus sentences was not excessively large, analyses of variance were calculated on the combined data (i.e., over all 96 subjects). In analogy with other psycholinguistic studies, F1-values refer to analyses over subjects and F2-values to analyses over stimuli. ANOVAs on total reading times with the variables Study (four levels, between-subjects for F1 and within-subjects for F2), Verb inducement, and Disambiguation (both two levels, within-subjects) indicated a significant difference between the studies [$F1(3,92) = 10.21$, $MSe = 8,735,018$, p

$< .01$; $F2(3,9) = 57.26$, $Mse = 259,655$, $p < .01$] mainly due to the long reading times in the word-by-word experiment, and a significant interaction between Verb and Disambiguation across subjects [$F1(1,92) = 6.21$, $MSe = 2,200,344$, $p < .01$] but due to the small number of sentences not across items [$F2(1,3) = 2.67$, $MSe = 851,354$, $p = .20$]. No other effect approached significance. In particular the main effect of Disambiguation, which would have been evidence for late closure, was absent ($F1$ and $F2 < 1$). Planned comparisons further showed that the interaction between Verb and Disambiguation was mainly due to a significant advantage of N2 disambiguation relative to N1 disambiguation for the N2 sentences [type 7a (4,709 ms) and 7b (5,278 ms); $F1(1,92) = 3.82$, $Mse = 4,074,025$, $p < .06$; $F2(1,3) = 2.34$, $MSe = 1,107,953$, $p < .25$] rather than to a significant difference for the N1 sentences [type 9a (5,303 ms) and 9b (5,118 ms); $F1(1,92) < 1$; $F2(1,3) < 1$]. Finally, Table 1 shows that the difference in reading time for the word-by-word and the phrase-by-phrase experiments was indeed situated in the disambiguating region; in the eye-tracking study, the effect was mostly located in the beginning of the sentence, which was due to the tendency of the subjects to reread passages of the text when the unexpected disambiguating information was encountered.

DISCUSSION

Although the scope of the present article is limited due to the small number of test sentences, the results nevertheless clearly indicate that sentences (7a,b) of Flores d'Arcais (1990) cannot be used to prove the existence of late closure in Dutch. It is all too easy to choose other verbs to construct equally plausible sentences that give rise to null-effects or preferences for the opposite attachment (contrary to late closure). This is true for Dutch as well as for English (Mitchell & Holmes, 1985). Because of the small number of stimuli, the data in a strict sense do not allow to generalize to new materials in the F2 analysis, but the mere fact that it is possible to find a sample of sentences which produce reliable subjects (F1) effects, is sufficient to establish that attachment preferences vary with verb-identity in sentences of the kind discussed by Flores d'Arcais (1990). In addition, a recent off-line grammaticality-judgment task we ran with eight new sentences (see Appendix 2) indicates that it is quite easy to construct additional materials with equally strong tendencies to violate late closure. It thus follows that it is premature to reach any conclusion about the role of

late closure in these sentences. This issue can only be resolved by the use of experimental studies that either tap structural preferences prior to the influence of lexical verb effects or that make careful efforts to ensure that the verbs are sampled in such a way that they do not introduce a systematic bias in one direction or the other. Until this has been achieved there is no way of telling whether late closure applies to these particular structures in Dutch.

Although our data query the status of cross-linguistic evidence for late closure, at the same time they argue for cross-linguistic verb-induced influences (see also Vonk, 1984, 1985). In this respect, it may be interesting to examine whether Taraban and McClelland's (1988, 1990) findings can be replicated in Dutch as well. For these authors noted that not only late closure depends on the words used in the sentence structure, but also minimal attachment (see above; sentence (3)). More specifically, they compared sentence pairs like (10a,b)

(10a) The spy saw the cop with binoculars.
(10b) The spy saw the cop with a revolver.

with sentence pairs like (11a,b)

(11a) The couple admired the house with a friend.
(11b) The couple admired the house with a garden.

and found that only sentence pair (10a,b) gave rise to minimal attachment. Sentences (11a,b) led to exactly the opposite pattern of findings. Intuition suggests that the same pattern of results may be true for Dutch as well.[4]

REFERENCES

Balota, D. A., Flores d'Arcais, G. B., & Rayner, K. (Eds.) (1990). *Comprehension processes in reading*. Hillsdale, NJ: Erlbaum.

---

[4]It may be noted that the materials used by Flores d'Arcais (1990) are not completely neutral with respect to minimal attachment. For, in principle, the modifying clause could not only be attached to N1 or N2, but also to the verb phrase including the noun phrase of N1 and the verb. This is especially clear in the sentences of Appendix 1 where the clauses with the present particles (which are quite rare in Dutch) have been replaced by their more natural PP equivalents. This further undermines the use of this particular sentence structure to investigate the existence of late closure in Dutch.

