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ABSTRACT

This study, consisting of two experiments, investigated the role of verb information in resolving ambiguous noun phrases (NPs) in reading comprehension. Both experiments extended earlier studies. The first measured and compared reading time for sentences containing temporarily ambiguous subject complements and unambiguous complements, which were preceded by NP- or subject-biased verbs. Subjects were 24 university students, undergraduates and graduates fluent in American English. In the second experiment, new conditions were added; reading time was measured on sentences containing temporarily ambiguous NP complements and containing ambiguous subject complements and unambiguous complements, also preceded by NP- or subject-biased verbs. Subjects were 36 university students, undergraduates and graduates fluent in American English. In each experiment, the length of ambiguous NP was independently varied by the presence or absence of a following modifier. Results of both experiments support the filtering view; when readers encountered ambiguous NPs, they minimally attached the ambiguous NPs as NP complements and later used verb information to evaluate and possibly filter this analysis. Contains 28 references. (MSE)

The Role of Verb Information in Syntactic Ambiguity Resolution*

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1. Introduction

In the last two and a half decades, there has been an increasing interest in how information associated with verbs is used during language comprehension (see Ferreira & Henderson, 1991a; MacDonald, Pearlmutter, & Seidenberg, 1994; Mitchell, 1987; Trueswell & Tanenhaus, 1994 for reviews). Verb information, i.e., verb-specific lexical structure, is assumed to be part of each language user's knowledge of language, and because it is not fully predictable from the meaning of a verb, it is also assumed to be acquired. The present paper presents two experiments that investigated whether readers' resolution of temporarily ambiguous noun phrases is influenced by verb information. Noun phrases were ambiguous between noun phrase complements (NP complements, e.g., "The students knew the answer by heart.") and subjects of tensed sentence complements (S complements, e.g., "The students knew the answer was correct."). Noun phrases were preceded either by verbs that occur most frequently with NP complements (NP-biased verbs) or by verbs that occur most frequently with S complements (S-biased verbs).

Several, otherwise different theories assume that verb information can guide the initial processing of ambiguous phrases, e.g., constraint satisfaction (MacDonald, 1994; MacDonald, Pearlmutter, & Seidenberg, 1994a; 1994b; Trueswell & Tanenhaus, 1994; Trueswell, Tanenhaus, & Kello, 1993) and the licensing theories of Abney (1987; 1989), Pritchett (1991; 1992), and others. Constraint satisfaction, the most successful of these theories, assumes that during comprehension, multiple constraints weight the possible alternative analyses of an ambiguous phrase. The most highly weighted alternative determines which analysis is constructed. MacDonald (1994) suggested how verb information may be

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used as a constraint in her partial activation hypothesis, which assumes that when a verb is comprehended, the syntactic structures in which the verb can occur become activated in parallel, according to their frequency of usage with that verb. These structures become candidate analyses and can guide the resolution of a following ambiguous phrase.

Other researchers, most notably advocates of the Garden Path Model (Ferreira & Clifton, 1986; Frazier, 1978; Frazier, 1987; 1989; Frazier & Fodor, 1978; Frazier & Rayner, 1982; Rayner, Carlson, & Frazier, 1983), assume that verb information plays a limited role in ambiguity resolution, influencing processing only after the selection of an syntactically-driven analysis. Syntactic parsing principles, such as minimal attachment, are applied initially to resolve ambiguous phrases. Minimal attachment assumes the selection of the least syntactically complex, possible analysis. Verb information may be used to evaluate the initial analysis, and in some cases, act as a "filter", leading to its rejection (see lexical filtering, Clifton, Speer, & Abney, 1991; Ferreira & Henderson, 1990; Frazier, 1987). Verb information may also be during syntactic revision to guide the selection of an alternative analysis (Rayner, Carlson, & Frazier, 1983).

