Pronouns and People: Some preliminary evidence that the accessibility of antecedents in processing can vary with clause relation and biology*

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The research reported here bears on two distinct complexes of issues in psycholinguistics. The experimental work described below was conceived within an ongoing investigation of certain anaphoric processes that appear to be embedded in the syntactic processing system. From this perspective, the main goal of the work described here was to explore the effect the presence of an antecedent may have on the processing of a pronoun, especially as this is affected by the syntactic relation between the clauses bearing the antecedent and pronoun. The second complex of issues concerns the relation in the brain and mind between the specifically linguistic components of the language processing system (e.g., syntax) and other seemingly more versatile cognitive systems (e.g., those that deal with discourse structure and that interpret utterances against the listener's background of general knowledge). One question of particular relevance to the present study is whether this relation is uniform across individuals.

If the preliminary analyses to be presented here bear up under further scrutiny, it will be evident that these two complexes of questions are intimately intertwined. In brief, in the overall results it appears that an antecedent in the preceding clause can facilitate processing over a span of a few words following a pronoun. This occurs where the relation between the clauses is subordinate-main, but not where the two clauses are coordinate. This general pattern, however, seems to be a reflection of effects that arise in one specific group of subjects, those who have no left-handers among their biological relatives. In those with left-handed relatives the antecedent effect is present regardless of the syntactic relation between the two clauses.

These results are relevant to central theoretical questions about anaphoric processing, the logical architecture of the language comprehension system, and the relation between language and human neurobiology.

1. Background

1.1. Pronominal anaphora within syntactic processing

Much recent linguistic research has suggested that there is an interesting set of syntactic principles bearing on pronominal anaphora (among other phenomena). Within single sentences these principles appear to tightly constrain what pairs of potential antecedents and pronouns must, may or must not be taken to be coreferential (see, for example, Chomsky, 1981, 1986, Reinhart, 1983, Aoun, 1985). Though there are linguists who advocate quite different approaches (Bolinger, 1979, Bosch, 1983, Cornish, 1986), the large body of linguistic work bearing on syntactic aspects of intrasentential pronominal anaphora at least suggests that this area merits some attention in the language processing literature.

Psychological research on pronominal anaphora has been concerned almost exclusively with cases where the pronoun and antecedent are in different sentences (see, for example, Hirst & Brill, 1980, Dell, McKoon & Ratcliff, 1983, Tyler and Marslen-Wilson, 1982, and the review in Garnham, 1985, pp. 148-152). Intrasentential relations have sometimes been examined, but not in ways that exercize the syntactic principles featured in the linguistic literature. For example, Corbett and Chang (1983) used coordinate structures that function as two separate sentneces with respect to the binding theory discussed in Chomsky (1981). Garvey and Caramazza (1974) used main/subordinate clause structures that constitute a more integrated syntactic domain, but their research was concerned with semantic influences on reference relations.

The larger investigation of which the present work is a part is designed, among other things, to explore the role of the syntactic processing system in the assignment of reference relations among pronouns and their various candidate antecedents. In particular, it has examined the possibility that some reference relations (or at least some relations that ultimately get interpreted as reference relations) are assigned by the syntactic processor. Previous experimental results indicate that certain cataphoric instances of they can exert an influence on the syntactic analysis of ambiguous gerund phrases (e.g., flying planes), that the reference relations implicated in this finding are assigned even when they result in a manifestly odd or implausible interpretation, that these relations are blocked when they violate syntactic constraints on reference relations, that these relations are unaffected by alternative antecedents in a preceding sentence, and that effects of these kinds are demonstrable with several experimental paradigms (Cowart & Cairns, in press, Cowart, 1986a, 1986b).

The work described here extends this line of investigation to more commonplace instances of pronominal anaphora where the antecedent precedes the pronoun and where a wider variety of pronouns can be investigated. The most basic goal of the work described here was to determine whether a certain variant of the word-by-word reading procedure can detect any indication that pronouns are processed differently according to whether or not an antecedent appears ahead of the pronoun in the same sentence. A second more theoretically significant goal was to determine whether any effects of this kind are sensitive to the syntactic relation between two clauses where the antecedent is in the first and the pronoun in the second. The reference-assigning mechanism that appears to be involved in the cataphoric cases investigated earlier applies, by hypothesis, to third-person pronouns generally (apart from reflexives), and thus should be relevant here. If it is, and it is, as proposed, an essentially syntactic mechanism, it should be sensitive to syntactically significant variations in clause relations.

