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Comprehension of Anaphoric Pronouns

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This study was undertaken to demonstrate that a property of verbs, implicit causality, is an important factor in determining coreference of potentially ambiguous anaphoric pronouns in a timed comprehension task. Subjects were required to decide the coreferentiality of a pronoun in pairs of sentences such as *John telephoned Bill because he withheld some information/wanted some information.* Verbs were first empirically classified into those that bias assignment toward the first noun phrase of the main clause and those that bias assignment toward the second noun phrase. Pairs of sentences were constructed for each verb such that the subordinate clause in one sentence established a reading consistent with the natural bias of the verb while the others established a reading inconsistent with the bias of the verb. Time to respond was faster for the congruent sentences. This was also true for control sentences such as *Sue telephoned Bill because he withheld some information* in which gender differences eliminated all potential ambiguities. It was argued from these results that implicit causality is an important determinant of pronoun assignment and that ambiguities are normally resolved at clause boundaries.

The assignment of pronouns to appropriate antecedents is essential for successful conversation. Yet the mechanisms that govern assignment are poorly understood, especially in sentences that are ambiguous. For example, the pronoun *she* in sentences (1) and (2)

(1) Jane hit Mary because she had stolen a tennis racket.
(2) Jane angered Mary because she had stolen a tennis racket.

could refer to either Jane or Mary, as both antecedent nouns agree in gender with the pronoun. However, the preferred interpretation for sentence (1) is to assign the pronoun coreferential with Mary while in (2) the more natural assignment is to Jane. The problem for the psychologist is to account for the fact that the listener understands the pronoun differently in each of the two sentences above.

Garvey and Caramazza (1974) have suggested that a property of verb roots, referred to as implicit causality, is responsible for biases in pronoun assignment. This feature selects one noun or the other as the probable instigator or causal source for a series of events. Implicit causality operates much like a linguistic transfer feature (Weinreich, 1966) located in the verb but affecting the interpretation of surrounding phrases.

Further study of active causal sentences like (1) and (2) has led to a better understanding of the implicit causality feature and its influence on pronoun assignment (Garvey, Caramazza, & Yates, 1976; Grober, Beardsley, & Caramazza, Note 1). Groups of subjects were given sentence fragments consisting of an

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active clause followed by *because* plus a pronoun (e.g., John telephoned Bill because he ...) and were asked to give a reason or motive for the action. Although subjects were generally unaware that the sentence fragments were ambiguous, their responses represent a judgment of implicit causality to the extent that the continuations they supplied disambiguated antecedent assignment. This procedure provides an empirical method for defining bias. One major finding from these studies was that the implicit causality feature can best be represented as a continuum. When bias is defined as the proportion of completions in which the first noun is the antecedent, bias values range continuously from 1.0 [the first noun phrase (NP1) is the unanimous antecedent] to 0.0 [the second noun phrase (NP2) is the unanimous antecedent]. Thus, it appears that the implicit causality feature is "squishy," a property of increasing interest to linguists (Ross, 1972).

Results from the previous studies indicate that subjects regularly make use of implicit causality relations marked by verbs in generating appropriate explanations for actions. Part of the process of understanding a sentence presumably involves establishing a causal relationship between component terms of the underlying proposition such as between participating actors. This, in turn, determines which actor is the appropriate referent for the pronoun. The present study was undertaken in an effort to explicate the role of implicit causality features in real-time sentence comprehension processing.

If the presence of this implicit causality feature determines the direction of pronoun assignment in a sentence completion task, then it should facilitate the choice of an appropriate antecedent in a speeded comprehension task. When the subordinate clause of a sentence like (3),

(3) John telephoned Bill because he wanted some information.

establishes a causal relationship that is consistent with the causal relationship set up by the main verb's natural bias, subjects should be quick to select the appropriate antecedent for the pronoun. When the causal relationship established in the subordinate clause is inconsistent with the verb's bias as in (4),

(4) John telephoned Bill because he withheld some information.

subjects should be slower to choose the appropriate referent.