There has been empirical evidence to support both the view that verb information guides ambiguity resolution and the view that verb information does not guide ambiguity resolution. Consider the case of the NP complement/S complement ambiguity. There have been three notable investigations, which have yielded contradictory evidence (Ferreira & Henderson, 1990; Holmes, Stowe, & Cupples, 1989; and Trueswell, Tanenhaus, & Kello, 1993). Each of these studies tested the same experimental design. NPs occurred in either ambiguous (No-'that') or unambiguous ('that') S complements (see 1), preceded by NP-biased verbs (e.g., "forgot"), or S-biased verbs (e.g., "hoped"). Holmes et al. (1989) and Trueswell

(1) a. The student forgot (that) the solution was in the back of the book.
    b. The student hoped (that) the solution was in the back of the book.

et al. (1993) provided evidence that verb information influenced how readers resolve ambiguous noun phrases. In NP-biased verb conditions, reading time at the disambiguating complement verb ("was in the") was longer in ambiguous (No-"that") S complements than in unambiguous ("that") S complements, and in S-biased verb conditions, initial reading time did not significantly differ between ambiguous and unambiguous S complements. These results suggested that in NP-biased verb conditions, readers initially analyzed ambiguous NPs as NP complements and later performed a revision, but in S-biased verb conditions, readers initially analyzed ambiguous NPs as subject NPs of S complements. In contrast, Ferreira and Henderson (1990) observed longer initial reading time in ambiguous S complements as compared with unambiguous S complements for both verb types, suggesting that readers generally analyzed ambiguous NPs as NP complements and performed revisions for both NP- and S-biased verb conditions.

The aim of the present research was to extend this prior research. The two experiments that are presented provide important new evidence which supports the claim that verb information does not always guide resolution of ambiguous phrases. Experiment 1 tested an experimental design similar to that used in each of the prior investigations. Reading time was measured on sentences containing temporarily ambiguous S complements and unambiguous S complements, which were preceded by NP- or S-biased verbs. In Experiment 2, new conditions were added. Reading time was measured on sentences containing temporarily ambiguous NP complements, and containing ambiguous S complements and unambiguous S complements, which were also preceded by NP- or S-biased verbs.

Each experiment also involved an additional manipulation. The length of the ambiguous NP was independently varied, by the presence or absence of a following modifier. Prior investigations have shown that longer ambiguous regions were either associated with larger (Ferreira & Henderson, 1991b; Frazier & Rayner, 1982; Kennedy & Murray, 1984) or smaller differences in processing difficulty on a subsequent disambiguating regions (Holmes et al., 1989). However, in the experiments reported in this paper, NP length did not significantly influence reading time differences between ambiguous and unambiguous complements and consequently will not be discussed. Readers are referred to Kennison (1995) for a complete report.

2. Experiment 1

Eye tracking was used to measure reading time on forty experimental sentences, which were similar to the example sentence displayed in Table 1. As the collection of eye movement data occurred throughout a trial, a reader's first pass through the sentence and any rereading that occurred was analyzed separately. First pass reading time was defined as the sum of all fixations in a region from the time of first entering the region to the time of first leaving the region. Total reading time was defined as the sum of all fixations in a region. Analysis regions are indicated by '|' symbols in Table 1.

Table 1
Sample Stimulus from Experiment 1

NP-Biased Verb
The waiter | confirmed | (that) | the reservation | was made | by a woman.

S-biased Verb
The waiter | insisted | (that) | the reservation | was made | by a woman.

The view that verb information guides ambiguity resolution (hereafter the verb guidance position) predicts that differences in processing difficulty should occur between ambiguous and unambiguous S complements in NP-biased verb conditions, but should not occur in S-biased verb conditions. The view that verb information does not guide ambiguity resolution, but may be used to filter initial minimal attachments (herafter the filtering position) predicts that differences in processing difficulty should occur between ambiguous and unambiguous S complements for both NP- and S-biased verb conditions.

2.1. Method

2.1.1. Participants

Twenty-four undergraduate and graduate students at the University of Massachusetts, who had normal or corrected vision, were fluent in American English, and were naive to the purpose of the experiment, participated for course credit or for $5.00.

2.1.2. Materials

Table 2. displays the frequencies of NP complements and S complements for the NP- and S-biased verbs used in the experiment. These frequencies were assessed using verb preference questionnaires following Connine, Ferreira, Jones, Clifton, and Frazier (1984). A complete list of the 40 experimental sentences is provided in Kennison (1995b). There were 100 filler sentences. Forty fillers contained verbs that permitted both NP or S complements and that were followed by NP complements. Eight counterbalancing lists were used, so that each item was viewed equally often in each condition across participants.