1.2. Laterality and language processing

There has long been evidence suggesting that the distribution of language-related functions across and within the two hemispheres of the brain is subject to some variation. Though this evidence is difficult to interpret and still the focus of much controversy, it is nonetheless noteworthy that it has had virtually no effect on the bulk of sentence processing research, apart from spotty attempts to control for subject handedness. This

apparently has two causes: 1) it is difficult to assess dominance, and 2) when it is assessed, there is little evidence that it has any effects.

Note, however, that as a point of logic, for intact subjects variation in the distribution of functions should have consequences only where this variation affects the way that various functions interact. Furthermore, there could be variations in the way functions interact that are not very directly related to their distribution.

Recently, Bever, Carrithers and Townsend (1986) reported findings that suggest that more fruitful work on the relation between these matters and sentence processing may be possible. Bever and his collaborators found evidence that some processing phenomena are linked to the presence of left-handers among a subject's biological relatives. For example, in one experiment subjects were asked to indicate whether a probe word heard in isolation shortly after the auditory presentation of a sentence fragment was one of the words in the fragment. Considering only the correct positive responses, subjects who reported no left-handers in their families (hereafter these will be termed 'Right' subjects) were much slower in responding to probes drawn from the latter part of the fragment than they were with words drawn from the earlier part. By contrast, subjects with one or more left-handed relatives ('Lefts' hereafter), showed no serial order effect whatever; the Lefts responded equally rapidly to probes drawn from early or late parts of the fragment and they also responded more rapidly overall than the Rights. Note that all subjects were themselves strongly right-handed. Bever suggests that the performance of the Rights reflects their reliance upon a self-terminating serial search through a linear representation of the utterance just heard. The Lefts, by contrast, are presumed to treat the task by way of a semantic representation that provides simultaneous access to all parts of the context material.

It is, of course, not at all obvious why processing effects of these kinds should be related to the presence of left-handers in a subject's family. Bever's suggestion is that left-handedness is associated with a heritable biological trait that results in a number of neurophysiological consequences. Among these is a richer interconnection between the language processing system, especially its syntactic component, and the balance of the cognitive system, especially those components involved in semantics and interpretation. Thus, the presence of left-handers in a subject's family is merely an index of the likelihood that the subject will be affected by this biological trait. There is an independent line of investigation in neurolinguistics (see, for example, Geschwind and Galaburda, 1984) that seems to lend some credibility to this analysis.

Against this background, the work discussed below was intended to provide a test of Bever's proposals via methods and linguistic phenomena different than those he used. Pronoun-antecedent relations are notoriously subject to a great diversity of influences, ranging from stress to syntactic structure to discourse structure. If the phenomena Bever and his colleagues discovered are related to the degree of interconnection between syntactic and semantic modes of processing, anaphoric phenomena should provide a useful body of experimental material. To the degree that the richness of interconnection between the syntactic and semantic (and discourse) processing

components varies, this should affect the relative accessibility of various approaches to antecedent-finding.

2. Experimental Evidence

Kennedy and Murray (1984) provide evidence that a certain variant of the word-by-word reading procedure is much more sensitive to syntactic structure than were earlier forms of this method. One goal of the present experiment was simply to determine whether this revised procedure can detect effects related to the presence or absence of an antecedent for a pronoun. Secondly, the experiment was designed to manipulate the syntactic relation between the clauses bearing antecedent and pronoun to determine whether any simple antecedent effects that might appear are sensitive to this factor. Finally, the experiment was planned to be run on two distinct samples, a group of strongly right-handed Right subjects and an equally strongly right-handed group of Left subjects.

2.1. Method

The experimental materials consisted of 24 sets of items similar to (1).

(1) a. Even though the librarians had made an awful lot of noise, she kept on working on her own stuff.
b. Even though the librarian had made an awful lot of noise, she kept on working on her own stuff.
c. The librarians had made an awful lot of noise, but she kept on working on her own stuff.
d. The librarian had made an awful lot of noise, but she kept on working on her own stuff.

