

## The correspondence between sentence production and corpus frequencies in modifier attachment

Timothy Desmet, Marc Brysbaert, and Constantijn De Baecke  
*Ghent University, Ghent, Belgium*

We examined the production of relative clauses in sentences with a complex noun phrase containing two possible attachment sites for the relative clause (e.g., “Someone shot the servant of the actress who was on the balcony.”). On the basis of two corpus analyses and two sentence continuation tasks, we conclude that much research about this specific syntactic ambiguity has used complex noun phrases that are quite uncommon. These noun phrases involve the relationship between two humans and, at least in Dutch, induce a different attachment preference from noun phrases referring to non-human entities. We provide evidence that the use of this type of complex noun phrase may have distorted the conclusions about the processes underlying relative clause attachment. In addition, it is shown that, notwithstanding some notable differences between sentence production in the continuation task and in coherent text writing, there seems to be a remarkable correspondence between the attachment patterns obtained with both modes of production.

In 1988, Cuertos and Mitchell published an article in which they presented a syntactic structure that was parsed in an unexpected way. The structure concerned the attachment of a relative clause to a complex head of the type NP1–of–NP2 as shown in Sentence 1.

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

In materials of this kind, the relative clause (“who was on the balcony”) can be attached to one or the other of two noun phrases (“the servant” or “the actress”, hereafter referred to as NP1 and NP2). So, a fully syntactic analysis of the sentence requires the disambiguation of the relative clause (RC) attachment.

---

Requests for reprints should be sent to Timothy Desmet, Department of Experimental Psychology, Ghent University, Henri Dunantlaan 2, B-9000 Ghent, Belgium. Email: Timothy.Desmet@rug.ac.be

Timothy Desmet is a Research Assistant of the Fund for Scientific Research–Flanders (Belgium) (F.W.O.–Vlaanderen). The research was supported in part by grant G.0250.99 of the Research Programme of the Fund for Scientific Research–Flanders (Belgium) (F.W.O.–Vlaanderen) to Constantijn De Baecke. We would like to thank Ted Gibson and two anonymous reviewers for their comments.

Contrary to the predictions of the major theories at the time, such as the garden-path theory of Frazier (1987), which all assumed that syntactic principles applied universally, Cuetos and Mitchell (1988) found that the preferred attachment of the RC varied as a function of the language under scrutiny. Questionnaire data indicated that English readers tended to solve the ambiguity by attaching the relative clause to NP2, whereas Spanish readers revealed a bias in favour of NP1 attachment, both in a questionnaire study and an on-line reading experiment. Subsequent research has corroborated this cross-linguistic difference, with some languages predominantly preferring NP2 attachment, and others preferring NP1 attachment. The case for the first category is best documented for English (e.g., Carreiras & Clifton, 1999; Fernandez, 1998; Frazier & Clifton, 1996; Henstra, 1996), but there is also some emerging evidence of NP2 favouring in Brazilian Portuguese (Miyamoto, 1998), Swedish, Norwegian, and Romanian (Ehrlich, Fernandez, Fodor, Stenshoel, & Vinereanu, 1999). NP1 attachment is well documented in Spanish (Carreiras & Clifton, 1993, 1999; Cuetos, Mitchell, & Corley, 1996; Gibson, Pearlmutter, & Torrens, 1999; Igoa, Carreiras, & Meseguer, 1998; Thornton, MacDonald, & Gil, 1999), Dutch (Brylsbaert & Mitchell, 1996; Mitchell, Brylsbaert, Grondelaers, & Swanepoel, 2000; Wijnen, 1998), Afrikaans (Mitchell et al., 2000), French (Frenck-Mestre & Pynte, 2000; Mitchell, Cuetos, & Zagar, 1990; Zagar, Pynte, & Rativeau, 1997) and German (Hemforth, Konieczny, & Scheepers, 2000). As the evidence accumulates, it seems likely that Italian also falls into this category (see Frenck-Mestre & Pynte, 2000), although this is a language in which the facts are hotly contested (e.g., Baccino, De Vincenzi, & Job, 2000; De Vincenzi & Job, 1993, 1995; Frenck-Mestre & Pynte, 2000; Pynte & Frenck-Mestre, 1996).

The cross-linguistic variation was not the only problem uncovered by Cuetos and Mitchell's (1988) original finding. Also the fact that Spanish (and many other languages since) preferred NP1 over NP2 attachment was at odds with the prevailing theories of sentence parsing. These structurally based theories all predicted attachment of new, incoming information to the most recently processed, non-terminal node in the phrase marker—for example, Kimball's (1973) right association and Frazier's (1978) late closure.

Several attempts have been made to explain both the cross-linguistic variation and the violation of the right association in structures like Sentence 1. Broadly, they can be grouped into three main approaches (see Cuetos et al., 1986; and Mitchell & Brylsbaert, 1998, for more detailed reviews). First, some theories have proposed new structural principles on which the human sentence parser would be based. A typical example of this approach is the tuning hypothesis (Brylsbaert & Mitchell, 1996; Cuetos et al., 1996; Mitchell & Cuetos, 1991; Mitchell, Cuetos, Corley, & Brylsbaert, 1995), which claims that the sentence parser is experience based and that initial parsing choices are made on the basis of the relative frequencies with which the reader or listener has resolved the structural ambiguity in favour of one or other analysis in the past. Another example of this approach is Gibson's predicate-proximity/recency model (Gibson, Pearlmutter, Canseco-Gonzalez, & Hickok, 1996). The basic proposal here is that two competing factors play a role in the process of selecting an attachment site for a modifier. These are the structural proximity of the potential host sites to the head of the entire predicate phrase (predicate proximity) and the relative distances between the modifier and each of the potential heads. The suggestion is that there are processing tendencies favouring attachments that are close to the head of the predicate phrase,

together with biases pushing for attachment to more recent sites (recency preference), and that the site associated with the lowest processing cost is the preferred host.

The second main approach is the lexicalist account (e.g., MacDonald, Pearlmutter, & Seidenberg, 1994; Spivey-Knowlton & Sedivy, 1995), which claims that modifier attachment is based on the relative modifiability of the possible host nouns. In its simplest form, the account says that RC attachment in Sentence 1 depends on the specific nouns used in the head. Usually, this proposal is embedded within a larger theory that also allows other non-lexical constraints to influence the attachment preference (see Mitchell et al., 1995, for a more detailed discussion).

Finally, a third type of explanation claims that the RC attachment in Sentence 1 is based on discourse factors rather than on syntactic principles. For instance, Hemforth et al. (2000) noticed that, in German, structures involving a RC, like the one in Sentence 2, are resolved differently from structures involving a prepositional phrase like the one in Sentence 3.