Bever, T. G. (1970). The cognitive basis for linguistic structures. In J.R. Hayes (Ed.), *Cognition and the development of language* (pp. 279-362). New York: Wiley.

Brysbaert, M. (1991). Algorithms for randomness in the behavioral sciences: A tutorial. *Behavioral Research Methods, Instruments, & Computers, 23,* 45-60.

Brysbaert, M., & Mitchell, D. C. (1993, December). *Sentence parsing: Another departure from late closure*. Paper presented at the Vierde Congres Nederlandse Vereniging voor Psychonomie. Noordwijkerhout, the Netherlands.

Caplan, D., Baker, C., & Dehaut, F. (1985). Syntactic determinants of sentence comprehension in aphasia. *Cognition, 21,* 117-175.

Caramazza, A., & Zurif, E. B. (1976). Dissociation of algorithmic and heuristic processes in language comprehension: Evidence from aphasia. *Brain and Language, 3,* 572-582.

Carreiras, M. (1992). Estrategias de anàlisis sintàctico en el procesamiento de frases: cierr temprano versus cierre tardio. *Cognitiva, 4,* 3-27.

Carreiras, M., & Clifton, C., Jr. (1993). Relative clause interpretation preferences in Spanish and English. *Language and Speech, 36,* 353-372.

Clifton, C. Jr. (1988, August). *Restrictions on late closure: Appearance and reality*. Paper presented at the 6th Australian Language and Speech Conference, University of South Wales, Sydney.

Crane, H. D., & Steele, C. M. (1985). Generation-V Dual-Purkinje-Image-Eyetracker. *Applied Optics, 24,* 525-537.

Cuetos, F., & Mitchell, D. C. (1988). Cross-linguistic differences in parsing: Restrictions on the use of the Late Closure strategy in Spanish. *Cognition, 30,* 73-105.

Flores d'Arcais, G. (1990). Parsing principles and language comprehension during reading. In D.A. Balota, G.B. Flores d'Arcais, & K. Rayner (Eds.), *Comprehension processes in reading* (pp. 345-357). Hillsdale, NJ: Erlbaum.

Fodor, J. (1983). *The modularity of mind*. Cambridge, MA: MIT Press.

Forster, K.I., & Ryder, L.A. (1971). Perceiving the structure and meaning of sentences. *Journal of Verbal Learning & Verbal Behavior, 10,* 285-296.

Frazier, L. (1979). *On comprehending sentences: Syntactic parsing strategies*. Bloomington: Indiana University Linguistics Club.

Frazier, L. (1987). Sentence processing: A tutorial review. In M. Coltheart (Ed.), *Attention and performance XII: The psychology of reading* (pp. 559-586). Hillsdale, NJ: Erlbaum.

Frazier, L. (1993). Processing Dutch sentence structures. *Journal of Psycholinguistic Research, 22,* 85-108.

Frazier, L., & Rayner, K. (1982). Making and correcting errors during sentence comprehension: Eye movements in the analysis of structurally ambiguous sentences. *Cognitive Psychology, 14,* 178-210.

Garrett, M.F. (1975). The analysis of sentence production. In G. Bower (Ed.), *Psychology of learning and motivation* (Vol. 9, pp. 133-177). New York, NY: Academic Press.

Garvey, C., & Caramazza, A. (1974). Implicit causality in verbs. *Linguistic*

Inquiry, 5, 459-464.

Gibson, E., Pearlmutter, N., Canseco-Gonzales, E., & Hickock, G. (1994). *Cross-linguistic attachment preferences: Evidence from English and Spanish.* Manuscript submitted for publication.

McKoon, G., Greene, S. B., & Ratcliff, R. (1993). Discourse models, pronoun resolution, and the implicit causality of verbs. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 19,* 1040-1052.

Mitchell, D. C. (1987). Lexical guidance in human parsing: Locus and processing characteristics. In M. Coltheart (Ed.), *Attention and performance XII: The psychology of reading* (pp. 601-618). Hillsdale, NJ: Erlbaum.

Mitchell, D. C., & Cuetos, F. (1991). The origins of parsing strategies. In C. Smith (Ed.) *Current issues in natural language processing* (pp. 1-12). Center for Cognitive Science, University of Texas, Austin.

Mitchell, D. C., Cuetos, F., & Zagar, D. (1990). Reading in different languages: Is there a universal mechanism for parsing sentences? In D.A. Balota, G.B. Flores d'Arcais, & K. Rayner (Eds.), *Comprehension processes in reading* (pp. 285-302). Hillsdale, NJ: Erlbaum.

Mitchell, D. C., & Holmes, V. M. (1985). The role of specific information about the verb in parsing sentences with local structural ambiguity. *Journal of Memory and Language, 24,* 542-559.