These predictions were derived from one of two general classes of theories about the effect of ambiguity on sentence comprehension. One view holds that all readings of a sentence are processed in parallel and that a particular reading is rejected when information incompatible with its reading is encountered. Stating this view differently, a reading is chosen from among various possibilities when confirming evidence for that interpretation becomes available (MacKay, 1970; Olson & MacKay, 1974). The other view holds that only one reading is processed at any one time and that the particular reading chosen is a function of bias information contained in the sentence (Foss, Bever, & Silver, 1968; Carey, Mehler, & Bever, 1970).

Predictions motivated by these two general views have both received experimental support. Typically an effect of ambiguity is obtained in those experimental tasks that require a response during the processing of a sentence, while the no effect of ambiguity is obtained in those situations where a response is required after the processing of the sentence is presumably completed. Lackner and Garrett (1973) have attempted to reconcile these results. Their model holds that within a clause (the primary processing unit) both readings for an ambiguous sentence are available, but by the time the end of the clause is reached one reading has been chosen and the other has been dropped, usually as a result of some disambiguating context (Bever, Garrett, & Hurtig, 1973).

The potentially disambiguating information in the present study is supplied by the verb in the main clause temporally prior to the

ambiguous portion of the sentence. The analysis of the main clause may bias the interpretation of the subordinate clause in the following manner. After reading the main clause of a sentence such as (3), the underlying structural relations of the main clause are assigned by a set of mapping rules. These rules are sensitive to specific features inherent in individual lexical items that signal particular underlying structural relations (e.g., "who," "when" that explicitly mark relative clauses). Clauses with verbs that are strongly marked by the implicit causality feature will lead the listener to organize its underlying semantic relations in a particular way. The causal relationship that is set up between the actors in the main clause will help determine how the pronoun in the subordinate clause will be assigned. When the semantic relations in the subordinate clause are consistent with the direction of pronoun assignment established by the main verb as in (3), a subject can immediately respond with the name of the pronoun's referent. If, however, the semantic relations are inconsistent with the causality relations established previously as in (4), then the pronoun must be reassigned, thereby requiring extra processing time.

A different strategy would be for the subject to postpone the assignment of the pronoun until the interpretation of the subordinate clause is relatively complete. Since both structural options for the clause (i.e., NP1 and NP2 readings) would be available until the end of the clause (MacKay, 1970), and since by this account pronoun assignment is made independently of the main verb's bias, then it should not matter whether the direction of assignment in the subordinate clause is consistent or inconsistent with the main verb's bias. The use of this strategy would result in equal response latencies for both conditions.

Briefly then, our prediction for an effect based on the type of verb depends on the satisfaction of two conditions: that the implicit causality feature helps determine or bias the assignment of the anaphoric pronoun and that the assignment of the pronoun is already partly determined by the end of the major clause of our experimental sentences. In other words, a positive effect due to verb type is implicit support for a clausal analysis of sentence comprehension (Fodor, Bever, & Garrett, 1974) where disambiguation, if necessary, takes place at the end of each clause. Obviously, a null result could mean either that implicit causality is not a relevant construct in real-time processing or that disambiguation does not occur until the whole sentence is processed.

The addition of two control conditions permits an even stronger test of the two strategies. Not only can information inherent in individual lexical items influence pronoun assignment; surface properties of the sentence can affect it as well. One obvious constraint for third person pronouns is that they agree in gender with their antecedents. This has been called the Gender Agreement Constraint by Springston (Note 2). In sentences (5) and (6),

(5) John telephoned Sue because he needed some information.
(6) Sue telephoned John because he withheld some information.

gender agreement is sufficient to determine pronoun assignment. Yet subjects may still be influenced by the verb-based feature in establishing the causal relationship between the actors. If so, subjects should be faster to name the referent in control sentences such as (5) in which the direction of pronoun assignment is the same for both clauses, than in control sentences such as (6).