2. The daughter of the teacher who came from Germany met John.
3. The daughter of the teacher from Germany met John.

Whereas in Sentence 2, there was a preference for high attachment (to “the daughter”), in Sentence 3 the syntactically predicted low attachment preference (to “the teacher”) was observed. On the basis of this finding, Hemforth et al. (2000) proposed the anaphoric resolution hypothesis, according to which the presence of a relative pronoun initiates a search for an appropriate discourse referent to which the pronoun points. In this view, relative pronouns elicit the same processes as other pronouns do. Similarly, Frazier and Clifton (1996; see also Gilboy, Sopena, Clifton, & Frazier, 1995), in their construal theory, hypothesized that RC attachment is based on a different set of (discourse) principles from the principles that govern the primary relations in a sentence (roughly, the relations between verbs and their arguments).

With respect to these approaches, it is important to keep two things in mind. First, the approaches mainly differ in the time course with which the different factors affect the attachment decision. All approaches agree that the final attachment can be based on any of the three kinds of variable (structural, lexical, or discourse related). They only differ in the factors that govern the initial decision. Second, in the current state of affairs, none of the proposed approaches can account for all the empirical findings, and they all have been seriously questioned. For instance, the lexical account is called into question by the finding that the RC attachment preference shifts when the same nouns occupy different positions within the complex head (Gibson et al., 1999; see also Mitchell et al., 1995). In Spanish Gibson et al. (1999) found a large processing cost when the RC was attached to the noun “planeta (planet)” in Sentence 4, but not when it was attached to the very same noun in Sentence 5.

4. El astrónomo predijo las *órbitas* del *planeta* que se observó desde el satélite.  
[The astronomer predicted the orbits of the planet that was observed from the satellite.]
5. El astrónomo predijo los *cambios* de las *órbitas* del *planeta* que se observó desde el satélite.  
[The astronomer predicted the changes of the orbits of the planet that was observed from the satellite.]

Likewise, a number of studies have questioned the discourse-based explanations. In particular, Mitchell et al. (2000) provided evidence against the suggestion, made by several discourse-based accounts, that the presence of an unambiguous alternative genitive structure in English (e.g., “the actress’s servant”), which is not available in Spanish, could explain the cross-linguistic difference. In addition, there is some evidence suggestive of the fact that the initial attachment preference seems little influenced by the surrounding context making one or the other noun of the complex head more likely to require modification (Desmet, De Baecke, & Brylsbaert, in press; Zagar et al., 1997).

The tuning hypothesis is called into question by two findings. According to the hypothesis, RC attachments in sentences like Sentence 1 should mimic the relative frequencies with which RCs are attached to NP1 and NP2 in structures of the type NP1–of–NP2–RC in the language under scrutiny (Mitchell et al., 1995). In its simplest form, the claim is that the reader always opts for the most frequent interpretation, although alternative formulations could propose that different readings are selected with probabilities that are proportional to the relative frequencies with which they have occurred in the past. However, in a series of papers, Gibson and colleagues presented empirical evidence against this prediction (Gibson & Schütze, 1996, 1999; Gibson, Schütze, & Salomon, 1996). They examined conjunctions of noun phrases to complex heads with three noun phrases, as shown in Sentence 6:

6. The salesman ignored a customer with a child with a dirty face and \_\_\_\_\_.
  - a. a wet diaper (NP3 attachment)
  - b. one with a wet diaper (NP2 attachment)
  - c. one with a baby with a wet diaper (NP1 attachment)

Both off-line and on-line studies showed that readers preferred conjunctions to NP1 rather than those to NP2, but detailed corpus analyses revealed that in texts NP2 attachments significantly outnumber NP1 attachments. Gibson and Schütze (1993, p.263), therefore, concluded “that the sentence comprehension mechanism is not using corpus frequencies in arriving at its preference in this ambiguity, and hence the decision principles of sentence comprehension and sentence production must be partially distinct. It is proposed that there is a factor operative in sentence comprehension that is not operative in sentence production, and this factor favours attachment to the first noun phase.”

Another finding that is problematic for the tuning hypothesis comes from the Dutch language. To test exposure-based accounts of cross-linguistic variation in parsing, Mitchell and Brylsbaert (1998) analysed a Dutch corpus to investigate whether the NP1 attachment preference that they found in reading times (Brylsbaert & Mitchell, 1996; Mitchell et al., 2000) was also present in a representative sample of the Dutch language. They extracted 675 sentences with the structure NP1–van–NP2–RC (“van” is the Dutch translation of the preposition “of”) from a corpus based on Dutch magazines and newspapers (see later). Against their own prediction, they found a strong and consistent NP2 attachment bias in the corpus: A total of 469 of the sentences (i.e., 69%) contained an attachment to the most recent noun phrase. Mitchell and Brylsbaert mentioned two possible hypotheses for the discrepancy between their on-line reading data and the corpus findings. First, it could be that for one reason or another, the sentences they had used in the reading experiments were not representative for the sentences in

the corpus. Alternatively, it could be that the syntactic parser does not tune to the structure NP1–van–NP2–RC, but to a finer grained or a coarser grained structure (see Mitchell et al., 1995, for a discussion of the grain problem). In this paper, we focus on the first possibility, although the results also have implications for the second alternative, as we will see in the General Discussion section.

### FURTHER ANALYSIS OF THE MITCHELL AND BRYLSBAERT (1998) CORPUS

Going through the sentences of the Mitchell and Brylsbaert (1998) corpus, we noticed that there were very few sentences of the type “Someone shot the servant of the actress who . . .”. In particular, the combination of two nouns referring to humans was relatively rare. Many more instances were found in which one or both of the noun phrases referred to non-human entities. Actually, the fact that the majority of cross-linguistic research on RC attachment has been based on sentences including two human hosts is the result of a combination of two factors. The first is that because the research was initiated within a tradition that predominantly looked at structural variables, researchers were not preoccupied with the nature of the NPs in the stimulus materials that they used (also because the few experiments that looked at this variable failed to find convincing evidence; see earlier). The second factor was that in English, human referents preferentially take the relative pronoun “who”, whereas non-human referents only take the relative pronouns “that” or “which”. This made Cuetos and Mitchell (1988) conclude that complex heads containing one human and one non-human noun were less interesting to study in English, because any attachment effect could be due to the relative pronoun that was used. As virtually all subsequent cross-linguistic research has been based on translations of the initial English stimulus materials, Cuetos and Mitchell’s option induced a human–human bias in the research. The most notable exceptions to this bias have been the three-site research of Gibson and colleagues (Gibson & Schütze, 1996, 1999; Gibson, Schütze, & Salomon, 1996) and a study by Traxler, Pickering, and Clifton (1998).