Rayner, K., Carlson, M., & Frazier, L. (1983). The interaction of syntax and semantics during sentence processing: Eye movements in the analysis of semantically biased sentences. *Journal of Verbal Learning and Verbal Behavior, 22,* 358-374.

Taraban, R., & McClelland, J. L. (1990). Parsing and comprehension: A multiple-constraint view. In D.A. Balota, G.B. Flores d'Arcais, & K. Rayner (Eds.), *Comprehension processes in reading* (pp. 231-263). Hillsdale, NJ: Erlbaum.

Vonk, W. (1984). Eye movements during comprehension of pronouns. In A.G. Gale & F. Johnson (Eds.), *Theoretical and applied aspects of eye movement research.* Amsterdam: North-Holland.

Vonk, W. (1985). On the purpose of reading and immediacy of processing pronouns. In R. Groner, G.W. McConkie, & C. Metz (Eds.), *Eye movements and human information processing.* Amsterdam: North-Holland.

Zagar, D., & Pynte, J. (1992, September). *The role of semantic information and of attention in processing syntactic ambiguity: Eye-movement study.* Paper presented at the 5th conference of the European Society for Cognitive Psychology, Paris.

Department of Psychology
Tiensestraat 102
3000 Leuven

APPENDIX 1

De terreinknecht/achtervolgde/het meisje/zwaaiend/met een stok/in zijn handen.
De terreinknecht/achtervolgde/het meisje/zwaaiend/met een stok/in haar handen.
De terreinknecht/bemerkte/het meisje/zwaaiend/met een stok/in zijn handen.
De terreinknecht/bemerkte/het meisje/zwaaiend/met een stok/in haar handen.
(The groundsman chased/noticed the girl waving a stick in his/her hands.)

De serveerster/ging/naar de zeeman/met een glas bier/in haar hand.
De serveerster/ging/naar de zeeman/met een glas bier/in zijn hand.
De serveerster/ontweek/de zeeman/met een glas bier/in haar hand.
De serveerster/ontweek/de zeeman/met een glas bier/in zijn hand.
(The servant girl went to/avoided the sailor holding a glass of beer in her/his hand.)

De dienster/ging/naar de politieman/met een dienblad/onder haar arm.
De dienster/ging/naar de politieman/met een dienblad/onder zijn arm.
De dienster/wantrouwde/de politieman/met een dienblad/onder haar arm.
De dienster/wantrouwde/de politieman/met een dienblad/onder zijn arm.
(The servant girl went to/distrusted the policeman holding a tray under her/his arm.)

De soldaat/achtervolgde/de vrouw/op zijn paard.
De soldaat/achtervolgde/de vrouw/op haar paard.
De soldaat/vluchtte/voor de vrouw/op zijn paard.
De soldaat/vluchtte/voor de vrouw/op haar paard.
(The soldier chased/ran away from the woman on his/her horse.)

APPENDIX 2

Sentences administered to 10 subjects (graduates and research assistants from the K.U.Leuven). Subjects were asked to order the sentence pairs according to the grammatical acceptability of the sentences (N1 means that the sentence with attachment to the subject is the most acceptable one of the pair; N2 means that the sentence with attachment to the object is the most acceptable one; NP stands for no preference for either construction; the numbers before the code indicate the number of subjects marking the alternative).

1. De terreinknecht zat het meisje achterna zwaaiend met een stok in zijn/haar handen.
   (The groundsman chased the girl waving with a stick in his/her hands.)
   10xN1, 0xN2, 0xNP

2. De ruiter achtervolgde de amazone galopperend op zijn/haar paard.
   (The horseman chased the horsewoman galloping on his/her horse.)
   10xN1, 0xN2, 0xNP

3. Jan liep naar An hinkend op zijn/haar linkerbeen.
   (Jan ran to An limping with his/her left leg.)
   8xN1, 1xN2, 1xNP

4. De prostituée bedreigde de zeeman waggelend met een bierglas in haar/zijn hand.
   (The prostitute threathened the sailor tottering with a glass of beer in her/his hand.)
   7xN1, 2xN2, 1xNP

5. Piet praatte tegen Miet wijzend met zijn/haar vinger naar het blad.
    (Piet talked to Miet pointing with his/her finger at the sheet of paper.)
    10xN1, 0xN2, 0xNP

6. De politieagent strafte de inbreekster knipperend met zijn/haar ogen tegen het felle licht.
    (The policeman punished the female burglar blinking his/her eyes in the bright light.)
    5xN1, 4xN2, 1xNP

7. Het kind pestte zijn moeder stampend met zijn/haar voeten tegen de kou.
    (The child pestered his mother stamping with his/her feet because of the cold.)
    5xN1, 4xN2, 1xNP

8. De dienster slenterde naar de dokwerker een sigaret vasthoudend tussen haar/zijn vingers.
    (The servant girl strolled to the dockworker holding a cigarette in her/his hands)
    10xN1, 0xN2, 0xNP