Method

Materials and design. Two sentences were constructed for each of 28 verbs. The bias value of the verbs, determined from an earlier sentence completion study (Garvey et al., 1976), ranged from .99 to .01. All sentences were of the format: *NP1 past V NP2 because Pro ...*, and both nouns were either male or female names. For one of the two sentences,

the completion-induced (henceforth, preferred) pronoun assignment was consistent with the verb's bias. By then changing one or two words in the final clause, a second sentence was then created in which the preferred assignment of the pronoun was to the other noun. Items (7) and (8)

(7) Tom scolded $Bill_i$ because he_i was annoying.[1]
(8) Tom_i scolded Bill because he_i was annoyed.

are examples of consistent experimental and inconsistent experimental sentences, respectively.

Of the 28 sentence pairs, 16 pairs were judged to have equally compelling pronoun assignments. This was determined by having 52 judges, recruited from two introductory psychology classes at Johns Hopkins, read all 56 sentences and indicate whether the pronoun referred back to the first or second person mentioned in the sentence. At least 91% of the responses to each of the 32 experimental sentences were in the preferred direction. These 16 pairs of sentences with equally strong pronoun assignments to NP1 and NP2 were used in the present experiment. Of the 16 verbs used, nine were strong NP1 types, $p < .01$, 70% or more NP1 completions, and five were strong NP2 types, $p < .01$, 74% or more NP2 completions. The biases of the remaining two verbs were not reliably in the direction of either NP1 or NP2. They were included in the study only to provide a context of continuous variation from NP1 to NP2 bias. Data from these two verbs will not be analysed.

A control sentence was constructed for each experimental one by changing the gender of either the first or second name so that the integrity of the final clause could be maintained. Items (9) and (10)

(9) Sue scolded Bill because he was annoying.
(10) Bill scolded Sue because he was annoyed.

are the control sentences for (7) and (8), respectively. The names in the experimental and control sentences were equated for syllable length. The 64 test sentences are presented in the appendix.

The four sentences for a verb [i.e., experimental consistent (EC), experimental inconsistent (EI), control consistent (CC), and control inconsistent (CI)] were presented separately on slides. A typed sentence appeared on two lines centered one above the other. In order to keep subjects from developing a strategy for pronoun assignment that was based on the location of particular key words, the break between the lines was arranged differently from one verb to the next depending upon the length of the final clause.

There were four blocks of 16 trials. A block consisted of equal numbers of EC, EI, CC, and CI sentences. Within each block, a given verb appeared in one sentence only but always appeared in the same position across blocks. The order of blocks was counterbalanced across subjects. A block of 16 practice trials, reflecting the distribution of the test sentences, was seen first.

Procedure and subjects. The slides were displayed on a screen by a carousel projector in a dimly illuminated room. The subject, seated at a comfortable distance from the screen, indicated his choice for pronoun assignment by saying the appropriate person's name out loud. His verbal output activated a voice relay which stopped a digital clock. The sequence of events on a trial was as follows: (i) the experimenter said "ready"; (ii) approximately 1 second later the slide appeared on the screen activating the timer; (iii) the subject's response terminated the timer; and (iv) the screen was blank for approximately 2 seconds while the experimenter recorded the reaction time (RT). Reaction time was measured from the onset of the slide to the subject's response.

Forty-eight subjects from The Johns Hopkins University were paid for their participation in the 30-minute experiment. Each subject was assigned to one of the 24 possible orderings of the test blocks. They were told that they would see sentences which describe an action and a reason for that action such as

[1] Identical subscripts indicate coreferentiality.

John wrote to Bill because he wanted some information. Their task was to decide whether the pronoun following the word *because* referred back to the first or second person mentioned in the sentence. They were to indicate their choice by saying the appropriate name out loud.

Results

Of the 16 verbs used in the study, 14 were either strong NP1 or strong NP2. The biases of the remaining two verbs were intermediate in value and consequently their data were eliminated. Analyses of variance were performed on each of the remaining 14 verbs separately as well as on the 14 verbs together. There were two fixed factors in all the analyses: control versus experimental sentences and consistent versus inconsistent final clause completions. In the separate analyses the only random factor was subjects, while in the larger analysis verbs nested within the two fixed factors were the second random factor. Each cell of the analysis contained a single data point, and therefore RTs had to be estimated for the 3.3% of trials on which subjects made nonpreferred assignments and for the 1.7% of trials in which the equipment malfunctioned. The method that was used provides a conservative estimate of possible interaction effects (Winer, 1971, p. 48). All analyses reported below were performed on logarithmically transformed RTs; a similar pattern of significant results was obtained with the untransformed RTs. All the reported effects were significant beyond the .05 level.

