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The Psychological Reality of Linguistically Defined Gaps

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In five experiments, recognition times for an adjective from a sentence-initial noun phrase were examined following the processing of coreferential gaps in syntactic structure as a means of determining whether linguistically defined gaps access their antecedents. Recognition latencies and/or error rates following the processing of gaps were found to be lower than a non-anaphoric control in a number of constructions, including two instances of constructions with NP-movement gaps—namely, the passive and raising-to-subject—and constructions with a PRO gap in an infinitival clause. Additionally, NP-movement gaps were found to produce lower latencies and error rates than PRO-gaps. The results are interpreted as evidence for the psychological reality of representational assumptions of Government and Binding Theory (Chomsky, 1981).

One feature of Government and Binding Theory (GB; Chomsky, 1981) that serves to distinguish it from other current grammatical theories is the existence of movement rules, in particular NP-movement. Such movement is critical to the manner in which GB captures the intuition that a noun phrase (NP) displaced from its canonical position nevertheless receives grammatical features (e.g., thematic role, agreement) from this position. For example, consider the passive and raising-to-subject constructions in (1) and (2), respectively.

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(1) *John$_i$* was hit [e_i] by Mary.
(2) *John$_i$* was certain [e_i] to leave.

GB assumes that in both structures the surface subject (*John*) carries the underlying thematic role marked by the missing argument (*e*), namely, the theme of the verb *hit* in (1) and the subject of the infinitival *to leave* in (2). For reasons internal to the theory, movement of the NP from the underlying structural position to the athematic subject position is mandatory and requires that a trace (*t*) is deposited in the extraction site. This trace is viewed as an implicit anaphor, which is linked to its antecedent NP through a chain.

In contrast to GB, a number of recent grammatical theories, such as Generalized Phrase Structure Grammar (GPSG; Gazdar, Klein, Pullum, & Sag, 1985) and Lexical Functional Grammar (LFG; Bresnan, 1978; Bresnan & Kaplan, 1982), among others, have proposed analyses of these constructions without assuming NP-movement. These alternative accounts postulate feature-passing mechanisms at either a functional (LFG) or a semantic (GPSG) level of representation that do not in and of themselves emphasize the purported anaphoric nature of such constructions. Since grammars that do not posit NP-movement are often presented as more plausible models of human sentence processing (e.g., Bresnan, 1978; Bresnan & Kaplan, 1982; Crain & Fodor, 1985), it is of some interest to attempt to isolate the types of processes recruited in the course of parsing these constructions—in particular, to examine whether they show evidence of anaphoric processing as suggested by GB.

The processing of constructions with implicit anaphoric relationships, typically referred to as filler-gap constructions, has been the focus of a growing body of psycholinguistic research. However, this research has almost exclusively examined instances of *wh* gaps and, to a lesser extent, obligatory PRO gaps associated with particular matrix verbs (see Experiment 1). One line of research has centered on issues concerning the potential difficulties associated with identifying filler-gap relationships during comprehension, particularly when multiple dependencies exist within a construction. Since an unbounded dependency may span an indefinite number of lexical items and may be subject to various degrees of ambiguity, this research has focused on the relative importance and independence of structural and lexical strategies that may aid in gap identification and filler assignment (Clifton & Frazier, 1986; Clifton, Frazier, & Connie, 1984; Crain & Fodor, 1985; Frazier, Clifton, & Randall, 1983; Wanner & Maratsos, 1978). A related line of research has sought to examine whether *wh* and PRO gaps show direct evidence of accessing their antecedents during comprehension. Tanenhaus, Carlson, and Seidenberg (1985) report pilot work suggesting that lexical decisions for a word phonologically related to the filler item are speeded relative to a control shortly after processing a gap. Similarly, Clifton and Frazier (1988) report that vocalization times for a high associate of the filler item are faster than for a low associate. In a series of studies, Swinney, Ford, Bresnan, and Frauenfelder (1988) have clearly demonstrated that lexical decisions for associates of an antecedent filler item are facilitated following the processing of *wh* gaps.