To examine whether the discrepancy between the reading data and the corpus findings could be due to the nature of the NPs used, we reanalysed Mitchell and Brylsbaert’s (1998) corpus as a function of whether or not the NPs referred to human entities. In addition, we decided to limit our analysis to sentences with the relative pronoun “die”, leaving out the sentences with the relative pronoun “dat”. In Dutch, the relative pronoun “die” is used for words that take the definite article “de”—that is, non-neuter nouns and plurals—whereas the relative pronoun “dat” is exclusively related to words that take the definite article “het”—that is, neuter nouns and diminutives. There are two reasons for not taking into account sentences that contain the relative pronoun “dat”. First, our conclusions do not differ whether or not we take the pronoun “dat” into account. In the Mitchell and Brylsbaert corpus,  $370/498 = 74\%$  of the sentences with the relative pronoun “die” had a NP2 disambiguation, against  $99/177 = 56\%$  of the sentences with the relative pronoun “dat”. Second, the relative pronoun “dat” is rarely used to refer to humans. Because the relative pronoun “dat” refers to singular nouns with a neuter gender, its frequency is not only more limited than that of “die” (a ratio of roughly 1:3) but it is also rarely used to refer to people (who usually have a non-neuter gender; see Brylsbaert & Mitchell, 2000). First, we describe in more detail how the corpus was constructed, as this was not done in the Mitchell and Brylsbaert study.

## Method

### *Materials*

The corpus analysis was based on two CD-ROMs. The first was a CD distributed by Roularta Media Group, a Belgian publishing company that sells a number of Dutch and French magazines. For the Dutch-speaking community, its most important publication is “Knack”, a general weekly magazine that is widely read. It is certainly popular among university students. The CD included all articles over the years 1991–1994 (a total of 12,051 different texts). Two other publications that were available on the CD were “Trends” (a magazine on economics, with a total of 12,865 articles in 1991–1994) and “Style” (a lifestyle magazine with a total of 693 articles). This CD had software that allowed us to search for any combination of words. The second CD contained all 1994 articles of the “Volkskrant”, one of the major daily newspapers in the Netherlands. The software of this CD, however, only provided facilities for searching for a limited set of tagged words. Neither “van [of]” nor “die [who]” figured among these words (too frequent). Therefore, a number of articles had to be downloaded, and software had to be written to look for particular word strings. This was only done for the articles published on February 1, 1994 (a total of 97 articles), and on March 1, 1994 (a total of 107 articles), because these data were mainly meant as a cross-national check—that is, to make sure that the data from the Belgian magazines were comparable to data from texts published in the Netherlands.

### *Procedure*

The corpus was originally selected in order to test the tuning hypothesis. In its most straightforward version, this theory predicted that NP1 attachment should prevail in all constructions of the type “NP1–van–NP2–die” [NP1–of–NP2–who]. This was tested by searching the sequence “van\*die” in the corpora, in which “\*” stood for any sequence of one to five words. For each magazine, the Roularta software gave a list of articles containing at least one instance of the sequence. Because the numbers of articles were very high, only the first 100 articles were analysed for each of the three magazines. An exception was made for the “Knack” magazine, which is arguably the most pertinent to our student population. Here, the last 100 articles were analysed in addition to the first 100.

The sequences were scored in three steps. First, it was decided whether or not the sequence could be considered as a modifier attachment to a double NP head. A frequent example of an irrelevant “van\*die” sequence was “De stijl van al die films . . .” [the style of all those movies . . .], where “die” is used as a demonstrative pronoun (and consequently there is no RC to be attached). In a second step of the analysis, it was decided whether a relevant sequence was a clear example or a debatable one. Examples of the latter were “de minderheid van mulatten en blanken die . . .” [the minority of mulattos and whites who . . .] and “kerels van zestien jaar die . . .” [guys of 16 years who . . .]. In the first example the second NP is conjoined, and it is possible to refer only to “whites” instead of to “mulattos and whites”. This example is debatable because of the syntactic structure of the complex head (which contains two noun phrases within NP2). Although there is an NP1–of–NP2 structure, the second example is debatable because it is almost impossible to refer to the second NP (16 years). The distinction between clear and debatable instances was made to ensure that no conclusion was drawn on the basis of questionable stimulus materials. However, as we will see, there were no substantial differences between both kinds of stimulus. Finally, in the third step it was decided, for both debatable and clear instances, whether there was an NP1 or an NP2 attachment. Decisive disambiguating information (by either syntactic or semantic cues) had to be present for a decision to be made. Otherwise, no decision was made. This only happened for some 5% of the relevant cases. The materials were rated independently by two native Dutch-speaking judges. Only in a few cases did the judgements of the two judges differ, and the attachment was decided by deliberation.

## Results and discussion

The first analysis consisted of 498 different examples of “NP1–van–NP2–die” sequences (remember that Mitchell & Brysbaert, 1998, had 675 instances, but 177 of them contained the relative pronoun “dat”). Table 1 presents the number of clear and debatable attachments to NP1 and NP2 for each of the text samples examined by Mitchell and Brysbaert

The results show that for all sources NP1 attachments (128 in total) were seriously outnumbered by NP2 attachments (370). There were no inconsistencies between the different sources, including the “Volkskrant”. Although there were no major differences between the clear and the debatable instances, we decided to limit the remaining analyses to the clear instances, because these were the instances that we could use in the production task. To examine the importance of whether or not a noun referred to a human, we made a distinction between four types of complex head: (1) sentences with a human NP1 and NP2 (h/h; e.g., the servant of the actress), (2) sentences with a human NP1 and a non-human NP2 (h/nh; e.g., the author of the novel), (3) sentences containing a non-human NP1 and a human NP2 (nh/h; e.g., the car of the salesman), and (4) sentences with a non-human NP1 and NP2 (nh/nh; e.g., the abstract of the article). Table 2 lists the number of clear attachments from Table 1 as a function of head type.