Note that the second clauses, including their pronoun subjects, are identical throughout, apart from the coordinating conjunction in the (c) and (d) forms. The subject of each first clause is a lexical NP that provides an acceptable antecedent for the pronoun in the (b) and (d) cases only. The pronouns used included he and she, but they predominated. The two clauses of the (a) and (b) cases are in the relation subordinate-main, while those of the (c) and (d) cases are coordinate. A complete listing of the materials together with a summary of the results for each item is available from the author.

The experimental design involved three within-subjects factors, Antecedent (No Antecedent, Antecedent Present), Clause Relation (Subordinate, Coordinate) and Word Position (the position of each stimulus word relative to the pronoun in the second clause). These three factors were crossed by a fourth, History (Right vs. Left subjects, those lacking or having left-handed relatives, respectively).

These materials, together with 48 fillers of diverse kinds, were presented to subjects via a minor variant of the cumulative word-by-word procedure discussed by Kennedy and Murray (1984). In this task the subject must press a key to see each succeeding word in the stimulus sentence on a computer display. The interval between key presses is recorded and serves as a crude measure of reading time per word. Unlike other versions of the word-by-word task, each word is presented one space to the right of the word preceding (apart from line breaks) and stays on the screen until the subject

presses the key following presentation of the last word. Thus the effect is that of seeing a normally formatted text appear one word at a time. A yes/no question appeared after each sentence presentation and the subject responded via a key press. This response was timed, evaluated and recorded, and the subject was given feedback as to the correctness of the reply. When average response time per word went above 550 msec., the feedback message also urged the subject to respond more rapidly.

In preparation for this work, a survey form was distributed to a large number of students in various undergraduate courses at Ohio State University. This form was derived from Geschwind's variant of the Oldfield inventory. It asked for, among other things, information about the handedness of the respondent's biological relatives. Fifty subjects for this experiment were drawn from a pool of about 430 individuals who completed this form. All were strongly right-handed, with laterality scores (using Geschwind's LS) of 90 to 100. Twenty-four had no left-handed relatives and 26 had one or more such relative.

2.2. Results

The results are summarized in Figures 1A and 1B. Note that when an antecedent was present, Right subjects responded faster on the pronoun and the three words following it, but only where the clause relation was subordinate/main. By contrast, with Left subjects the antecedent produced faster responses for several words after the pronoun regardless of the relation between the two clauses. This pattern seems to be reliable.

The principal statistical analyses covered the first three words following the pronoun. The limits of this zone were determined post hoc; it excludes some potentially relevant contrasts on responses to the pronoun itself and to words following this zone but seems on the whole to include effects representative of the overall result. An analysis covering the span running from the pronoun through the fifth word following the pronoun produced similar but somewhat weaker results. For the purposes of this preliminary report effects and interactions that do not seem to be theoretically relevant will be ignored. Extreme response values were reset to +/- 2SD from the subject's mean.

An overall analysis covering results from both subject types produced only inconclusive results. There was an interaction in the by-subjects analysis involving the Antecedent, Clause Relation and History factors, $F_1(1,42)=4.67$, $MSe=1638$, $p<.05$., $F_2(1,22)=1.2$, NS, as well as a main effect for the Antecedent factor, $F_1(1,42)=7.68$, $MSe=1929$, $p<.01$, $F_2(1,22)=3.02$, $MSe=4644$, $p<.1$. The interaction supports the view that the included two-way interaction between the Antecedent and Clause Relation factors is different for Right and Left subjects.

The strongest statistical evidence for a contrast between the performance of Right and Left subjects appears when analyses are restricted to just one of these groups at a time. For the Right subjects the Antecedent by Clause Relation interaction is highly significant, $F_1(1,20)=8.89$, $MSe=1357$, $p<.01$, $F_2(1,22)=8.78$, $MSe=1470$, $p<.01$, indicating that the apparent contrast between the effects of the Antecedent factor in the two Clause

