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On the Temporal Course of Gap-Filling During Comprehension of Verbal Passives

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The work presented in this paper examines the time course of antecedent reactivation following movement gaps found in passive sentences. Using a cross-modal lexical priming technique, (re)activation of the subject noun phrase (NP) was examined at various critical points following the verb (near the posited gap) for verbal passive sentences and for active (control) sentences. Subjects made lexical decisions to visual targets that were presented at three locations during auditory sentence comprehension: immediately after the matrix verb, 500 msec after the verb, or 1000 msec after the verb. Responses to targets related to the subject NP were faster than those to controls during passive sentences (gap sentences), but not during active sentences (no-gap sentences), thus indicating that reactivation of the matrix subject did occur in the passive cases. Furthermore, the magnitude of the priming increased with distance and time from the verb, going from a nonsignificant trend at the verb to a highly significant effect at 1000 cosec following the verb. These results are discussed in terms of both formal and processing models of language.

INTRODUCTION

Issues concerning. the nature of coreferential relations among sentence constituents have come to play an increasingly important role in recent

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years both within formal and processing theories of language. Current formal theories of grammar can be distinguished, in part, by their differing proposals concerning the typology and distribution of coreferential entities within sentences. For processing theories, the critical issues center around the type of information (e.g., structural constraints, agreement constraints, etc.) that is recruited in successfully determining a particular coreferential relationship and the temporal course of processing involved in such a computation. The study reported here was designed to investigate the processes that assign an antecedent to one type of *implicit* anaphoric element (NP-trace) posited within one formal theory of grammar (government and binding (GB) theory; Chomsky, 1981, 1986). In particular, our goal was to examine the temporal course of, antecedent reactivation following instances of NP-trace, and to compare this pattern of activation with that previously observed following other referentially dependent entities.

A large array of evidence in the past decade or so has been taken to indicate that *explicit* coreferential entities (pronouns and reflexives) lead to a "reactivation" or "reaccessing" of their antecedents (see, e.g., Chang, 1980; Cloitre & Bever, 1988; Corbett & Chang, 1983; Dell, McKoon, & Ratcliff, 1983; MacDonald & MacWhinney, 1990). This reactivation has been assessed using several variations of a probe response task. Standardly in these tasks, subjects perform a recognition task in which they decide whether or not a probe word appeared in the preceding (or ongoing) sentence. For example, Corbett and Chang (1983) presented subjects with two-clause sentences containing two potential antecedents in the first clause and a subject pronoun in the second (e.g., "Ellen stole the ball from Sue and then she scored a basket"). An end-of-sentence recognition task indicated that responses to both potential antecedents of the pronoun (*Ellen and Sue*) were facilitated, relative to controls. These findings were interpreted as evidence that the occurrence of a pronoun in discourse leads to reactivation of a set of candidate antecedents (see also MacDonald & MacWhinney, 1990; Nicol, 1988; Nicol & Swinney, 1989).

More recently, a number of investigators have attempted to determine whether antecedents to *implicit* anaphoric entities posited by formal theories of language structure lead to a similar reactivation of their antecedents. These implicit entities, or *gaps,* represent empty positions within syntactic structure, resulting from the "movement" of a sentence constituent from its canonical (deep) position to a new (surface) position within the sentence. Consider, for example, sentences (1) and (2):

(1) John bought [the book]$_i$ that Mary read [e]$_i$.
(2) [John]$_i$ was reminded [e]$_i$ about the party by Bill.

Within GB theory, relative clause formation [as in (1)] results in movement of the logical object of the verb *read* from its canonical position after the verb to the head of the relative clause. Similarly, passivization [as in (2)] results in movement of the logical object of the verb *remind* from object position to subject position. In both cases, in order to maintain the canonical relationship of the verb to its object, the moved constituent is depicted as leaving a *trace* in its canonical position, and this trace shares a coreferential relation with its (moved) antecedent in a manner formally similar to the relation between overt coreferential entities and their antecedents. (In the examples above, the coreferential relationship is indicated by indices.[4]) Furthermore, for reasons internal to the theory, different forms of movement are claimed to result in distinct types of gaps. Question and relative clause constructions result in wh-trace, while passive and raising construction result in NP-trac.[5]