These latter studies suggest that *wh* and PRO gaps serve in comprehension as implicit anaphors in that they, like explicit anaphors, cause the reactivation of their antecedents. We report a series of studies that directly examine whether constructions that according to GB are derived from NP-movement similarly cause activation of their antecedents (see also Bever & McElree, 1988; McElree, 1985). The studies use a modification of a recognition probe task that has proved fruitful in examining issues concerning the activation of discourse antecedents following the processing of explicit anaphors (Chang, 1980; Cloitre, 1985; Dell, McKoon, & Ratcliff, 1983; McKoon & Ratcliff, 1980). In our version of the task, subjects are presented sentences to read in a self-paced manner. At some point following the region assumed to contain a gap, a probe word drawn from the antecedent NP is presented, and subjects are required to make a rapid (yes/no) recognition judgment. Direct evidence for activation of the antecedent following the processing of a gap is observed when reaction time and/or error rates are lower than those produced by an appropriate (nonanaphor) control construction. Since the studies we report differ only in terms of experimental stimuli, we present a general experimental method section and subsequently discuss the rationale and results for each experiment separately.

GENERAL METHOD

Subjects

The subjects were all Columbia University students who either participated in order to fulfill an introductory psychology course requirement (Experiments 1, 4, and 5) or were paid $5 for their participation (Experiments 2 and 3). All were native English speakers and none participated in more than one of the experiments. Thirty subjects were used in Experiments 1, 2, and 4, while 20 and 24 subjects were used in Experiment 3 and Experiment 5, respectively.

Materials

The experimental materials (see individual experiments) were divided into sets such that an equal number of critical sentences occurred in each set and no sentence was repeated within a set. The sets were counterbalanced across groups of subjects to ensure that each recognition probe occurred equally often in each condition. Following Cloitre (1985), the adjective from the sentence-initial noun phrase served as the recognition probe for all experimental sentences.

Each of the sets of experimental materials was combined with a set of 100 to 150 filler passages. To prevent subjects from anticipating the probe position in the experimental set, the passages were varied from one to three sentences in length. Each filler passage was associated with either a positive or a negative recognition probe. Positive probes were either a noun or a verb from varying positions in the passage in an attempt to keep subjects from paying special attention to the initial adjectives of the experimental set (see Cloitre, 1985).

Procedure

Stimulus presentation, timing, and response collection were all carried out by a TRS-80 model I computer. The stimuli were presented on a CRT screen using a standard character set (approximately 64 mm by 25 mm). The subjects read the sentences a section at a time, with each section presented in the center of an otherwise clear screen in a normal mixture of upper- and lower-case characters. The subjects paced themselves through the sentences by pressing the space bar after reading each section. At a point unknown to the subject, a press of the space bar initiated the presentation of the probe word. The probe word was presented in upper-case letters enclosed by two asterisks. It remained on the screen until the subject responded by pressing one of two keys designated as ''yes'' or ''no.''

Subjects were instructed to read the passages as they would normally read any text. To encourage them to do so, they were required to answer a ''yes/no'' comprehension question on approximately 1/4 of the trials. Subjects were instructed to respond to the probe word ''as quickly and accurately'' as they could.

Data Analysis

The mean recognition time for each experimental condition was calculated by including correct responses only, excluding response times that fell below or exceeded 2.5 standard deviations of a subject's average positive response. All statistical analyses (analyses of variance, t tests, and planned comparisons) were performed taking into account both subject and sentence variability separately. The results of both analyses are reported, with the former denoted by the subscript 1 (e.g., F_1) and the latter by the subscript 2 (e.g., F_2).

ANTECEDENT ACCESS FOLLOWING NP-RAISING AND PRO GAPS

Experiment 1

In the first experiment, we examined the recognition profile for a sentence-initial NP following the processing of constructions that according to GB contain a coreferent gap, comparing each with a control (nonanaphor) construction and a construction with an explicit pronoun. The materials are illustrated in Table I. Construction (1a) illustrates the constructions used to examine the effect of an obligatory PRO gap in the missing subject position of an infinitival clause. Construction (1b) examines the effect of what GB assumes is a gap or trace in the subject position of an embedded clause resulting from NP raising-to-subject. (1c), a so-called "tough" construction, examines the effect of a gap in the direct object position of an embedded clause. The fourth type of construction, (1d), uses a pronoun in the approximate place of the gap as a means of directly assessing the relative degree to which an explicit anaphor accesses its antecedent. These four types of constructions are contrasted against control constructions of the form illustrated in (1e). The controls consist of a single, main clause construction formed by converting the final verb in (2a–d), *argue,* into a related nominal form, *argument*: Otherwise, they are equal to the filler-gap constructions in terms of the sheer number of lexical items and are matched, as closely as possible, in terms of content items.