In general, the preferred noun was chosen faster when the gender of the pronoun matched only one of the two antecedent nouns, F' (1, 89) = 28.92. This was true for 13 of the 14 verbs analyzed separately; for one verb (*confide*) the effect was not reliable. Speed of pronoun assignment was influenced not only by the surface property of gender agreement but also by the lexically marked feature of implicit causality. The preferred noun was

TABLE 1

Mean RTs for Test Sentences

Verbs (bias)	Control sentences		Experimental sentences		Significance level
	Inconsistent	Consistent	Inconsistent	Consistent	
Won (99)	3.399	3.169	4.091	3.910	**
Confessed to (97)	3.071	2.894	3.893	3.435	*
Lied to (96)	3.562	3.019	4.061	3.998	*
Approached (85)	2.612	2.800	2.911	3.395	—*[a]
Questioned (82)	3.192	2.769	3.191	3.492	NS
Sold (78)	3.375	2.812	3.869	3.627	*
Read (77)	3.438	3.289	3.832	3.569	**
Follow (72)	2.716	2.864	3.257	3.665	—*
Confided in (70)	3.075	2.907	3.535	2.838	*
Praised (26)	3.122	3.458	4.430	3.818	NS
Loaned (23)	3.671	3.036	3.843	4.124	*
Envied (23)	3.305	2.729	4.205	3.175	*
Punished (14)	3.142	2.897	3.716	3.387	*
Scolded (12)	2.739	2.569	3.331	3.322	*
Mean RTs	3.228	2.908	3.722	3.586	*

[a] Dash (—), nonpreferred direction.

* $p < .05$.

** $.05 < p < .10$.

chosen faster when the subordinate clause of the sentence established an interpretation that was consistent with the verb's natural bias, $F'(1, 68) = 4.36$. Separate analyses revealed that the effect was reliable for eight of the verbs, marginal for two of them, and nonsignificant for two others. The mean RTs for the test sentences are presented in Table 1. Pronoun assignment was faster in the nonpreferred direction for two NP1 type verbs, *follow* and *approach*. There is a striking similarity between the sentences for these two verbs that may account for this reversal. The NP1 reading for both sentences was of the form *John followed (approached) Bill because he felt suspicious (friendly)*. The form of the NP2 reading was *John followed (approached) Bill because he looked suspicious (friendly)*. These sentences differed from our other experimental sentences in that, according to the normative ratings we obtained for this experiment, the NP2 reading for both verbs [i.e., inconsistent with the verb's bias completion data from Garvey et al. (1976)] was more compelling than the NP1 readings.

Interestingly, the influence of the implicit causality feature was as strong in control sentences as in experimental ones, even though in the former gender agreement was sufficient to determine pronoun assignment. This was reflected in the lack of an interaction between the two fixed factors, $F' < 1$.

The pattern of errors paralleled the RT data. An analysis of variance was performed on the arc sine transform of the proportion of errors made to the 14 verbs obtained by summing error responses across subjects. Not surprisingly, fewer errors occurred when pronoun assignment was constrained by gender agreement than when it was not, $F(1, 13) = 29.65$. Also, fewer errors were made when the direction of causality in the subordinate clause was consistent with the verb's bias than when it was not, $F(1, 13) = 8.76$. The two fixed factors interacted, $F(1, 13) = 5.22$. No errors occurred for CC sentences where implicit causality and gender agreement selected the same reading. Some errors were made on EC sentences where the gender of the pronoun permitted both readings.

Discussion

This discussion focuses on the two major issues raised in the introduction: (1) the effects of verb type on determining coreference and (2) the unit or level at which disambiguation takes place.