Since gaps are assumed to share a coreferential relationship with their antecedent, one reasonable prediction is that gaps will lead to a reactiviation of their antecedents, in much the same way that pronouns and overt anaphors lead to a reactivation of their antecedents. A number of studies have tested this prediction. For example, using a cross-modal priming paradigm, Swinney, Ford, Frauenfelder, and Bresnan (1988) examined activation patterns in response to wh-traces contained in relative clause constructions (e.g., "The policeman saw the *boy*$_i$ that the crowd at the party* accused [wh-trace]$_i$* of the crime"). Sentences were presented auditorily, and subjects made lexical decisions to visually presented word/nonword targets at the points indicated by the*. In the critical conditions, the visual targets were semantic associates of the antecedent to the wh-trace (the object of the verb: *boy*) or matched control words. In such conditions, facilitation of responses to targets related to the antecedent occurring at the point indicated by the wh-trace (i.e., in the gap), relative to responses to controls and relative to baseline measures, is taken to reflect reactivation of that antecedent at that point. Significant facilitation was observed immediately after, but not before the wh-trace,

[4] The antecedent to the gap in relative clause constructions is actually the relative pronoun *that* rather than the head of the relative. However, it is reasonable to assume that the relative pronoun inherits the semantics of the head of the relative, and for reasons of simplicity we depict it that way.

[5] We will use GB terminology throughout this paper for convenience even though it conflicts with other linguistic theories.

suggesting that there had been a rapid reactivation of the object at the gap position. (For much additional evidence about such wh-trace reactivation, see Garnsey, Tanenhaus, & Chapman, 1989; Nicol & Osterhout, cited in Nicol & Swinney, 1989; Tanenhaus, Boland, Garnsey, & Carlson, 1989).

Other researchers have examined antecedent reactivation in the types of movement constructions argued by GB theory to be involved in passive and raising structures (Bever & McElree, 1988; MacDonald, 1989; McElree & Bever, 1989). For example, MacDonald employed an end-of-sentence probe recognition task to measure antecedent reactivation in verbal passive constructions similar to (2) above. Subjects responded faster to the probe word when that word corresponded to the antecedent of the gap, suggesting that NP-trace also leads to reactivation of its antecedent (see also excellent pioneering and detailed work with this task by Bever & McElree, 1988; Bever, Straub, Shenkman, Kim, & Carrithers, 1989; Bever & McElree, 1988; Cloitre & Bever, 1988; McElree & Bever, 1989).

Such results are clearly consistent with the claim that implicit coreferential entities exist within sentences, and that they lead to a reactivation of their antecedents. However, several important questions remain unresolved. Most importantly, in that most of these tasks are end-of-sentence probes, they leave uncertain the actual point during processing when the reactivation takes place (i.e., when coreference is established). (Note that while a few of the probe experiments were carried on during sentence comprehension, the data obtained were quite equivocal with the only significant effects appearing in the error rate data, not in reaction time data.) Further, there is some reason to be concerned that the probe task may often reflect memorial* representation searches rather than perceptual processing. In the current study, we employed the cross-modal priming technique (Swinney, Onifer, Prather, & Hirschowitz, 1979) previously used by Swinney et al. (1988) and Nicol and Swinney (1989). This method has the advantage of being an on-line measure of activation that does not require an explicit check of memory prior to a response, and is one that is relatively unintrusive on normal compehension (up to the point of the presentation of the visual lexical target, of course), in that it does not require reflection about the sentence in terms of the target item.