The constructions were presented to the subjects to read in sections denoted by the slashes in Table I. Two probe points, denoted by (P1) and (P2), were used. The first probe position (P1) occurred at the first point at which a subject could in principle detect the presence of a gap in constituent structure. The second probe position (P2) occurred 4 to 5 items after the gap, a point that potentially completes the final clause.

Fifty sentence frames consonant with each of the five forms in

Table I. Example Materials

	Experiment 1
PRO gap	1a. The stern judge/ who met with the defense/ adamantly refused [*PRO*] to (P1)/ argue about the appeal. (P2)
NP-raising gap	1b. The stern judge/ who met with the defense/ is sure [*t*] to (P1)/ argue about the appeal. (P2)
NP-tough gap	1c. The stern judge/ was difficult for the defense/ to argue with [*t*] about (P1)/ the pending appeal. (P2)
Explicit pronoun	1d. The stern judge/ who met with the defense/ thought he should (P1) / argue about the appeal. (P2)
Control	1e. The stern judge/ who met with the defense/ flatly rejected the (P1) / arguments for an appeal. (P2)
	Recognition probe: stern
	Experiment 2
PRO gap	2a. The conceited actor/ who worked with the leading lady/ was eager [*PRO*] to (P1)/ rehearse for the entire evening. (P2)
NP-raising gap	2c. The conceited actor/ who worked with the leading lady/ was sure [*t*] to (P1)/ rehearse for the entire evening. (P2)
Adjective control	2e. The conceited actor/ who worked with the leading lady/ was rude to (P1)/ the rehearsers in the evening. (P2)
	Recognition probe: conceited
	Experiment 3
Passive	3a. The shrewd lawyer/ who argued for the defense/ was suspected [*t*] (P1)/ by the judge. (P2)
Active	3b. The shrewd lawyer/ who argued for the defense/ had spoken (P1)/ to the judge. (P2)
	Recognition probe: shrewd
	Experiment 4
Passive	4a. The ragged drifter/ traveling the land/ was resented [*t*]/ constantly. (P1)
Adjectival	4b. The ragged drifter/ traveling the land/ was resentful/ constantly. (P1)
	Recognition probe: ragged
	Experiment 5
Passive	4a. The dazed cabbie/ who drove the beat-up taxi/ was resented [*t*] (P1) / constantly. (P2)
Adjectival	4b. The dazed cabbie/ who drove the beat-up taxi/ was resentful (P1) / constantly. (P2)
	Recognition probe: dazed

Table II. Recognition Latencies (in msec) and Error Rates (in proportions)

	Probe position	
Sentence type	Early (P1)	Late (P2)
	Experiment 1	
PRO	928(.06)	958(.15)
NP-raising	873(.04)	919(.07)
NP-tough	898(.03)	869(.07)
Pronoun	881(.04)	933(.07)
Control	862(.03)	1,052(.12)
	Experiment 2	
ADJ-PRO	909(.09)	986(.15)
NP-raising	882(.10)	922(.13)
ADJ-control	905(.10)	1,022(.16)
	Experiment 3	
Passive	928(.03)	837(.07)
Active	887(.06)	923(.07)
	Experiment 4	
Passive	998(.07)	
Adjectival	1,115(.08)	
	Experiment 5	
Passive	901(.05)	932(.09)
Adjectival	909(.06)	1,008(.11)

(1a–e) were generated. A short version of each of the 50 frames was constructed by truncating the sentences after the first probe point (P1). The complete list of 500 sentences was divided into 10 sublists according to the method outlined above.

Results and Discussion

Mean recognition latency and error rates for the five sentence types are presented in Table II by probe position. The position of the probe significantly affected both recognition latencies ($F_1(1, 29) = 7.29, p = .012$, and $F_2(1, 49) = 8.28, p = .0059$) and error rates ($F_1(1, 29) = 16.2, p = .000$, and $F_2(1, 49) = 11.4, p = .001$), reflecting the fact that responses were slower and less accurate as more items intervened between reading and testing of the adjective probe. Overall, sentence type significantly influenced recognition latencies ($F_1(4, 116) = 3.178, p = .016$, and $F_2(4, 196) = 5.72, p = .0002$) and less reliably error rates ($F_1(4, 116) = 2.6, p = .040$, and $F_2(4, 196) = 1.9, p = .11$). There was some indication of an interaction between probe position and sentence type in the subject analysis of recognition latencies ($F_1(4, 116) = 3.793, p = .0062$) but not in the item analysis ($F_2(4, 196) = 1.26, p > .05$).