Table 2 shows a potentially interesting pattern: The overall NP2 attachment preference in the corpus is due to the many instances in which NP1 does not refer to a human entity. When NP1 refers to a person, attachment preferences are less pronounced and numerically point towards an NP1 preference. If this pattern is genuine, it means that up to now research on modifier attachment in Dutch has mainly been based on an infrequent type of sentence, which seems to be disambiguated differently from the majority of sentences containing a relative clause attachment ambiguity. Arguably, this may have led to wrong conclusions about the processing of this particular syntactic structure. For instance, it could mean that for the majority of sentences used by Brysbaert and Mitchell (1996) and by Mitchell et al. (2000) the corpus data were not in contradiction with the reading data. As the sentences in the reading experiments mainly contained complex heads with a human NP1 (see later), the corpus data predict

TABLE 1  
Number of NP1–of–NP2–RC instances with a clear or debatable relative clause attachment to either NP1 or NP2 in the different sources of the first corpus analysis

<i>Source</i>	<i>Clear</i>		<i>Debatable</i>	
	<i>NP1</i>	<i>NP2</i>	<i>NP1</i>	<i>NP2</i>
Knack (first 100)	27	80	13	24
Knack (last 100)	14	61	08	16
Trends	22	26	05	28
Style	17	61	08	30
Volkskrant	08	23	06	21
Total	88	251	40	119

TABLE 2  
 Number of NP1 and NP2 attachments as a function of head type,  
 based on the clear instances from Table 1

<i>Head type</i>	<i>NP1</i>		<i>NP2</i>		<i>Total</i>
	<i>No.</i>	<i>%</i>	<i>No.</i>	<i>%</i>	
h/h	12	80	03	20	15
h/nh	15	71	06	29	21
nh/h	21	13	136	87	157
nh/nh	40	27	106	73	146
Total	88	26	251	74	339

*Note:* h/h: human NP1, human NP2; h/nh: human NP1, non-human NP2; nh/h: non-human NP1, human NP2; nh/nh: non-human NP1, non-human NP2.

that they should have induced an NP1 preference, at least if the distinction between human and non-human NPs is genuine.

A problem at this point is that there are many other possible differences between the stimulus materials used in the reading experiments and the corpus sentences. The most prominent probably is that the corpus sentences formed part of a coherent text, whereas the reading sentences were presented in isolation. According to the referential hypothesis of Crain and Steedman (1985) and Altmann and Steedman (1988), the presence of discourse context may have been the reason that the sentences of the corpus were disambiguated the way they were. Maybe non-human NPs already had a unique referent in the previous discourse, whereas human NPs needed further modification? Another difference between the reading stimuli and the corpus stimuli is that the former were carefully controlled for plausibility, length, and overall difficulty of the two nouns in the complex head. In addition, the main clause of the reading sentences mostly consisted of a subject-verb-object sequence, whereas in the corpus data a much greater variety of structures was present (e.g., sentences with the verb of the main clause not yet encountered when the RC started). The use of carefully constructed sentences is a necessity in psychological experiments, because it eliminates obvious confounds, reduces the noise, lowers the variance, and, hence, maximizes the probability of finding whether or not the experimentally manipulated variable has an effect. However, it may lead to interpretation problems when there is an imperfect match between the results based on this type of stimulus material and the findings obtained with freely produced materials. The last thing one would want is that the conclusions drawn on the basis of experimental research do not generalize beyond the highly artificial sentences used in the experiments.

Therefore, to find out whether the distinction between human and non-human nouns drawn in Table 2 is a factor that matters in RC attachment during sentence production, it would be good if we could replicate it under better controlled circumstances. An experimental technique that is often used in sentence production is the sentence completion task (e.g., Spivey-Knowlton & Sedivy, 1995; Zagar et al., 1997). Participants are given the beginning of a sentence and are asked to write down the first continuation of the sentence that comes to their mind. If the humanness of the nouns is indeed an important factor in sentence production, as suggested by the corpus data, then we should find a similar pattern in the sentence completion



task. Moreover, if the sentence completion task returns the same results as the corpus analysis, then we have a powerful tool to look at how the experimentally constructed stimuli of Mitchell et al. (2000) relate to uncontrolled texts in the Dutch language, because we can then present these stimuli in exactly the same task. Note that many researchers thus far have simply assumed that the sentence completion task is a valid measure of sentence production without really checking the results against corpus analyses.

## SENTENCE COMPLETION STUDY I

Although both the sentence continuation task and the corpus analysis involve the production of sentences, there are some notable differences. For example, whereas text authors have the possibility to make the meaning of the sentence clear by providing a referential context, the participants performing a sentence continuation task have to disambiguate within the given sentence when they want to be clear. To investigate whether the same processes influence the production task and the corpus patterns we used sentences that were taken directly from the corpus. However, the small number of sentences with a human NP1 prevented us from drawing samples out of the corpus that would be big enough in each of the four conditions. Therefore, this sentence completion study started by collecting two new samples of corpus sentences, in order to increase the number of sentences with a human NP1.

The first new sample was again taken from the magazine "Knack" and was based on the five first issues of the magazine in 1993 (January 7, 14, 21, and 28, and February 4) and in 1996 (January 3, 10, 17, 24 and 31), with a total of 700 articles. This selection ensured that there was no overlap with the materials from Mitchell and Brysbaert (1998). The second sample came from 539 articles published in "Het Nieuwsblad", one of the major newspapers of the Dutch-speaking part of Belgium. The publishing company of this newspaper maintains a website with an electronic text-archive, which is extended daily with a selection of four articles from the most recent newspaper edition. For this analysis we used all articles starting from July 14, 1999 until December 30, 1999.

In order to find the critical sentences in the new corpus materials, we used a concordance program (Concapp Version 3.0 for Windows 95) that allowed us in a first step to extract all sentences containing the word "die". In a second step, we examined the extracted pool of sentences and sorted out all sentences in which "die" was introducing a relative clause that referred to a complex head with the NP1-van-NP2 structure. Subsequently, it was decided whether an NP1 or an NP2 attachment was made. In this corpus study, we looked for all instances in the selected texts and not just for the first 100 as in the corpus study by Mitchell and Brysbaert (1998). We also did not restrict our searches to sentences with one to five intervening words between "van" and "die". In the Mitchell and Brysbaert corpus this may have led to the exclusion of very long NP2s, which may have been a problem given that Fodor (1998) argues that the length of the NPs can influence the attachments. The materials were rated by a native Dutch-speaking judge. In case of doubt a second independent judge was consulted. Only the sentences that were clearly disambiguated were included in the analysis.

The results of the new corpus analysis are shown in Table 3 and provide further evidence for the suggestion that humanness of the noun hosts influences RC attachment. When NP1 is human, attachments to this noun phrase predominate; when NP1 does not refer to a human, attachments to NP2 predominate. As in Table 1, there was no reliable difference between the

TABLE 3  
Number of NP1 and NP2 attachments as a function of head type  
in the second corpus<sup>a</sup>

<i>Head type</i>	<i>NP1</i>		<i>NP2</i>		<i>Total</i>
	<i>No.</i>	<i>%</i>	<i>No.</i>	<i>%</i>	
h/h	23	62	14	38	37
h/nh	24	83	05	17	29
nh/h	13	9	126	91	139
nh/nh	37	33	76	67	113
Total	97	31	221	69	318

*Note:* h/h: human NP1, human NP2; h/nh: human NP1, non-human NP2; nh/h: non-human NP1, human NP2; nh/nh: non-human NP1, non-human NP2.