There are compelling reasons, reflecting both formal and processing considerations, for being concerned with the relative time course of antecedent reactivation following instances of wh-trace and NP-trace, and, indeed, for anticipating considerable differences between the two. At the formal level, current theories of grammar propose differing analyses regarding movement-related gaps. Within GB theory, both wh-trace and NP-trace exist at the syntactic level and are linked to their antecedents by syntactic principles. In contrast, within generalized phrase structure grammar (GPSG; Gazdar, Klein, Pullum, & Sag, 1985) only wh-trace is syntactically realized and syntactically linked to its antecedent; the missing object in passive and raising constructions, treated as NP-trace in GB theory, is represented only at a semantic/interpretative level in GPSG and its more recent incarnations. If one assumes that syntactic representations are computed more rapidly than semantic/interpretative representations (cf. J. A. Fodor, 1983; Forster, 1979), then evidence that wh-trace leads to a more rapid reactivation of its antecedent than does NP-trace could be construed as support for the representational claims of GPSG (see J. D. Fodor, 1991, for intriguing and detailed discussions of this and related issues).

Processing considerations also lead to the prediction that antecedent reactivation will be more immediate following wh-trace than following NP-trace. In most cases, the existence of a wh-trace is unambiguously signalled long before the gap is actually encountered. For example, the presence of a relative pronoun in relative clause constructions indicates that the moved constituent is in a nonargument position within the sentence, and that a wh-trace is to be represented at some later point in the sentence. In contrast, the existence of NP-trace is typically not indicated until the passive morphology has been encountered just prior to the posited location of the gap, since the moved constituent is in an *argument position* within the sentence (see Nicol, 1988, for a detailed yet concise discussion of this issue). Hence, while the processing system might begin to actively *seek* a gap in sentences containing wh-trace as soon as the moved constituent is encountered, this might not be a reasonable strategy for sentences containing NP-trace .[6]

[6] Recent work suggests that reactivation of antecedents to several types of coreferential elements might be significantly delayed. Specifically, McElree and Bever (1989) used a probe recognition task to examine reactivation in sentences with the empty categories PRO and NP-trace, and explicit pronouns. Probe words were presented either directly after the referential entity or at the end of the sentence. Response times to probes that were part of the antecedent noun phrase were not faster than response times to controls at the early location for any of the entities examined, but were faster at the end of the sentence for all types of anaphoric entities. However, recent work involving the cross-modal priming method has indicated that candidate antecedents to pronouns are reactivated very rapidly after the pronoun has been encountered (Nicol, 1988; Nicol & Swinney, 1989). Hence, it is posible that the cross-modal priming method is, in some circumstances, more sensitive than the probe recognition task to antecedent activiation.

Thus, the current study was designed to examine two questions. First, can evidence of antecedent reactivation be obtained with tasks that do not require an explicit check of memory? Second, if such evidence is obtained, then what is the time course of antecedent reactivation?

METHOD

Subjects.

Sixty undergraduates participated for course credit. All subjects were native speakers of English. Twenty subjects were tested at each of three probe points.

Materials and Design

Twenty-four sentence pairs were constructed, with each pair comprised of an active and verbal passive version of the sentence (see Table I and appendix). The two versions in each pair of sentences differed only in the presence or absence of the passive morphology *(was* and *by).* These sentences were modified versions of the materials presented by Nicol and Osterhout (cited in Nicol and Swinney, 1989). In each sentence, both the noun in subject position and the postverbal noun represented distinct occupations (e.g., *doctor)* or titles (e.g., *duke*). The postverbal noun phrase was followed by an infinitival clause.

For each pair of experimental sentences, a pair of target words (always nouns) were selected. One of these target words was a semantic associate of the noun in subject position. The second target word did not have an obvious semantic relationship to any words in the sentences, and

Table I. Sample Materials Presented During the Experiment; Numbered Carets Indicate Approximate Probe Locations

Active sentence:

The dentist from the new medical center in town invited the actress to go the the party.

*1 *2 *3

related target: tooth

Verbal passive sentence:

The dentist from the new medical center in town was invited (t) by the actress to go to the party.

*1 *2 *3

related target: tooth

(*t*) = NP trace

was matched for length in letters, number of syllables, and frequency (as determined by the Kucera and Francis, 1967, norms) with the semantic associate. The entire set of experimental sentences and target words is listed in the appendix.

Sixty-eight filler sentences were also constructed. These varied in complexity, and included passive, cleft, and pseudocleft sentences. Forty-six of these filler sentences were paired with a pronounceable nonword letter string. The remaining 22 filler sentences were paired with a noun not highly related to any of the experimental material.