Since the main point of the experiment was to assess the degree to which sentences containing one of the gaps or a pronoun would activate the probe item over and above that of the control sentences, a Dunnett's test (by subjects and items) was used to compare the recognition times following these sentences against the control sentence at each of the two probe points. At the .05 level, there were no significant differences at the early probe point (Dunnett's critical difference was 76 msec by subjects and 80 msec by item). However, at the late probe point (P2) all of the purported gap sentences along with the pronoun construction resulted in significantly faster recognition latencies than the control sentences, supporting the claim that these linguistically defined gaps, like explicit anaphors, access a representation of their antecedent during comprehension.

The absence of facilitation at the early probe point may suggest that readers do not immediately access the antecedent after processing the region containing the gap. Note that the early probe point was in fact the earliest point at which a gap could in principle be detected. Readers may simply delay either in postulating a gap or assigning a filler until subsequent input confirms the validity of the analysis. However, such a claim should be tempered with caution since the null result may simply reflect a limitation on the sensitivity of the probe task. Our task may not be sensitive to the specific processes involved in actually filling a gap but rather only to the net result of such processing, specifically restoring a previously processed constituent to active processing. If this is the case, then we might expect differences to manifest only after some substantial lag, even though the gap may be immediately accessing its antecedent.

Irrespective of this ambiguity concerning the early probe point, the results at the late position clearly indicate that by clause end all of the gap constructions show evidence of having accessed their antecedents to a degree comparable to an explicit anaphor. Inspection of Table II further reveals a tendency for the two purported instances of movement—namely, the raising and tough constructions—to produce greater activation than the PRO construction, measured by both lower latencies and error rates. We find such a result intriguing since raising and PRO gaps, in particular, can be formally distinguished within the GB framework, but not within other frameworks such as GPSG and LFG. We performed separate analyses contrasting these two gaps and found that the raising constructions produced marginally faster response times ($F_1 = 3.23$, $p = .08$, and $F_2 = 3.51$, $p = .07$) and significantly lower error rates ($F_1(1, 29) = 5.00$, $p = .033$, and $F_2(1, 49) = 5.19$, $p = .027$) than the PRO constructions. In the next experiment, we explored the differences between PRO and raising gaps more directly.[4]

Experiment 2

In the previous experiment, the PRO gap and the control passage were formed around a matrix verb (e.g., *adamantly refused [PRO] to* and *flatly reject the*), while the raising gap was formed around an adjectival phrase (e.g., *is sure [t] to*). We know of no principled reason why this fact alone would produce differences in recognition accuracy or latency; however, we avoid this potential artifact in the following experiment by contrasting PRO and raising gaps using the materials illustrated in (2a–c) of Table I. Note in this case that the PRO and control constructions are formed around adjectival rather than verb phrases, making both more directly comparable to the NP-raising constructions. In other respects, the experiment directly paralleled Experiment 1.

Results and Discussion

The recognition latencies and error rates for the various constructions are presented in Table II by probe position. As with the first experiment, the position of the probe significantly affected recognition latencies ($F_1(1, 29) = 19.9$, $p = .0001$ and $F_2(1, 49) = 12.8$, $p = .0008$) and error rates ($F_1(1, 29) = 6.4$, $p = .014$, and $F_2(1, 49) = 7.9$, $p = .007$), with the late position producing slower and less accurate

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[4] The tough constructions were eliminated from subsequent experiments for both methodological and theoretical reasons. First, because the tough construction involves movement from an underlying direct object, it can not be adequately equated with the implicit subject position of both the PRO and raising construction. Moreover, there is evidence, at least in the processing of relative clause constructions, that direct object gaps are more difficult to process than subject gaps (Frauenfelder, Segui, & Mehler, 1980; Wanner & Maratsos, 1978). On theoretical grounds, the exact derivation of tough constructions within GB appears to be in dispute. Chomsky's (1977) initial analysis suggested that it involved *wh* movement. However, more recent analyses have treated it as an instance of NP movement (see Pesetsky, 1987).

responses. The effect of sentence type on recognition latencies was significant by subjects ($F_1(2, 58) = 4.84, p = .011$) but not by items ($F_2(2, 98) = 2.32, p > .05$). There was no effect of sentence type on error rates, nor was there any indication of an interaction between probe position and sentence type in either the latency or error analyses (F's $\approx 1, p > .05$).