1. One of the major social functions of language is to give reasons for actions (Dakin, 1970). Part of such explanations often involves setting up a causal relationship between the participants of the action. A feature intrinsic to the meaning of many verbs seems to influence the direction of this causal relationship. Moreover, this feature corresponds to one of the most pervasive components used in componential analysis of meaning, namely, the semantic feature CAUSE (McCawley, 1971). Given the general assumption that one of the cognitive operations involved in interpreting utterances is the extraction of meaningful components, we have attempted to validate the thesis that causality is represented as a nondiscrete feature implicit in many verbs specifying the causal relationship between the participants of an action. The data support this thesis. Subjects were faster to select an antecedent for a potentially ambiguous relationship that was consistent with the causal relationship set up by the main verb's natural bias. This was true even for sentences in which gender agreement was sufficient to determine pronoun assignment.

Implicit causality is not the only verb-based feature to influence pronoun assignment. Springston (Note 2), has reported that verbs that describe introspective states restrict the assignment of anaphoric pronouns. Specifically, verbs that mark their surface structure object as the experiencer of the emotion, for example, *bored* and *amazed*, as in *John bored him*, restrict assignment of an object position pronoun in a complement construction to the subject of a declarative communication verb such as *told*. For example, the antecedent of

him in *Bill told Harry that John bored him* is clearly constrained to *Bill*, the subject of *told*. However, when the pronoun is the subject of these experiencer verbs the assignment is unconstrained and presents a potential ambiguity as in *Bill told Harry that he bored John*. Here *he* could refer to either *Bill* or *Harry*. A similar but opposite situation obtains when verbs mark their surface structure subjects as the experiencer of the emotion, for example, *like* and *feared*; in this latter case the pronoun is constrained when it is in subject position while unconstrained in object position. Sentences (11) and (12)

(11) Bill told Harry that he liked John.
(12) Bill told Harry that John liked him.

are examples of this effect.

The Experiencer Constraint, as this restriction on coreferentiality has been called, reflects a pragmatic principle, namely, that the person who has experienced an emotional state, a private experience, is in an epistemologically privileged position to make statements about that state. It is much more likely that, in discussing a private experience, the experiencer himself (if present) will be the speaker rather than any other participant in the conversation. These linguistic intuitions have received experimental support. Springston (Note 2) found that subjects were faster to resolve pronoun assignment in constrained sentences such as *Bill told Sue that Mary bored him* than in unconstrained ones such as *Bill told Sue that he bored Mary* even though the Gender Constraint was sufficient to determine pronoun assignment in both.

The Experiencer Constraint can be reinterpreted within the framework of implicit causality. Verbs which mark their surface structure objects as the experiencer of the emotion (e.g., John bored Bill) mark their surface structure subjects as the cause of the emotion (i.e., NP1 type verbs). Conversely, verbs which mark their subjects as experiencer of the emotion (e.g., John feared Bill) mark their objects as the cause of the emotion (i.e., NP2 type verbs). In fact, the verb *fear* was identified as an NP2 type verb in earlier work (Garvey et al., 1976).

Verbs that mark introspective states fall at the subjective end of the classification scheme proposed by Kanouse (1971). Subjective verbs express emotions or opinions. These are mental states that are relatively enduring and not directly observable. Emotions are commonly *elicited* by an outside force and opinions are necessarily *of* something. At the other end of the continuum are manifest verbs that generally express actions and accomplishments. These represent acts *emitted* by subjects that are directly observable and relatively delimited in time. There is some correspondence between this classification and the implicit causality feature. While NP1 type verbs (e.g., *confess*, *win*, *lie*) are generally manifest, NP2 type verbs can be both manifest (*congratulate, punish*) and subjective (e.g., *envy, fear*).

2. In addition to validating our claims about implicit causality, the results we have reported also support the view that ambiguities are normally resolved at clause boundaries. That is, even though the sentence fragment *NP1 V NP2 because pro ...* may be linguistically ambiguous, at a psychological level the assignment of the pronoun may not be problematical at all. A listener will normally use all the contextual information available to assign a single reading to the sentence and reject improbable readings at the end of each clause.

But what of those cases where the bias value of the verb is not sufficiently strong to determine either an NP1 or an NP2 assignment? In these cases the assignment is determined by what has been called parallel function strategy (Sheldon, 1974) that assigns the pronoun coreferential with the NP in the main clause that has the same grammatical function as the pronoun in the subordinate clause. In a recently completed study (Grober et al., Note 1) we have demonstrated the generality of the parallel function strategy in the assignment of anaphoric pronouns in sentences like the ones used in the present report.