Two tape recordings were made from these materials. Each recording included one version (active or passive) of each of the 24 experimental sentence pairs, with active and passive variants being equally represented on each tape. Both recordings also included the 68 filler sentences, randomly interspersed among the experimental sentences. These materials were recorded on a TEAC reel-to-reel tape player by a practiced male speaker, speaking at a rate of approximately four syllables per second. A 1000-Hz signal was placed on the left channel of the tape coincident with the acoustic offset of the matrix verb in experimental sentences. In filler sentences, the signal was placed at random locations within each sentence, with the constraint that the signal was positioned no earlier than the third syllable and no later than the penultimate syllable in the sentence. These signals, inaudible to the subjects, initiated presentation of the visual target items, and started the response timing routines used to time subject responses. All timing and visual presentation was under computer control.

Procedure

Subjects were seated individually in semidarkened booths. Up to three subjects participated simultaneously. The taped sentences were binaurally presented over Nova Pro headphones, with approximately 2 sec separating successive sentences. Visual targets were presented on a CRT screen. Probe point (i.e., the location within the sentence at which the visual targets were displayed on the CRT) was manipulated in a between-subjects manner: Targets were presented either immediately after the offset of the matrix verb (i.e., concomitant with the presumed gap in passive sentences), 500 msec after the offset of the matrix verb, or 1000 msec after the matrix verb in each experimental sentence. Subjects were instructed to decide whether each visually presented target was a word or a nonword by pressing one of two buttons *(word* or *nonword)* as rapidly as possible. Subjects kept their hands on the response buttons and watched a fixation point throughout the procedure.

On 10 randomly selected trials, subjects were presented with an audible tone after a sentence. The tone indicated that the subjects were to write down the preceding sentence on a piece of paper provided by the experimenter. Approximately 30 sec intervened between the tone and the commencement of the experiment. The purpose of this secondary task was to encourage subjects to attend carefully to each sentence. Subjects' responses in this task were highly accurate and will not be discussed further.

RESULTS

Prior to data analysis, missing data points, erroneous responses, and response times greater than 3 standard deviations from a subject's mean response time were treated as errors and discarded. These procedures eliminated less than 10% of the data. Two analyses of variance were performed, one treating subjects as a random variable (F_1), and the second treating items as a random variable (F_2). In addition, planned comparison tests, in the form of pairwise two-tailed t-tests (treating subjects as a random variable), were performed to compare response times to semantic associates and controls for each condition of interest.

Table II presents mean response times to visual targets, collapsed over the probe location factor. A three-way ANOVA with one between-subjects factor (probe location) and two within-subject factors [sentence type (passive and active) and target type (associate vs. control)] revealed a significant main effect for target type, F_1 $(1, 48) = 13.04$, $p < 0.01$; $F_2(1, 60) = 4.95$, $p < .05$. This main effect was qualified by a significant interaction between target type and sentence type, $F_1(1, 48) = 4.23$, p = < .05; $F_2(1, 60) = 3.56$, $p = .06$. No other main effects or interactions approached significance. Planned comparisons indicated that, during passive sentences, subjects responded more quickly to targets related to

Table II. Mean Response Times (in msec) to Visual Targets, Collapsed Across Probe Point; Percent Correct Responses Indicated in Parentheses

	Target type		
	Associate	Control	Priming
Active sentences	631 (94)	635 (94)	4
Passive Sentences	614(92)	643 (92)	29°

P < .001.

the antecedent (filler) to the (trace) gap than they did to control targets $t(71) = -4.55, p < .001$. The difference in responses to associates and controls did not differ during the comprehension of active sentences, $t(71) < 1$.[7]

Although the triple interaction between target type, sentence type, and probe location was not reliable ($p > .1$ under both subjects and items analyses), inspection of mean response times collected at each of the three probe locations, presented in Table III, indicates that the overall priming effect observed during the comprehension of passive sentences was variable across probe locations. Specifically, the differences in response times to associates and controls were smallest

Table III. Mean Response Times (in msec) to Visual Targets at Each of Three Probe Points; Percent Correct Responses Indicated in Parentheses