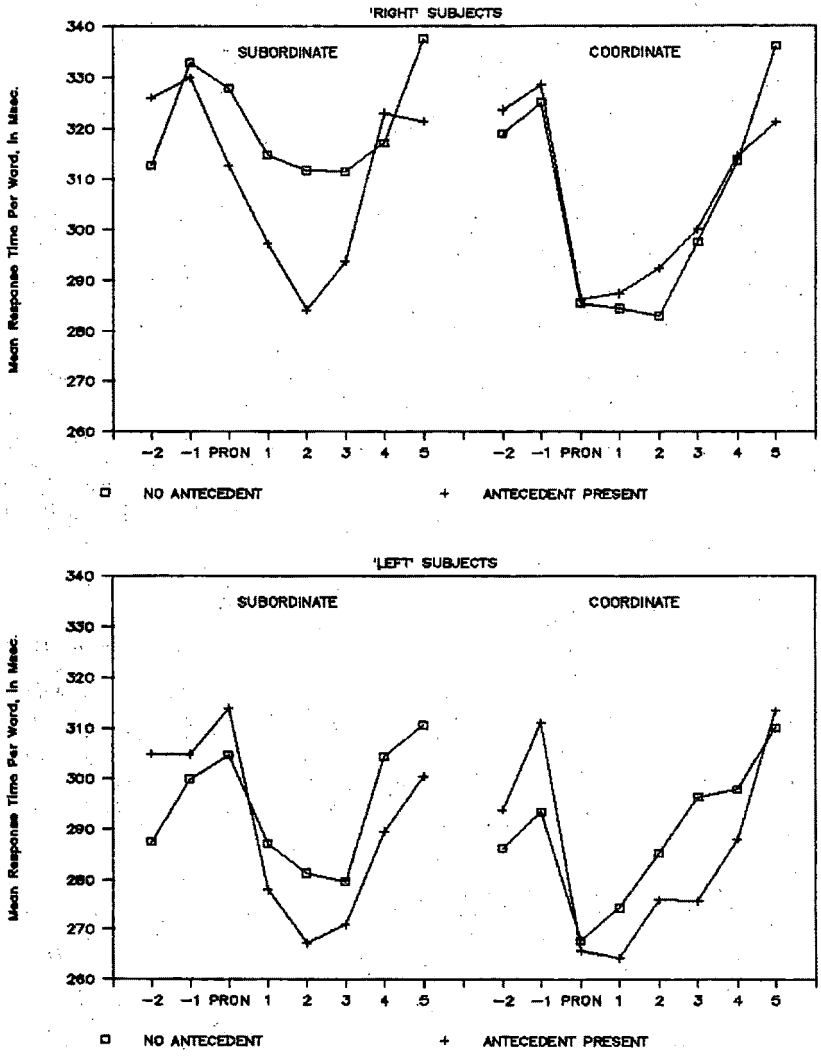

Figure 1A & 1B. Mean response time per word for Right subjects and Left subjects as a function of 1) the presence or absence of an antecedent, 2) the syntactic relation between the two clauses, and 3) word position relative to the pronoun ('PRON').

Relation conditions is reliable. In the Left subjects, this same interaction does not approach significance, $F_{1,2}<1$.

On the other hand, the main effect of the Antecedent factor is significant in the results for the Left subjects, $F_1(1,22)=5.64$, $MSe=1949$, $p<.05$, $F_2(1,22)=4.64$, $MSe=2092$, $p<.05$, indicating that the antecedent speeded responses generally, without regard to the relation between the clauses. For the Right subjects, this main effect falls well short of significance, $F_1(1,20)=2.42$, $MSe=1907$, $p>.1$, $F_2(1,22)<1$.

Pilot studies as well the present experiment suggest that one reliable distinction between Right and Left subjects is that the latter generally respond faster. Though this contrast (the History main effect) is not significant in the by-subjects analysis, it is highly significant in the by-sentences analysis (where it is treated as a within-'subjects' factor), $F_1(1,42)<1$, $F_2(1,22)= 25.7$, $MSe=1900$, $p<.001$. Comparing the four Right subject cells at each of eight word positions with the corresponding four Left subject cells shows that the Right subjects were slower in 30 of 32 comparisons, $p<.001$.

These results support two important conclusions. First, there is some antecedent-finding mechanism that can influence performance when an antecedent for a pronoun is available in a prior clause that is syntactically integrated with the one bearing the pronoun. Second, effects attributable to such a mechanism are apparent only with subjects who have no left-handers among their close biological relatives.

3. General Discussion

Pronouns are important from several points of view. Questions about how pronouns are associated with their antecedents define one of the central problems in the theory of discourse processing. These questions bear quite directly on the general organization of the language comprehension system, especially questions about 1) how the diverse kinds of information involved in language comprehension are brought to bear on an incoming utterance, and 2) how the results of diverse analyses are integrated. This in turn can be seen as a special case of the complex of problems in the philosophy of mind that have recently been discussed under the heading of modularity theory (Fodor, 1983).