<sup>a</sup>Het Nieuwsblad July 14–December 30, 1999, Knack January 7–February 4, 1993, and Knack January 3–January 31, 1996.

two different sources. Also in line with Mitchell and Brylsbaert's (1998) data, sentences with a non-human NP1 considerably outnumbered those with a human NP1 (252 against 66), giving rise to an overall NP2 attachment bias in the corpus ( $221/318 = 69\%$ ).

## Method

### *Participants*

A total of 80 undergraduate students at Ghent University participated for course credit. All were native Dutch speakers and were naive to the research questions.

### *Materials and design*

In this study, 112 sentences were randomly selected from the combined corpus described in Tables 2 and 3. The sentences were evenly distributed over the four conditions (28 h/h, 28 h/nh, 28 nh/h, 28 nh/nh sentences). To make sure each participant saw the same number of instances of the four different types we made four different lists. Each list included seven sentences of each sentence type, according to a Latin-square design (7 h/h, 7 h/nh, 7 nh/h, 7 nh/nh sentences). In addition to these 28 critical sentences all lists had the same 80 filler sentences, in order to divert the attention of the participants from the specific NP1–van–NP2 structure. The filler sentences belonged to a variety of syntactic structures. The order of sentences in the lists was randomized for each participant, so that sequence effects were precluded.

### *Procedure*

Of each sentence only the beginning was presented. The experimental sentences were made by taking the corpus sentence and deleting everything that followed the relative pronoun (see Sentences 7 to 10).

#### 7. human–human

Het is onbegrijpelijk dat juist hem zoiets moet overkomen, reageren de collega's van de agent die

[It is incomprehensible that something like that happened to him, said the colleagues of the policeman who \_\_\_\_]

8. human – nonhuman

Gillespie speelde trompet en was de pionier van de bebop-muziek die \_\_\_\_  
 [Gillespie played the trumpet and was the pioneer of the bebop music that \_\_\_\_]

9. nonhuman – human

Het gelijkvloers is voorbehouden aan de schilderijen van tijdgenoten die \_\_\_\_  
 [The ground-floor is reserved for the paintings of the contemporaries that \_\_\_\_]

10. nonhuman – nonhuman

Aan de muur hing een poster van de space-shuttle die \_\_\_\_  
 [On the wall, there was a poster of the space shuttle that \_\_\_\_]

The beginnings of the experimental and filler sentences were typed on sheets of paper. Each participant was randomly assigned to one of the four lists and was asked to work silently and to fill out each trial, without returning to the previous trials. The participants were instructed to read the beginning and immediately complete the sentences by writing down the first continuation that came to mind. The completion of all sentence fragments took about 40 minutes.

## Results

Only the test sentences were analysed for this study. All sentence beginnings for which no continuation was provided, and completions that resulted in either an ambiguous sentence or an unacceptable sentence (e.g., ungrammatical sentences or sentences in which the relative pronoun “die” was used as a demonstrative pronoun), were excluded from the analyses. This amounted to a total of 12% of the data. Mainly because of the differences in the number of sentences that were not disambiguated, this percentage varied between the sentence types. The number of missing data was particularly high for the sentences with a human NP1 (h/h: 15% and h/nh: 15%) compared to those with a nonhuman NP1 (nh/h: 8% and nh/nh: 9%).

Table 4 lists the percentages of NP1 completions for the remaining sentences as a function of head type. Sentences with a human NP1 were more often continued with a relative clause referring to NP1. Analysis using *t*-tests revealed that the 64% NP1 bias for h/h sentences was reliably different from 50% in the analyses over participants,  $t_1(79) = 7.21, p < .001$ , but not over items,  $t_2(27) = 1.69, p > .05$  ( $t_1$  and  $t_2$  refer to analyses treating participants and items respectively, as random effects). The NP1 bias of 79% in the h/nh sentences was significantly different from chance in both analyses,  $t_1(79) = 15.52, p < .001, t_2(27) = 4.34, p < .001$ . In both types of sentence with a non-human NP1 the majority of the continuations contained a relative clause attached to the second NP. For both nh/h (84% NP2 bias) and nh/nh (79% NP2 bias) sentences, this bias was reliably different from 50%: nh/h,  $t_1(79) = 22.95, p < .001; t_2(27) = 5.74, p < .001$ ; nh/nh,  $t_1(79) = 16.02, p < .001; t_2(27) = 5.79, p < .001$ .

We also ran analyses of variance (ANOVAs) to examine whether the percentages of NP1 continuations differed significantly between the four types of sentence (h/h, h/nh, nh/h, nh/nh). Sentence type was considered as a repeated measure in the  $F_1$  analysis and as a between-items variable in the  $F_2$  analysis. These analyses revealed that the NP1 percentages differed between the four conditions,  $F_1(3, 237) = 368.83, p < .001, F_2(3, 108) = 24.33, p <$

TABLE 4  
 Percentages of NP1 attachments in  
 the first completion study compared  
 to the corpus<sup>a</sup>, as a function of head  
 type

<i>Head type</i>	<i>Completion</i>	<i>Corpus</i>
h/h	64	67
h/nh	79	78
nh/h	16	11
nh/nh	21	30

*Note:* h/h: human NP1, human NP2; h/nh:  
 human NP1, non-human NP2; nh/h:  
 non-human NP1, human NP2; nh/nh:  
 non-human NP1, non-human NP2.

<sup>a</sup>First and second corpus data combined.

.001. Planned comparisons showed that the sentences with a human NP1 yielded a larger percentage of NP1 attachments than the sentences with a non-human NP1 (all  $p$ s < .001).

## Discussion

The present study had two main findings. First, we replicated the finding from the corpus analysis that the humanness of NP1 hosts influences RC attachment in Dutch. When Dutch-speaking participants are asked to complete sentences ending on “NP1–van–NP2–die”, they prefer NP1 continuations when NP1 refers to a human entity and NP2 continuations when NP1 does not refer to a human. In addition, when we look at the percentages of attachments in Table 4, we see not only a trend in the same direction, but a very close correspondence between the estimates based on the corpus data and the estimates obtained from the sentence completion task. Such a finding is only possible if (1) the completion task activates the same processes as text writing, and (2) the production difference due to the nature of NP1 is a genuine one for the participants. The close match between the completion and the corpus data strongly suggests that the same processes are involved in both manifestations of sentence production and that the differences between them, such as discourse influences from outside the sentence, are not very important (also see Desmet et al., in press; Zagar et al., 1997). This is an important finding for further research on the topic of RC attachment, because it implies that the sentence completion task can be used to compare attachments in carefully controlled stimuli with those of the language in general (as estimated on the basis of corpus data). This also means that the sentence completion task can be used to see how well the sentences used by Mitchell et al. (2000) in their reading study match the Dutch language in general.