	Target type		
Probe location	Associate	Control	Priming
Immediate			
Active sentences	592(97)	600(93)	8
Passive Sentences	589(89)	607(92)	18
500-msec delay			
Active sentence	657(95)	654(94)	-3
Passive Sentences	637(93)	661 (92)	24
1000-msec delay			
Active sentences	645 (91)	653(94)	8
Passive Sentences	615 (94)	661(92)	46*

*p < .001

[7] Some mention should be made of the fact that the final probe point occurs in the vicinity of an infinitival clause. Within GB theory, the missing subject in such clauses is a third type of gap (PRO), also realized syntactically and indexed with an antecedent via syntactic principles. Furthermore, in the passive constructions used here PRO and NP-trace share a common antecedent. Hence, one possibility is that PRO, and not NP-trace, is leading to a reactivation of the antecedent NP. However, close inspection of the stimuli indicated that on all trials the visual probe word appeared prior to the infinitival marker *to*. It is currently unknown to what extent responses to such probes during a cross-modal experiment can be influenced by material that comes after presentation of the probe. It is also currently unclear how rapidly antecedents to PRO are retrieved. Osterhout and Nicol (cited in Nicol & Swinney, 1989), using similar materials and a cross-model task identical to the one used in the current study, found evidence that antecedents to PRO are not reactivated until at least 500 msec after the infinitival marker has been encountered. This delay would suggest that the current evidence of antecedent activation is in fact due to the object gap (NP-trace) and not the subject gaps associated with the infinitival clause.

immediately after the matrix verb (18 msec) and largest 1000 msec after the matrix verb (46 msec). Planned comparisons of response times to associates and controls for each sentence type, at each probe location, were performed. At the early location (immediately subsequent to the offset of the matrix verb), responses to semantic associates were 18 msec faster on average than responses to controls in passive sentences. This difference did not reach significance, $t(19) = -1.75$, $p = .10$ Nor was the 24-msec priming effect observed at the 500-msec probe point reliable under standard accepted levels of significance, $t(19) = -1.86$, $p = .08$. However, the 46-msec effect observed at the 1000-msec probe point was reliable, $t(19) = -5.00$, $p < .001$. Furthermore, the magnitude of priming was significantly greater at the 1000-msec probe point than at the 0-msec probe point, $t(38) = -2.20$, $P = .03$. Planned comparisons of response times to associates and controls presented during the comprehension of active sentences found no reliable effects, $p > .3$ in all comparisons.

DISCUSSION

This paper briefly reported additional evidence that one type of implicit anaphoric entity proposed by GB theory (NP-trace) leads to a reactivation of its antecedent during sentence comprehension. This evidence is consistent with previous claims that such entities have representational reality within the comprehension system (Bever and McElree, 1989; MacDonald, 1989; McElree & Bever, 1989; Nicol, 1988; Nicol & Swinney, 1989). Furthermore, this reactivation does not depend on the explicit check of memory inherent in the probe recognition task. Instead, given the more uncompromised properties of the CMLP task used here, it appears safe to argue that antecedent reactivation found in these structures occurs as the result of automatic perceptual (comprehension) processes initiated by the occurrence of the NP-trace. Finally, the results reported here tentatively indicate that antecedent reactivation has a measurable temporal course. Responses to targets related to the antecedent of NP-trace were primed to some extent immediately after and 500 msec after the posited location of NP-trace. However, large and reliable effects were observed only at the probe location 1000 msec subsequent to the gap.