To properly determine pronoun-antecedent relations, listeners must employ many different kinds of information. Some of the kinds of information used are clearly syntactic, but most are semantic or have to do with discourse structure or knowledge of the world. Modularity theory is consistent with only certain possible accounts of the interface among these various kinds of knowledge. Strictly speaking, the linguistic system is modular in Fodor's sense, so long as there is an informationally-encapsulated parser, regardless of how the syntactic aspects of pronoun-antecedent relations are handled. Nevertheless, there are ways to handle syntactic constraints on pronoun-antecedent relations that would be a serious embarrassment to modularity theory. Suppose that a putatively autonomous syntactic processing system is put in harness with a discourse processing system that, together with various sorts of semantic and discourse analyses, computes c-command relations in the course of assigning antecedents to

pronouns. The question would naturally arise as to why other aspects of syntactic analysis might not also be undertaken by this system, thus making the autonomous syntactic processor at least partly redundant. If modularity theory is generally correct, a more consistent outcome would seem to be that an inventory of the capacities of the syntactic processor exhausts the syntactic capacities of the listener, and further, that (conscious reasoning aside) listeners have no capacity to handle syntactic relations apart from what is implemented in the syntactic processing system.

Within this framework, the interface problem for pronouns takes this form: how can the syntactic constraints on pronominal anaphora be implemented without compromising the uniqueness of the various processing subsystems, especially the syntactic processor? Of course, whatever solution is proposed here must respect the fact that for only a relatively small proportion of all pronoun instances will syntactic constraints uniquely and definitively determine an antecedent.

These considerations seem to allow several different ways to organize the interaction between syntactic and discourse processing. One would be for the syntactic processor to add a table to the syntactic representation of each sentence that specifies all possible syntactically acceptable coreference relations within that sentence (cf., Jackendoff, 1972). Another possibility is for the syntactic processor to propose some specific network of coreference relations within each sentence, thus resolving sentence-internal ambiguities. This set of relations is then evaluated by the discourse processor, which has the capacity to revise many of the relations posited by the syntactic processor. The inverse must also be considered; it could be that the syntactic processor makes no assignments of its own, but only evaluates those made by the discourse processor. This would apparently require that there be some mechanism by which it might 'insist' on certain relations, as with reflexives and reciprocals.

The evidence reviewed here suggests that the second of these possibilities is the better model for Right subjects. The large Antecedent effect in the Subordinate condition indicates that something like a reference relation is being assigned, but the extreme sensitivity of this effect to variations in the syntactic relation between the clauses suggests that the mechanism that produces it is essentially syntactic; it seems unlikely that any mechanism that evaluates prospective antecedents in terms of their plausibility or reasonableness in the discourse would be so dramatically sensitive to this sort of syntactic variation. Since these subjects can, presumably, still take the NP in the first clause as the antecedent of the pronoun by later application of discourse processes, these processes seem to be positioned to receive an input from the syntactic processor with some reference relations already specified.

The results for the Left subjects reveal less about the interface between syntactic and discourse processing. The uniformity of the Antecedent effect clearly shows that the mechanism that produces it in these subjects is less sensitive to syntactic structure than is the mechanism controlling the performance of Right subjects. This, however, does not preclude the possibility that some relations are assigned by a syntactic mechanism; it might be that for these subjects the syntax-based assignments are more readily supplemented by those produced by the discourse processor. It does

seem clear, however, that a discourse-oriented mode of processing is at least more influential for these subjects than it is for the Right subjects.

The general question about the difference between Right and Left subjects will likely be hard to resolve. Bever (1986) seems to suggest that for Left subjects syntactic and interpretive processing are more intimately integrated, but that these subjects' capacity for syntactic analysis is no less developed than it is in Right subjects. Richer interconnection between syntactic and interpretive modes of analysis simply makes the interpretive modes more salient cognitively and more influential in behavior. Detailed demonstrations of syntactic influences on Left subjects may, however, be difficult to provide.

Though much further research is required, it is clear that the results reported here bear on the two sets of issues raised in the introduction. There does seem to be a syntax-based mechanism for assigning something like a coreference relation. There do seem to be biological differences between subjects that affect the way various modes of language processing are integrated.

Notes

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