## SENTENCE COMPLETION STUDY II

This second completion study was conducted to investigate whether the sentences used by Mitchell et al. (2000)—to show an on-line NP1 attachment preference in reading—were comparable to those in the corpus. The 36 experimental sentences used in their study consisted of

12 h/h sentences, 12 h/nh sentences, and 12 nh/h sentences. Our prediction was that the majority of these sentences (the 24 sentences with a human NP1) would show a bias towards NP1 attachment, meaning that there is no contradiction between reading and production (as concluded by Mitchell & Brysbaert, 1998). Furthermore, it will be interesting to see how the 12 nh/h sentences pattern, because according to the corpus data they should show a clear NP2 attachment preference, whereas Mitchell et al. (2000) reported a (non-significant) NP1 bias for these sentences.

## Method

### *Participants*

A total of 40 undergraduate students at Ghent University participated for course credits. All were native Dutch speakers and were unaware of the aim of the research. None had participated in the previous study.

### *Materials and design*

All participants received a list with 116 sentence beginnings. Of these sentences, 80 were fillers; the remaining 36 were the experimental sentence beginnings. The latter were made by deleting everything following the relative pronoun in the sentences used by Mitchell et al. (2000). Consequently, the 36 experimental sentence fragments ended with the structure “NP1–van–NP2–relative pronoun”. As in Mitchell et al. (2000), there were 12 h/h sentences (see Sentence 11), 12 nh/h sentences (see Sentence 12) and 12 h/nh sentences (see Sentence 13). Mitchell et al. (2000) did not include nh/nh sentences in their study.

11. Vreemd genoeg hadden de dorpelingen respect voor de verloofde van de baron die \_\_\_\_  
[Strangely enough the villagers respected the fiancée of the baron that \_\_\_\_]
12. De bankbediende deinsde achteruit voor de dolk van de overvaller die \_\_\_\_  
[The bank employee moved back for the dagger of the robber that \_\_\_\_]
13. De kranten loven de indiener van de wettekst die \_\_\_\_  
[The newspapers praise the proposer of the law that \_\_\_\_]

### *Procedure*

The procedure was identical to that in the first completion study.

## Results

A total of 14% of the data were omitted, because participants did not complete the sentence, made an ungrammatical sentence, wrote a relative clause that did not disambiguate, or used the relative pronoun as a demonstrative pronoun. Of the remaining answers, we calculated the percentages of NP1 and NP2 continuations, as a function of head type (see Table 5).

The correspondence between the attachment preferences in Table 5 (sentence completion) and Tables 2 and 3 (corpus data) is obvious: Both heads with a human NP1 resulted in a predominance of NP1 continuations, whereas the nh/h type yielded a NP2 preference. The NP1 preference was reliably different from 50% for the h/h sentences,  $t_1(39) = 3.45, p < .01, t_2(11)$

TABLE 5  
Percentages of NP1 and NP2  
completions as a function of head  
type in the second completion  
study

<i>Head type</i>	<i>NP1</i>	<i>NP2</i>
h/h	62	38
h/nh	69	31
nh/h	42	58

*Note:* h/h: human NP1, human NP2;  
h/nh: human NP1, non-human NP2;  
nh/h: non-human NP1, human NP2.

= 2.23,  $p < .05$ , and the h/nh sentences,  $t_1(39) = 4.70$ ,  $p < .01$ ,  $t_2(11) = 4.05$ ,  $p < .01$ . The NP2 preference for the nh/h sentences was only significant over participants,  $t_1(39) = 2.53$ ,  $p < .05$ ,  $t_2(11) = 1.44$ ,  $p > .05$ .

## Discussion

The results add further evidence to our hypothesis that the apparent contradiction between the reading data and the corpus data in Dutch, reported by Mitchell and Brylsbaert (1998), results from the fact that different types of sentence predominated in both types of study. The majority of sentences used in the reading studies had a human NP1 (this was also true for Brylsbaert & Mitchell, 1996), whereas these types of sentences are relatively rare in normal texts. In spontaneous writings, there are many more sentences containing an NP1 that does not refer to a human, and on the basis of the present studies we can conclude that these are disambiguated differently.

There still is a small contradiction between the reading and the production data for the 12 nh/h sentences, which according to the sentence completion studies should prefer an NP2 continuation, but for which Mitchell et al. (2000) reported an NP1 preference. However, looking at Table 5, it is clear that the 12 sentences of Mitchell et al. show only a small NP2 preference in the sentence production task (58%), compared to the corpus sentences (89%). Also, the NP1 reading preference was not reliable for this particular subset of sentences, so that it seems more prudent to wait for further empirical evidence before putting too much weight on this particular finding.

## GENERAL DISCUSSION

The first psycholinguistic models of sentence parsing heavily relied on Chomsky's linguistic theory (e.g., Chomsky, 1965): Grammar was the most important aspect of the human language, sentence parsing was based on structural relations between words and not on the content of the words or on the context within which sentences appeared, and the human sentence parser was rule based and universal. The last assumption was challenged by Cuetos and Mitchell's (1988) findings on RC attachments to complex heads. Spanish people (and since then also Dutch, French, and German people, among others) showed a preference for RC

attachment to the least recent of two possible noun phrases. This finding has led not only to a sharp increase in cross-linguistic research but also to a proliferation of models to account for the finding, only some of which remained in the structural tradition.

One of the models that remained within the structural tradition was the linguistic tuning hypothesis (Mitchell & Cuetos, 1991; Mitchell et al., 1995). This hypothesis continued to defend the idea that initial choices are made independently of the specific words of the sentence or the wider discourse context, but replaced the rule-based system by an experience-based account. Syntactic ambiguities were no longer decided on the basis of principles, but on the basis of statistical records of previous experiences. However, the model experienced difficulties when the data were extended to three-site heads (Gibson & Schütze, 1999; Gibson et al., 1996) and to the Dutch language (Mitchell & Brysbaert, 1998). In both cases, there was a contradiction between the frequencies with which structures occurred in written texts and the preferences in on-line processing (reading).

The present article focused on the Dutch findings, because if the contradiction between the reading and the corpus data cannot be solved, not only does the tuning hypothesis have to be rejected, but also we have to accept that language production (writing) is based on different mechanisms from language perception (reading). A suggestion along these lines was made by Gibson and Schütze (1999). They hypothesised that a factor that favours high attachment is involved in sentence comprehension. This factor—for example, predicate proximity (Gibson et al., 1996) or anaphoric binding (Hemforth et al., 2000)—would not be applicable in sentence production.