Table 2
Summary of Verb Statistics for Experiment 1

	NP Complements	S Complements
NP-Biased	76%	7%
S-Biased	13%	70%

2.1.3. Apparatus

Eye movements were recorded by a Stanford Research Institute Dual Purkinje Eye tracker, which has a resolution of less than 10 minutes of arc. Viewing was binocular with eye position recorded from the right eye. The eye tracker was interfaced with an 80486 microcomputer, which controlled the presentation of the sentences. Up to 80 character spaces per line were used. The characters were in lower-case, except where capital characters were called for (at the beginning of sentences and proper names). Participants were seated 62 cm from the monitor and 4 characters equaled one degree of visual angle. The luminance from the monitor was adjusted to a comfortable brightness level for the participant and then held constant throughout the study, and the room was dark.

2.1.4. Procedure

For each participant, a bite-bar was constructed to minimize head movements during the experiment. The eye tracking system was then calibrated. This procedure required the participant to fixate nine markers sequentially (three markers on the top, middle, and bottoms rows of the computer screen). The voltage was recorded and interpolated for the intervening columns and rows. Before each trial, the calibration was checked and repeated, if necessary. All experimental sentences were presented on a single line. Comprehension questions appeared in the lower half of the computer screen. After incorrect responses, the word "ERROR" appeared on the computer screen. Fifty percent of sentences had comprehension questions. The participant read 10 practice sentences followed by 140 experimental sentences (i.e., forty-eight experimental sentences and 82 fillers). Each session lasted between 30-50 minutes.

2.2. Results and Discussion

Following the recommendations of Rayner, Sereno, Morris, Schmauder, and Clifton (1989), fixations shorter than 80 ms in duration and only one character away from the prior or next fixation were merged with that fixation. Fixations shorter than 40 ms and less than three characters away from the prior or next fixation were deleted. Remaining individual fixations longer than 1000 ms or shorter than 50 ms were deleted. First pass reading time and total reading time in milliseconds were analyzed and ANOVAs were conducted[1] .

2.2.1. First Pass Reading Time

2.2.1.1 Disambiguating Complement Verb Region

Table 3 displays mean first pass reading time on the disambiguating complement verb region in milliseconds. The disambiguating verb region took longer to read in ambiguous than in unambiguous S complements for NP-biased verb conditions, significant by subjects and marginally significant by items, $F_1(1,23)=9.79$, $p < .005$, $F_2(1,38)=3.24$, $p < .08$, and for S-biased verb conditions, the difference approached, but failed to reach significance in the subjects analysis, $F_1(1,23)=3.84$, $p < .07$, $F_2(1,38)=1.26$, $p < .27$. The verb x ambiguity interaction was not significant.

Table 3
Mean First Pass Reading Time on the Disambiguating Complement Verb Region in Milliseconds

	Ambiguous (No-"that")	Unambiguous ("that")
NP-Biased Verb	418	370
S-biased Verb	381	363

[1] One item was excluded due to a typographical error.

2.2.1.2 Ambiguous Noun Phrase Region

Table 4 displays mean first pass reading time on the ambiguous noun phrase region in milliseconds. The pattern of results was the opposite of that observed on the disambiguating verb region. First pass reading time on the ambiguous noun region was longer in ambiguous than in unambiguous S complements for S-biased verb conditions, significant by subjects, $F_1(1,23)=4.91$, $p < .04$, $F_2(1,38)=2.67$, $p < .10$, but was not for NP-biased verb conditions. The verb type x ambiguity interaction was significant by subjects, $F1(1,23)=4.91$, $p < .04$, $F2(1,38)=2.93$, $p < .10$.

Table 4
Mean First Pass Reading Time on the Ambiguous
Noun Phrase Region in Milliseconds

	Ambiguous (No-"that")	Unambiguous ("that")
NP-Biased Verb	389	396
S-biased Verb	406	387

2.2.1.3 Complementizer Region

Table 5 displays mean first pass reading time on the complementizer 'that' (after missing cells in the subjects and items means were replaced following Myers and Well (1991)). First pass reading time on the word 'that' was not significantly influenced by verb type, $F_1(1,16)=1.23$, $p < .28$, $F_2(1,27)=3.46$, $p < .08$. First pass reading time on other regions of unambiguous S complements was also not significantly influenced by verb type.