Direct contrasts of the three constructions at each probe position revealed that recognition latencies, as in the first experiment, differ only at the late position. (There were no significant differences in error rate at either probe position.) At this point, the NP-raising constructions produced significantly faster latencies than the control constructions ($t_1(29) = 3.65, p = .001$, and $t_2(49) = 3.13, p = .003$) and the PRO constructions (although marginally so by the item analyses) ($t_1(29) = 2.29, p = .029$, and $t_2(49) = 1.91, p = .062$). Unlike the first experiment, however, the PRO constructions did not show strong evidence of antecedent activation over and above the control constructions ($p > .10$), although on average, response times were 32 msec faster (see Swinney et al., 1988, for a similar finding with a somewhat different experimental paradigm).

We note, then, that in both experiments and previous pilot work (McElree, 1985) the PRO construction tended to yield small amounts of facilitation relative to movement gaps. We suggest that a natural explanation of these differences rests within the formal distinction between these types of gaps given within the GB framework (see also Bever & McElree, 1988; Bever, Carrithers, & McElree (in preparation)). GB asserts that the antecedent of an obligatory PRO gap has an independent thematic role within its matrix clause. The (base-generated) PRO element in the infinitival clause is simply coindexed to this role. In contrast, the antecedent of an NP gap lacks an independent thematic role and receives one solely on the basis of the structural position of the gap. We suggest that more activation arises from the processing of a gap formed by NP-movement as a consequence of the fact that it cannot be coindexed to a previously built structural representation of the antecedent, but rather must itself denote and initiate the building of a structural representation for the antecedent.

ANTECEDENT ACCESS IN THE PASSIVE

If, as we have suggested, the formal distinctions concerning the types of gaps posited in GB have behavioral consequences in sentence comprehension, and, more specifically, if the processing of NP-movement gaps cause particularly strong reactivation of the moved NP, then we should observe the same pattern of antecedent activation in what is perhaps the least intuitive instance of NP-movement posited in GB—namely, the passive construction. As previously discussed, GB assumes that the passive surface subject has been extracted from the underlying direct object position associated with the verb. The resultant postverbal trace is assumed to assign thematic role to the athematic subject NP.

Experiment 3

In this experiment, we contrasted the full passive construction with a superficially similar active structure. The contrast is illustrated in (3a) and (3b) of Table I. Once again, two probe positions were used—the first (P1) immediately following the reading of the verb phrase and the second (P2) following a *by* or prepositional phrase. Rather than using the actual active version of the passive verb for a control (e.g., *had suspected*), an optionally intransitive verb was used to ensure that the active construction has the same potential as the passive for closure after the verb phrase (P1). In total, 24 active-passive pairs were generated each with a short and a long version. These sentences were divided into four sets of materials, counterbalanced according to the procedure outlined above, and then combined with the filler passages.

Results and Discussion

Table II presents the mean recognition times and error rates by probe point and sentence type. Neither the main effect of sentence type nor the main effect of probe position had a singularly significant effect on recognition latencies ($F_1(1, 19) < 1.0, p > .05$, and $F_2(1, 23) < 1, p > .05$; $F_1(1, 19) = 2.22, p > .05$, and $F_2(1, 23) = 1.06, p > .05$, respectively). However, the factors significantly interacted ($F_1(1, 19) = 12.4, p < .002$, and $F_2(1, 23) = 6.57, p < .05$). No significant differences were found in the error analyses.