However, there are many more differences between corpus materials and reading materials than the distinction between writing and reading. Therefore it may not be required to posit a difference between language production and language perception. To capture the short-lived parsing preferences in reading, researchers have to rely on carefully constructed sentences that allow a fair comparison between the different experimental conditions. In the case of research on RC attachments, this has led, for instance, to the majority of research being based on sentences with complex heads that referred to two different persons. This was partly due to the fact that it is unclear what relative pronoun to use for humans in English (“who” or “that”), but also to some extent because this enabled researchers to disambiguate the relative clause on the basis of the gender of the persons involved. For instance, the prime examples of sentences used by Brysbaert and Mitchell (1996) were (English translation):

14. The terrorists shot the son of the actress who was on the balcony with his arm in a cast.
15. The terrorists shot the son of the actress who was on the balcony with her arm in a cast.

Sentences 14 and 15 allowed a clear disambiguation of the sentence on the basis of one single word. So, by comparing the reading times of these two sentences, it was possible to reveal the attachment preference in Dutch. Unfortunately, this particular type of sentence (involving the attachment of a RC to a complex head consisting of two humans) turns out to be very rare in regular Dutch texts and, hence, in the corpus materials (see Tables 2 and 3).

To bridge the gap between corpus materials and reading materials, we have addressed two issues: (1) Is there a variable in the corpus materials that can account for the apparent contradiction between sentence production and sentence perception in Dutch? and (2) Can sentence production and perception be compared in a more direct and better controlled way? As for the

first question, we have shown that an important variable in Dutch sentence production is whether or not the first noun phrase refers to a human. If NP1 refers to a person, there is a preference to attach the relative clause to this host, just as in the reading data. However, if NP1 does not refer to a person, NP2 is the preferred host. Further research will have to indicate whether this also applies to reading (although preliminary data indicate that in this particular case it is often difficult to build well-controlled stimuli that are equally difficult/plausible and enable a clear disambiguation). At present, it is also unclear why the humanness of the second NP does not seem to influence the RC attachment. One possibility is that the preposition "of" does not introduce a new theta-domain. This would mean that only the head of the complex NP1-of-NP2 structure, namely NP1, would bear a thematic role frame. Further research will have to point out whether this explains why the humanness of the second NP is unimportant.

As for the second question, we have shown that exactly the same attachment pattern is obtained in a sentence continuation task as in the original corpus, provided the sentences are presented within a larger list that contains roughly two thirds of filler items. This makes it possible to directly compare reading and writing for the same stimulus materials and to compare attachment preferences for experimental sentences to those for the language in general (as estimated on the basis of corpora).

The results of the analyses presented here also allow us to reject Gibson and Schütze's (1999) hypothesis that sentence production is not influenced by a factor favouring high attachment. Our results indicate that this is not true for sentences containing a complex head with a human NP1. In two corpus analyses and two sentence completion studies, these materials consistently induced a high attachment preference. This means that not only locality considerations are playing a role in the production of these sentences, but that another factor favouring high attachment must be involved as well. This could either be the predicate proximity factor as suggested by Gibson et al. (1996) or a discourse variable (see later).

Finally, it might be concluded that our results also salvage the tuning hypothesis as there is a level of analysis (a grain) at which the reading data correspond to the corpus data. However, although the tuning hypothesis leaves open the possibility of such a grain (Mitchell et al., 1995), this is clearly a post hoc adaptation. In addition, the tuning hypothesis was basically conceived as a structural theory, with the parser tuning to frequencies of structures, not to characteristics of the individual words. So, saying that the parser tunes differently to human nouns than to non-human nouns extends the tuning theory in ways that depart from its original conception.

Rather, it would seem that the human/non-human distinction is a distinction more in line with discourse interpretations. Apparently, our understanding of RC attachment in Dutch sentence production (and possibly reading) is more likely to be advanced if in the future we focus on discourse variables than if we remain within the syntactic domain. A similar conclusion was reached by Gilboy et al. (1995), Frazier and Clifton (1996), Traxler et al. (1998), and Hemforth et al. (2000). Of course, as noted by Gilboy et al., a shift from syntax to discourse does not discharge us from the need to find out which factors govern RC attachment to complex heads; it just means that structures like Sentence 1 may have less to say about the functioning of the human sentence parser than once thought.



## REFERENCES

- Altmann, G., & Steedman, M. (1988). Interaction with context during human sentence processing. *Cognition*, *30*, 191–238.
- Baccino, T., De Vincenzi, M., & Job, R. (2000). Cross-linguistic studies of the Late Closure Strategy: French and Italian. In M. De Vincenzi & V. Lombardo (Eds.), *Cross-linguistic perspectives on language processing* (pp. 89–118). Dordrecht, The Netherlands: Kluwer Academic Publishers.
- Brybaert, M., & Mitchell, D.C. (1996). Modifier attachment in sentence processing: Evidence from Dutch. *The Quarterly Journal of Experimental Psychology*, *49A*, 664–695.
- Brybaert, M., & Mitchell, D.C. (2000). The failure to use gender information in parsing: A comment on van Berkum, Brown, and Hagoort (1999). *Journal of Psycholinguistic Research*, *29*, 453–466.
- Carreiras, M., & Clifton, C. (1993). Relative clause interpretation preferences in Spanish and English. *Language and Speech*, *36*, 353–372.
- Carreiras, M., & Clifton, C. (1999). Another word on parsing relative clauses: Eyetracking evidence from Spanish and English. *Memory and Cognition*, *27*, 826–833.
- Chomsky, N. (1965). *Aspects of the theory of syntax*. Cambridge, MA: MIT Press.
- Crain, S., & Steedman, M. (1985). On not being led up the garden path: The use of context by the psychological parser. In D.R. Dowty, L. Karttunen, & A.M.N. Zwicky (Eds.), *Natural language parsing* (pp. 320–358). Cambridge: Cambridge University Press.
- 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.
- Cuetos, F., Mitchell, D.C., & Corley, M.M.B. (1996). Parsing in different languages. In M. Carreiras, J.E. Garcia-Albea, & N. Sebastian-Galles (Eds.), *Language processing in Spanish* (pp. 145–187). Hillsdale, NJ: Lawrence Erlbaum Associates, Inc.
- Desmet, T., De Baecke, C., & Brybaert, M. (in press). The influence of referential discourse context on modifier attachment in Dutch. *Memory and Cognition*.
- De Vincenzi, M., & Job, R. (1993). Some observations on the universality of the Late Closure strategy. *Journal of Psycholinguistic Research*, *22*, 189–206.
- De Vincenzi, M., & Job, R. (1995). An investigation of Late Closure: The role of syntax, thematic structure and pragmatics in initial and final interpretation. *Journal of Experimental Psychology: Learning, Memory and Cognition*, *21*, 1305–1321.
- Ehrlich, K., Fernandez, E., Fodor, J.D., Stenshoel, E., & Vinereanu, M. (1999, March). *Low attachment of relative clauses: New data from Swedish, Norwegian and Romanian*. Poster presented at the 12th Annual CUNY conference on Human Sentence Processing, New York, USA.
- Fernandez, E.M. (1998). Language dependency in parsing: Evidence from monolingual and bilingual processing. *Psychologica Belgica*, *38*, 197–230.
- Fodor, J.D. (1998). Learning to parse? *Journal of Psycholinguistic Research*, *27*, 285–319.
- Frazier, L. (1978). *On comprehending sentences: Syntactic parsing strategies*. Unpublished doctoral dissertation, University of Connecticut, Storrs, CT, USA.
- Frazier, L. (1987). Sentence processing: A tutorial review. In M. Coltheart (Ed.), *Attention and performance XII* (pp. 559–585). Hove, UK: Lawrence Erlbaum Associates Ltd.
- Frazier, L., & Clifton, C. (1996). *Construal*. Boston: MIT Press.
- Frenck-Mestre, C., & Pynte, J. (2000). Resolving syntactic ambiguities: Cross-linguistic differences? In M. De Vincenzi & V. Lombardo (Eds.), *Cross-linguistic perspectives on language processing* (pp. 119–148). Dordrecht, The Netherlands: Kluwer Academic Publishers.
- Gibson, E., Pearlmutter, N.J., Canseco-Gonzales, E., & Hickok, G. (1996). Recency preference in the human sentence processing mechanism. *Cognition*, *59*, 23–59.
- Gibson, E., Pearlmutter, N.J., & Torrens, V. (1999). Recency and lexical preferences in Spanish. *Memory and Cognition*, *27*, 603–611.
- Gibson, E., & Schütze, C.T. (1996, March). *The relationship between the frequency and the perceived complexity of conjunction attachments: On-line evidence*. Poster presented at the 9th Annual CUNY Conference on Human Sentence Processing, New York, USA.