Table 5
Mean First Pass Reading Time on the Complementizer
in Milliseconds

	Unambiguous ("that")
NP-Biased Verb	270
S-biased Verb	257

2.2.1.4 Summary

The results of first pass reading time are compatible with either verb guidance or filtering. Verb guidance and filtering predict that readers should have difficulty in ambiguous (No-"that") NP-biased verb conditions (as compared with unambiguous ("that") conditions) at the disambiguating complement verb region, either because they used verb information to analyze the noun phrase as an NP complement or because they followed minimal attachment to analyze the noun phrase as an NP complement. The sentence continuation does not support the NP complement analysis, and a revision has to be made, presumably at the disambiguating complement verb region. For S-biased verb conditions, verb guidance predicts that readers should analyze the noun phrase as the subject of an S complement. The sentence continuation supports this analysis, and a revision is not necessary at the disambiguating complement verb region. Longer reading time on the noun phrase in ambiguous than in unambiguous complement conditions could result when the syntactically complex S complement structure is instantiated (see Trueswell et al. 1993 for more details on this explanation). In contrast, filtering predicts that readers should analyze the noun phrase as an NP complement and later use verb information to evaluate and to filter this analysis. Filtering mayoccur when the noun phrase is read, resulting in longer reading time in ambiguous than in unambiguous S complement conditions. After filtering occurs, readers adopt an S complement analysis, which the sentence continuation supports. Consequently, reading time on the disambiguating verb region would not be expected to differ for ambiguous and unambiguous complement conditions.

2.2.2. Total Reading Time

2.2.2.1 Disambiguating Complement Verb Region

Table 6 displays mean total reading time on the disambiguating verb region. Total reading time was longer in ambiguous than in unambiguous S complements for NP-biased verbs, $F_1(1,23)=25.62$, $p < .001$, $F_2(1,38)=13.61$, $p < .001$, and for S-biased verbs, significant by subjects only, $F_1(1,23)=6.04$, $p < .03$, $F_2(1,38)=2.70$, $p < .11$. The verb type x ambiguity interaction was significant by subjects, $F_1(1,23)=6.84$, $p < .02$, $F_2(1,38)=1.60$, $p < .21$.

Table 6
Mean Total Reading Time on the Disambiguating Verb Region in Milliseconds

	Ambiguous (No-"that")	Unambiguous ("that")
NP-Biased Verb	568	467
S-biased Verb	485	452

2.2.2.2 Ambiguous Noun Phrase Region

Table 7 displays mean total reading time on the ambiguous noun phrase region. There were no significant results.

Table 7
Mean Total Reading Time on the Ambiguous Noun Phrase Region in Milliseconds

	Ambiguous (No-"that")	Unambiguous ("that")
NP-Biased Verb	483	477
S-biased Verb	516	477

2.2.2.3 Complementizer Region

Table 8 displays mean total reading time on the complementizer. Total reading time was longer for NP- than S-biased verb conditions, $F_1(1,17)=8.90$, $p < .007$, $F_2(1,38)=10.46$, $p < .003$. In other regions of unambiguous S complements, the effect of verb type was not significant.

Table 8
Mean Total Reading Time on the Complementizer in Milliseconds

	Unambiguous ("that")
NP-Biased Verb	290
S-biased Verb	276

2.2.2.4. Summary

Total reading time results suggest that readers experienced more difficulty in ambiguous than in unambiguous S complements for both NP- and S-biased verb conditions. As these differences occurred primarily because readers engaged in more rereading in ambiguous than ambiguous conditions, it is unlikely that the difficulty in S-biased verb conditions could be due to readers initially constructing an S complement, as could be suggested by the verb guidance view. However, these results are consistent with the filtering view. It is possible that filtering on the basis of lexical information in S-biased verb conditions did not occur on every trial. Consequently, there may have been S-biased verb trials, in which readers maintained an NP complement analysis and had to revise this analysis after the disambiguating verb region was read, at which time readers may have regressed to an earlier part of the sentence for reprocessing.