As inspection of Table II shows, the active constructions produced recognition latencies that were on average 40 msec faster than the passive construction at the early probe point. However, correlated t tests show this difference to be unreliable ($t_1(19) = -1.56, p > .05$, and $t_2(23) = -1.37, p > .05$). At the late probe position, the difference reversed and increased in magnitude: Recognition latencies following the passive were on average 86 msec faster than the active construction, a difference that was reliable ($t_1(19) = 2.58, p < .01$, and $t_2(23) = 2.33, p < .025$). This pattern of data is, obviously, quite similar to that observed with the NP-raising construction in the two previous experiments. We provide further evidence for activation of the passive antecedent in the next experiment.

Experiment 4

In the previous experiment, a simple active construction with a different, optionally intransitive verb was used as a control for the passive. In this experiment, we contrasted the passive with what is perhaps a more minimally differing control. As illustrated in (4a) and (4b) of Table I, we used an adjectival form of the passive verb as a baseline control.

Unlike the previous experiments, only one probe point was used—a point (P1) following the reading of a final adverb. Since the previous experiment showed no evidence for greater accessibility of a coreferent NP immediately following the gap, this point is perhaps the earliest point at which differences emerge. Twenty sentence pairs as illustrated in (4a) and (4b) were generated and divided into two completely counterbalanced sets of materials.

Results and Discussion

Table II presents the mean reaction times and error rates across the two conditions. No differences were found in error rate. Once again, however, the passive showed evidence of greater availability of the initial NP relative to the control structure: Recognition latencies were on average 117 msec faster than the adjectival control, a difference that was significant ($t_1(29) = 2.85, p < .005$, and $t_2(19) = 2.84, p < .01$).

Experiment 5

In a final experiment, we controlled the reading time of the passive and adjectival phrases in order to examine whether previously observed differences in recognition performance are a consequence of differences in the amount of time subjects spend reading the respective phrases. We used materials similar to Experiment 4, but once again with two probe positions. The contrasts are illustrated in (5a) and (5b) of Table I.

As in previous experiments, subjects read the passages in a self-paced manner. However, the recognition probe appeared at a constant 900 msec after initiating the final phrase (either *was resented/resentful,* for the early probe position (P1) or *constantly* for the late probe position (P2)). Sixteen sentence pairs of the type illustrated in (5a) and (5b) were generated and divided into four completely counterbalanced sets of materials.

Results and Discussion

Table II presents the recognition latencies and error rates. As with the other passive studies, the error rates at both probe positions and the recognition latencies at the early probe point (P1) did not significantly differ. However, recognition latencies were once again significantly faster for the passive construction at the late probe position (P2) ($t_1(23) = 3.11$, $p < .005$, and $t_2(15) = 2.48$, $p < .025$).

This result suggests that our findings with the passive can not be attributed to any potential differences in the amount of time that subjects spend processing the final phrase before receiving the recognition probe. Together with the results of the previous two experiments, this clearly demonstrates that the surface subject is more salient following a passivized verb phrase than either a corresponding adjectival or active verb phrase. We interpret such a finding as evidence for the claim that the passive is parsed in a manner similar to other instances of NP-movement. That is, the postverbal trace initiates the retrieval of the antecedent NP and its incorporation into the structural representation of the verb phrase.[5]

GENERAL DISCUSSION

Previous research has demonstrated that both explicit anaphors (Chang, 1980; Cloitre, 1985; Dell et al., 1983; McKoon & Ratcliff, 1980) and implicit *wh* anaphors (Clifton & Frazier, 1988; Swinney et al., 1988; Tanenhaus et al., 1985) access a representation of their antecedents during comprehension. The results of the present set of experiments demonstrate activation or priming of the antecedent of NP-movement

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[5] Owing to space limitations, we do not consider alternative "discourse" explanations for the passive finding here. However, see Bever et al. (in preparation) and McDonald (1987) for a discussion of the limitations of these alternative explanations.

gaps, suggesting that these gaps similarly access a representation of their antecedent.

On its own, this simple demonstration lends credence to the notion that the representational assumptions of GB are relevant to the psychological processes operative in sentence comprehension. This notion is further supported by the demonstration that NP-movement gaps appears to activate their antecedent to a greater degree than PRO gaps. GB formally distinguishes between these types of gaps, and we have followed this analysis rather directly in suggesting that greater activation results from NP-movement gaps as a consequence of greater necessity of structure-building operations. In short, we assume that PRO gaps can be filled by access and coindexing to an independent structural representation of the antecedent, whereas NP-movement gaps provide the first opportunity to incorporate the antecedent into an argument structure. More research is needed to verify this claim. Elsewhere (Bever et al., in preparation), however, we suggest how this notion of a trace accessing its antecedent when coupled with appropriate processing assumptions can predict patterns of reading times across various critical constructions.