These findings allow one to speculate that important differences exist in the time course of antecedent reactivation following NP-trace and the implicit entity, wh-trace. In previous work employing similar materials and an identical methodology, researchers have observed significant priming of responses to targets related to the antecedent of wh-trace *immediately after* the posited occurrence of the gap (cf. Nicol, 1988, Nicol & Swinney, 1989). It is tempting to use these data to arbitrate between competing formal systems. Specifically, one explanation for these differences notes the differing status of passive and raising constructions within formal theories of language. As noted above, within GB theory such constructions involve movement of the object NP to subject position. The resulting gap is posited to exist at the level of syntactic structure (as well as at higher levels). In contrast, competing grammars (e.g., LFG and GPSG) do not invoke movement mechanisms to account for passive and raising constructions. The grammar deals with *such* relationships at functional and semantic levels, but not at the syntactic level. Hence, the discovered delay in the onset of significant priming of responses to targets related to the antecedent in passive sentences (relative to the speedy onset of such priming in sentences containing a relative clause) might reflect a distinction between gaps that are represented at a syntactic, structural level (which might lead to rapid antecedent reactivation), and those represented at a functional/semantic level (which might lead to slower antecedent reactivation). Such an interpretation favors grammars that posit a levels-of-representation distinction between NP-trace and wh-trace (e.g., LFG and GPSG) over grammars that do not (e.g., GB). (For far more detail about such predictions and arguments, see J. D. Fodor, 1991.)

However, an alternative interpretation of the time course differences found in this study as compared with those concerned with wh-trace has implications solely for processing theories of language comprehension. As noted above, the moved constituent in relative clause constructions sits in a nonargument position that clearly indicates the existence of an upcoming gap. In contrast, the moved constituent in passive constructions sits in an argument position and does not so clearly indicate the existence of an upcoming gap. The apparent rapid onset of antecedent activation in sentences with wh-trace, relative to NP-trace, might reflect the processor's sensitivity to this type of information. Similarly, it might be seen as evidence that filler-driven strategies hold for well-marked cases (as in the relative pronoun marking the moved objected in object-relative sentences), but that they have no force in poorly marked cases (as in NP-traces). Whatever the case, the data stand to argue that the processing device does deal somewhat differently in reactivating the antecedents (the moved arguments) in relative and passive constructions.

APPENDIX: SENTENCES PRESENTED DURING THE EXPERIMENT

Each sentence appeared in an active and passive form across lists. Semantic associates of the antecedent to NP-trace and matched control words are shown in parentheses.

1. The baker who had just moved into the neighborhood (was) asked (by) the woman to help out at the party. (cake, bolt)
2. The doctor from the small country in western Africa (was) urged (by) the queen to help the poor. (nurse, lodge)
3. The writer who was doing a piece on corporate crime (was) persuaded (by) the accountant to discuss the case. (story, hotel)
4. The heiress with the enormous estate just outside London (was) convinced (by) the sculpter to meet for tea the following afternoon. (rich, camp)
5. The nurse who was stationed on the seventh floor (was) invited (by) the chauffeur to go dancing this evening. (hospital, attitude)
6. The janitor of the large apartment building next door (was) bribed (by) the tenant to fix the leaky faucet. (clean, score)
7. The nephew of the former president of the company (was) invited (by) the artist to travel to the city for the opening. (niece, choir)
8. The detective who had been working behind the desk (was) persuaded (by) the journalist to talk about the case. (crime, grain)
9. The nun who was interested in group counseling (was) urged (by) the teacher to speak to the class about the matter. (pray, bark)
10. The ballerina who was in town for the performance (was) persuaded (by) the princess to meet for dinner the following evening. (dance, build)
11. The electrician from the department concerned with housing (was) convinced (by) the policeman to do something about the apartment building. (volt, pang)
12. The salesman who had recently worked for a large company (was) hired (by) the mechanic to deal with the equipment in the warehouse. (sell, path)
13. The duchess who was celebrating the birthday of an old friend (was) urged (by) the singer to propose a toast. (duke, hint)
14. The photographer working freelance for the agency (was) selected (by) the reporter to help out with the assignment. (camera, museum)
15. The student who always enjoyed a good murder mystery (was) advised (by) the banker to see the play at the theatre. (class, field)