In summary, the data we have reported are consistent with the following description of pronoun assignment in a comprehension task. Listeners normally employ a strategy that assigns the pronoun in a subordinate clause coreferential with the NP of the same grammatical function in the main clause provided that the verb in the main clause has not restricted the assignment of the pronoun (and, of course, that gender differences do not eliminate the ambiguity). In most cases, however, the verb will have determined a preferred reading by establishing a causal relation between NPs, minimizing any potential ambiguity of the anaphoric pronoun. This description is consistent with introspective reports of our subjects who were not even aware of the potential ambiguity of pronoun assignment.

Appendix

Sentences Used in Study[a]

EC Muriel won the money from Helen because she was a skillful player.
EI Patricia won the money from Janet because she was a careless player.
CC Christina won the money from Jimmy because she was a skillful player.
CI Benjamin won the money from Carol because she was a careless player.
EC Clinton confessed to Archie because he wanted forgiveness.
EI Dennis confessed to Arthur because he offered forgiveness.
CC Jimmy confessed to Mary because he wanted forgiveness.
CI Cathy confessed to Michael because he offered forgiveness.
EC Katie lied to Sue because she could not reveal the truth.
EI Debbie lied to Pam because she would not understand the truth.
CC Sarah lied to Ken because she could not reveal the truth.
CI Edward lied to Ann because she would not understand the truth.
EC Victor approached Gordon because he felt friendly.
EI Eddie approached Albert because he looked friendly.
CC Robert approached Nancy because he felt friendly.
CI Anna approached Richard because he looked friendly.
EC Roy questioned Anthony because he wanted to learn the truth.
EI Bob questioned Timothy because he hadn't told the truth.
CC John questioned Margaret because he wanted to learn the truth.
CI Lil questioned Frederick because he hadn't told the truth.
EC Cynthia sold the bike to Maureen because she needed the cash.
EI Monica sold the bike to Wendy because she could pay cash.
CC Monica sold the bike to Philip because she needed the cash.
CI Anthony sold the bike to Cathy because she could pay cash.
EC Claire read Sandra the memo because she was proud of it.
EI Ann read Paula the memo because she was mentioned in it.
CC Bess read Michael the memo because she was proud of it.
CI Mark read Marcia the memo because she was mentioned in it.
EC Rhoda followed Doris because she felt suspicious.
EI Diane followed Lois because she looked suspicious.
CC Lorraine followed Gary because she felt suspicious.
CI David followed Lucy because she looked suspicious.
EC Wayne confided in Reggie because he was frightened.
EI Bob confided in Archie because he was understanding.
CC Art confided in Nancy because he was frightened.
CI Fran confided in Bernard because he was understanding.
EC Susan praised Diane because she was responsible for the successful campaign.
EI Michelle praised Lucy because she was pleased with the successful campaign.
CC Gary praised Lois because she was responsible for the successful campaign.
CI Nancy praised David because she was pleased with the successful campaign.
EC Margaret loaned Suzy the book because she wanted to read it.
EI Bernadette loaned Peggy the book because she had finished reading it.

CC Oliver loaned Cathy the book because she wanted to read it.
CI Marjorie loaned Timmy the book because she had finished reading it.
EC Rose envied Mary because she always looked so neat.
EI Anne envied Vicki because she never looked as neat.
CC Ed envied Susan because she always looked so neat.
CI Fay envied Howard because she never looked as neat.
EC Helen punished Cathy because she confessed to shoplifting.
EI Ellen punished Lois because she disapproved of shoplifting.
CC William punished Mona because she confessed to shoplifting.
CI Rita punished Roger because she disapproved of shoplifting.
EC Ronald scolded Joe because he was annoying.
EI Barry scolded Pete because he was annoyed.
CC Susan scolded Mark because he was annoying.
CI Michael scolded Ann because he was annoyed.

[a] EC = Experimental Consistent; EI = Experimental Inconsistent; CC = Control Consistent; CI = Control Inconsistent.

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