To our knowledge, competing grammatical theories, such as GPSG and LFG, at present do not distinguish between PRO and NP-movement gaps in a manner that would a priori predict the pattern of results we found. If further research, with either different materials and/or experimental paradigms, continues to demonstrate dissociations between these types of gaps, then we believe this will provide strong convergent evidence for the psychological reality of the GB's linguistic descriptions.

REFERENCES

Bever, T.G., & McElree, B. (1988). Empty categories access their antecedents during comprehension, *Linguistic Inquiry*, *19*, 35–43.

Bever, T.G., Carrithers, C., & McElree, B. (in preparation). The psychological reality of Government and Binding theory.

Bresnan J. (1978). A realistic transformational grammar. In M. Halle, J. Bresnan, & G. Miller (Eds.), *Linguistic theory and psychological reality*. Cambridge, MA: M.I.T. Press.

Bresnan, J., & Kaplan, R. (1982). Grammars as mental representations of language. In J. Bresnan (Ed.), *The mental representation of grammatical relations*. Cambridge, MA: M.I.T. Press.

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

Chomsky, N. (1977). On *wh*-movement. In P. Culicover, T. Wasow, & A. Akmajian (Eds.), *Formal syntax*. New York: Academic Press.

Chomsky, N. (1981). *Lectures on Government and Binding.* Dordrecht: Foris.

Clifton, C., & Frazier, L. (1986). The use of syntactic information in filling gaps. *Journal of Psycholinguistic Research, 15,* 209–224.

Clifton, C., & Frazier, L. (1988). Comprehending sentences with long-distance dependencies. In M. Tanenhaus & G. Carlson (Eds.), *Linguistic structure in language processing.* Dordrecht: Reidel.

Clifton, C., Frazier, L., & Connie, C. (1984). Lexical expectations in sentence processing. *Journal of Verbal Learning and Verbal Behavior, 23,* 696–708.

Cloitre, M. (1985). *The effects of kinds of anaphor on the accessibility of antecedent information.* Unpublished doctoral dissertation, Columbia University.

Crain, S., & Fodor, J.D. (1985). How can a grammars help parsers? In D.R. Dowty, L. Karttunen, & A.M. Zwicky (Eds.), *Natural language parsing: Psychological, computational, and theoretical perspectives.* New York: Cambridge University Press.

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

Frauenfelder, U., Segui, J., & Mehler, J. (1980). Monitoring around the relative clause. *Journal of Verbal Learning and Verbal Behavior, 19,* 328–337.

Frazier, L., Clifton, C., & Randall, J. (1983). Filling gaps: Decision principles and structure in sentence comprehension. *Cognition, 13,* 187–222.

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

McDonald, M. (1987). Process binding in passive sentences. In A. Miller & J. Powers (Eds.) *Proceedings of the fourth eastern states conference on linguistics.* Ohio: Ohio State Press.

McElree, B. (1985). *Noun phrase accessibility as a function of filling gaps.* Unpublished Master of Philosophy essay, Columbia University.

McKoon, G., & Ratcliff, R. (1980). The comprehension process and memory structure involved in anaphoric reference. *Journal of Verbal Learning and Verbal Behavior, 19,* 668–682.

Pesetsky, D. (1987). Binding problems with experiencer verbs. *Linguistic Inquiry, 18,* 126–140.

Swinney, D., Ford, M., Bresnan, J., & Frauenfelder, U. (1988). Coreference assignment during sentence processing. In M. Macken (Ed.), *Language structure and processing.* Stanford, CA: CSLI.

Tanenhaus, M.K., Carlson, G.N., & Seidenberg, M.S. (1985). Do listeners compute linguistic representations? In D.R. Dowty, L. Karttunen, & A.M. Zwicky (Eds.), *Natural language parsing: Psychological, computational, and theoretical perspectives.* New York: Cambridge University Press.

Wanner, E., & Maratsos, M. (1978). An ATN approach to comprehension. In M. Halle, J. Bresnan & G. Miller (Eds.), *Linguistic theory and psychological reality.* Cambridge, MA: M.I.T. Press.