16. The stewardess who had reluctantly quit working (was) convinced (by) the lawyer to discuss the case. (plane, scene)
17. The senator who was always involved in some scandal (was) forced (by) the waitress to leave the country. (congress, standard)
18. The duke who was vacationing for several weeks in England (was) advised (by) the judge to go to the opera. (king, base)
19. The tailor from the shops on the outskirts of town (was) hired (by) the plummer to work on the project. (sew, dip)
20. The swimmer who was visiting from San Diego, California, (was) urged (by) the girl to practice for the games. (dive, herd)
21. The general who had always enjoyed good food (was) asked (by) the maid to try the new dessert. (army, easy)
22. The cook from the town across the lake (was) convinced (by) the minister to help out at the picnic. (chef, sigh)
23. The farmer from the small town in western Idaho (was) bribed (by) the burglar to keep quiet. (tractor, plaster)
24. The dentist from the new medical center in town (was) invited (by) the actress to go to the party. (tooth, flood)

REFERENCES

Bever, T. G., & McElree, B. (1988). Empty categories access their antecedents during comprehension. *Linguistic Inquiry, 19,* 35-45.

Bever, T. G., Straub, K., Shenkham, K., Kim, J. J., & Carrithers, C. (1989). The psychological reality of NP-trace. *Proceedings of NELS*.

Chang, F. R. (1980). Active memory processes in visual sentence comprehension: Clause effects and pronominal reference. *Memory & Cognition, 8,* 58-64.

Chomsky, N. (1981). *Lectures on government and binding.* Dordrecht, The Netherlands: Foris.

Chomsky, N. (1986). *Knowledge of language.* New York: Praeger.

Cloitre, M., & Bever, T. G. (1988) Linguistic anaphors, levels of representation, and discourse. *Language and Cognitive Processes, 3,* 293-322.

Corbett, A., & Chang, F. (1983). Pronoun disambiguation: Accessing potential antecedents. *Memory & Cognition, 11,* 283-294.

Dell, G. S., McKoon, G., & Ratcliff, R. (1983). The activation of antecedent information during the processing of anaphoric reference during reading. *Journal of Verbal Learning and Verbal Behavior, 22,* 121-132.

Fodor, J. A. (1983). *Modularity of mind.* Cambridge, MA: MIT Press.

Fodor, J. D. (1991). Sentence processing and the mental grammar. In P. Sells, S. M. Shieber, & T. Wasow (Eds.), *Foundational issues in natural language.* Cambridge, MA: MIT Press.

Forster, K. I. (1979). Levels of processing and the structure of the language processor. In W. E. Cooper & E. C. T. Walker (Eds.), *Sentence processing.* Hillsdale, NJ: Erlbaum.

Gazdar, G., Klein, E., Pullum, G. K., & Sag, I. A. (1985). *Generalized phrase structure grammar.* Cambridge, MA: Harvard University Press.

Garnsey, S. M., Tanenhaus, M. K., & Chapman, R. M. (1989). Evoked potentials and the study of sentence comprehension. *Journal of Psycholinguistic Research, 18,* 51-60.

Kucera, H., & Francis, N. (1967). *Computational analysis of present-day English.* Providence, RI: Brown University Press.

MacDonald, M. C. (1989) Priming effects from gaps to antecedents. *Language and Cognitive Processes, 4,* 35-36.

MacDonald, M. C., & MacWhinney, B. (1990). Measuring inhibition and facilitation from pronouns. *Journal of Memory and Language,* 29, 469-492.

McElree, B., & Bever, T. G. (1989). The psychological reality of linguistically defined gaps. *Journal of Psycholinguistic Research, 18,* 21-36.

Nicol, J. (1988). *Coreference processing during sentence comprehension.* Unpublished doctoral dissertation, MIT.

Nicol, J. & Swinney, D. A. (1989). The role of structure on coreference assignment during sentence comprehension. *Journal of Psycholinguistic Research, 18,* 5-20.

Swinney, D., Ford, M., Frauenfelder, U., & Bresnan, J. (1988). *On the temporal course of gap filling and antecedent assignment during sentence comprehension.* Unpublished manuscript.

Swinney, D. A., Onifer, W., Prather, P., & Hirshkowitz, M. (1979). Semantic facilitation across sensory modalities in the processing of individual words and sentences. *Memory & Cognition, 7,* 159-165.

Tanenhaus, M. K., Boland, J., Garnsey, S., & Carlson, G. N. (1989). Lexical structure in parsing long-distance dependencies. *Journal of Psycholinguistic Research, 18,* 37-50.