Experiment 1 did not test the ideal experimental design for distinguishing the verb guidance and filtering view. This ideal design would have included conditions in which ambiguous NPs were continued as both NP complements as well as S complements. This type of experimental design permits reading time on temporarily ambiguous S and NP complements to be compared. Verb guidance predicts that reading time would be longer when the initial verb guided analysis mismatches with the sentence continuation. Consequently, for NP-biased verb condition, the disambiguating regions of temporarily ambiguous S complements would take longer to read than the disambiguating regions of temporarily ambiguous NP complements, but for S-biased verb conditions, the disambiguating regions of NP complements would take longer to read than the temporarily ambiguous S complement regions. In contrast, lexical filtering predicts that readers would minimally-attach ambiguous NPs. Consequently, for both NP- and S-biased verb conditions, reading time on the disambiguating regions of temporarily ambiguous S complements should take significantly longer to read than the disambiguating regions of temporarily ambiguous NP complements. In contrast, filtering predicts that verb type would influence reading time in NP complement conditions only minimally, but would influence substantially reading time in ambiguous S complement conditions. The purpose of Experiment 2 was to test this experimental design.

3. Experiment 2

In Experiment 2, NPs occurred in emporarily ambiguous NP complements, temporarily ambiguous S complements, and unambiguous S complements, which were preceded by NP- or S-biased verbs. Table 9 displays a sample stimulus. The '|' symbols indicate analysis regions.

Table 9
Sample stimulus from Experiment 3

NP Complements

NP-Biased Verb
The athlete | revealed | his problem | because his parents | worried every single moment.

S-Biased Verb
The athlete | admitted | his problem | because his parents | worried every single moment.

Sentence Complements

NP-Biased Verb
The athlete | revealed | (that) | his problem | worried his parents | nearly every single moment.

S-Biased Verb
The athlete | admitted | (that) | his problem | worried his parents | nearly every single moment.

3.1 Method

3.1.1. Participants

Thirty-six undergraduate and graduate students at the University of Massachusetts, who had normal or corrected vision, were fluent in American English, and were naive to the purpose of the experiment, participated for course credit or for $5.00.

3.1.2. Apparatus

The same apparatus was used as in Experiment 1.

3.1.3. Procedure

The same procedure was used as in Experiment 1. Experimental sentences were presented on a maximum of three lines. For each item, the S- or NP-biased verb, temporarily ambiguous NP, and the disambiguating region occurred on the same line of text.

3.1.4. Materials

Forty-eight experimental sentences were constructed. Table 10 displays the frequencies of NP complements and S complements for NP- and S-biased verbs. Twelve versions of each experimental sentence were constructed. NP complement conditions were always disambiguated by a conjunction (e.g. 'because', 'even though', 'although'), which signaled the beginning of a subordinate clause. The disambiguating regions of NP and S complements were always three words, closely matched in length and printed frequency across NP and S complement conditions. Twelve counterbalancing lists were used so that each item was viewed equally often in each condition. A complete list of experimental sentences is provided in Kennison (1995). Ninety fillers sentences were used. Thirty-two of these were foils, which were sentences containing temporarily ambiguous NPs continued as NP complements.

Table 10
Summary of Verb Statistics for Experiment 2

	NP complements	S complements
NP-Biased	69%	13%
S-biased	26%	60%

3.2. Results and Discussion

The data were trimmed in the same manner as in Experiment 1. First pass and total reading time in milliseconds were analyzed for each analysis region. The results of these analyses were similar across both measures. Consequently, these results are discussed concurrently.

3.2.1 Disambiguating Regions

Table 11 displays mean first pass and total reading time on the complement verb region of ambiguous and unambiguous S complements. First pass reading time was significantly longer in ambiguous than in unambiguous S complements for both NP- and S-biased verb conditions, $\underline{F}_1(1,35)=15.64$, $\underline{p} < .001$, $\underline{F}_2(1,47)=14.10$, $\underline{p} < .001$. and, $\underline{F}_1(1,35)=11.57$, $\underline{p} < .002$, $\underline{F}_2(1,47)=9.36$, $\underline{p} < .004$, respectively. Total reading time was significantly longer in ambiguous S complements than in unambiguous S complements for both NP-biased verb conditions, $\underline{F}_1(1,35)=13.71$, $\underline{p} < .001$, $\underline{F}_2(1,47)=18.45$, $p < .001$, and S-Biased verb conditions, $\underline{F}_1(1,35)=11.37$, $\underline{p} < .002$, $\underline{F}_2(1,47)=24.05$, $\underline{p} < .001$. The verb type x ambiguity interactions were not significant, $\underline{F}s < 1$.