- Gibson, E., & Schütze, C.T. (1999). Disambiguation preferences in noun phrase conjunction do not mirror corpus frequency. *Journal of Memory and Language*, *40*, 263–279.
- Gibson, E., Schütze, C.T., & Salomon, A. (1996). The relationship between the frequency and the complexity of linguistic structure. *Journal of Psycholinguistic Research*, *25*, 59–92.
- Gilboy, E., Sopena, J.M., Clifton, C., & Frazier, L. (1995). Argument structure and association preference in Spanish and English complex NPs. *Cognition*, *54*, 131–167.
- Hemforth, B., Konieczny, L., & Scheepers, C. (2000). Syntactic attachment and anaphor resolution: Two sides of relative clause attachment. In M. Crocker, M. Pickering, & C. Clifton (Eds.), *Architectures and mechanisms for language processing* (pp. 259–281). Cambridge: Cambridge University Press.
- Henstra, J. (1996, September). *Relative clause attachment in English: Eye-tracking versus self-paced reading*. Poster presented at AMLaP–96, Turino, Italy.
- Igoa, J.M., Carreiras, M., & Meseguer, E. (1998). A study on late closure in Spanish: Principle-grounded versus frequency-based accounts of attachment preferences. *Quarterly Journal of Experimental Psychology*, *51A*, 561–592.
- Kimball, J. (1973). Seven principles of surface structure parsing in natural language. *Cognition*, *2*, 15–47.
- MacDonald, M.C., Pearlmutter, N.J., & Seidenberg, M.S. (1994). The lexical nature of syntactic ambiguity resolution. *Psychological Review*, *101*, 676–703.
- Mitchell, D.C., & Brylsbaert, M. (1998). Challenges to recent theories of crosslinguistic variation in parsing: Evidence from Dutch. In D. Hillert (Ed.), *Syntax and semantics: A crosslinguistic perspective* (pp. 313–335). San Diego, CA: Academic Press.
- Mitchell, D.C., Brylsbaert, M., Grondelaers, S., & Swanepoel, P. (2000). Modifier attachment in Dutch: Testing aspects of Construal Theory. In A. Kennedy, R. Radach, D. Heller, & J. Pynte (Eds.), *Reading as a perceptual process* (pp. 493–516). Oxford: Elsevier.
- Mitchell, D.C., & Cuetos, F. (1991). The origins of parsing strategies. In C. Smith (Ed.), *Current issues in natural language processing*. Austin: University of Texas, Centre for Cognitive Science.
- Mitchell, D.C., Cuetos, F., Corley, M.M.B., & Brylsbaert, M. (1995). Exposure-based models of human parsing: Evidence for the use of coarse-grained (nonlexical) statistical records. *Journal of Psycholinguistic Research*, *24*, 469–488.
- Mitchell, D.C., Cuetos, F., & Zagar, D. (1990). Reading in different languages: Is there a universal mechanism for parsing sentences? In D. Balota, G.B. Flores d'Arcais, & K. Rayner (Eds.), *Comprehension processes in reading* (pp. 285–302). Hillsdale, NJ: Lawrence Erlbaum Associates, Inc.
- Miyamoto, E.T. (1998). *Relative clause processing in Brazilian Portuguese and Japanese*. Unpublished doctoral dissertation, MIT, Cambridge, MA.
- Pynte, J., & Frenck-Mestre, C. (1996, September). *Evidence for early-closure attachments on first-pass reading times in French: A replication*. Poster presented at AMLaP–96, Turino, Italy.
- Spivey-Knowlton, M., & Sedivy, J.C. (1995). Resolving attachment ambiguities with multiple constraints. *Cognition*, *55*, 227–267.
- Thornton, R., MacDonald, M.C., & Gil, M. (1999). Pragmatic constraint on the interpretation of complex noun phrases in Spanish and English. *Journal of Experimental Psychology: Learning, Memory and Cognition*, *25*, 1347–1365.
- Traxler, M.J., Pickering, M.J., & Clifton, C. (1998). Adjunct attachment is not a form of lexical ambiguity resolution. *Journal of Memory and Language*, *39*, 558–592.
- Wijnen, F. (1998, March). *Dutch Relative Clause Attachment in Two- and Three-site Contexts*. Poster presented at the 11th Annual CUNY Conference on Human Sentence Processing, New Brunswick, NJ, USA.
- Zagar, D., Pynte, J., & Rativeau, S. (1997). Evidence for early closure attachment on first-pass reading times in French. *Quarterly Journal of Experimental Psychology*, *50A*, 421–438.