Verb Information

Table 11
Mean First Pass (and Total) Reading Time on the Disambiguating Verb Regions of Ambiguous and Unambiguous S Complements in Milliseconds

	Ambiguous (No-"that")	Unambiguous ("that")
NP-Biased Verb	896 (1201)	816 (982)
S-biased Verb	883 (1141)	792 (964)

Table 12 displays mean first pass and total reading time on the disambiguating regions of ambiguous NP and S complements. On the disambiguating regions of temporarily ambiguous S complements, first pass reading time was significantly longer than on the disambiguating region of temporarily ambiguous NP complements for both NP- and S-biased verb conditions, $F_1(1,35)=57.07$, $p < .001$, $F_2(1,47)=30.54$, $p < .001$, and $F_1(1,35)=27.49$, $p < .001$, $F_2(1,47)=21.98$, $p < .001$, respectively, as was total reading time for both NP-biased verb conditions, $F_1(1,35)=64.97$, $p < .001$, $F_2(1,47)=55.49$, $p < .001$, and S-biased verb conditions, $F_1(1,35)=31.81$, $p < .001$, $F_2(1,47)=46.40$, $p < .001$. The verb type x sentence type interaction was not significant for either of these measures, Fs < 1.25. The main effect of sentence type was highly significant for first pass reading time, $F_1(1,35)=66.92$, $p < .001$, $F_2(1,47)=44.66$, $p < .001$; for total reading time, $F_1(1,35)=75.02$, $p < .001$, $F_2(1,47)=72.20$, $p < .001$.

Table 12
Mean First Pass (and Total) Reading Time on the Disambiguating Regions of Ambiguous NP and S Complements in Milliseconds

	Ambiguous S Complement	Ambiguous NP Complement
NP-Biased Verb	896 (1201)	702 (823)
S-biased Verb	883 (1141)	697 (818)

3.2.2 Ambiguous Noun Phrase Region

Table 13 displays mean first pass and total reading time on the ambiguous noun phrase region. First pass reading time was significantly longer in ambiguous than in unambiguous S complements for S-biased verb conditions, $F_1(1,35)=4.49$, $p < .05$, $F_2(1,47)=5.47$, $p < .03$, but did not for NP-biased verb conditions. Total reading time on the determiner-noun region was significantly larger in ambiguous than unambiguous S complement conditions for S-biased verb conditions, significant by items, $F_1(1,35)=3.23$, $p < .08$, $F_2(1,47)=6.62$, $p < .02$, but was not for NP-biased verb conditions, Fs < 1.02. The differences in first pass reading time between ambiguous and unambiguous S complements on the determiner-noun region was larger for S- than for NP-biased verbs conditions, the verb type x ambiguity interaction was significant by items, $F_1(1,35)=3.37$, $p < .08$, $F_2(1,47)=4.38$, $p < .05$. The verb type x ambiguity interaction for total reading time on the determiner-noun did not reach significance.

Table 13
Mean First Pass (and Total) Reading Time on the Ambiguous Noun Phrase Region in Milliseconds

	Ambiguous (No-"that")	Unambiguous ("that")
NP-Biased Verb	470 (706)	476 (678)
S-biased Verb	510 (708)	461 (638)

3.2.3 Complementizer Region

Table 14 displays mean first pass and total reading time on the complementizer region. Neither first pass reading time or total reading time was influenced by verb type. No other region of the unambiguous S complement was significantly influenced by verb type.

Table 14
Mean First Pass (and Total) Reading Time on the Complementizer Region in Milliseconds

	Unambiguous ("That")
NP-Biased Verb	191 (299)
S-biased Verb	211 (281)

3.2.4 Summary

These results are inconsistent with the verb guidance, which predicted that no processing difficulty in ambiguous versus unambiguous S complements for S-biased verb conditions and predicted increased greater processing difficulty in NP complement continuations versus S complement continuations for S-biased verb conditions. These results are consistent with filtering, which predicted that processing difficulty in ambiguous versus unambiguous S complements would occur for both verb types and which predicted that the disambiguating regions of S complements would be more difficult to process than the disambiguating regions of NP complements for both verb types.

4. Conclusion

The results of two reading experiments support the filtering view. When readers encountered ambiguous noun phrases, which were ambiguous between NP complements and the subjects of S complements, they minimally attached the ambiguous NPs as NP complements and later used verb information to evaluate and possibly filter this analysis.

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