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THE TIME COURSE OF PRONOUN COMPREHENSION

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ABSTRACT

Two experiments investigated the time course of pronoun comprehension, and addressed the following questions. How soon, on reading a pronoun, is the retrieval of potential antecedents initiated? And at what point in the sentence is selection of an appropriate antecedent completed, reflecting successful comprehension?

Subjects were presented with sentences one phrase at a time on a computer screen. At certain points during the presentation of the phrases, a single test word appeared. Subjects were required to indicate, by pressing one of two keys, whether the test word had already appeared in the sentence being read. The test word appeared either before a phrase containing a pronoun or after a phrase containing a pronoun. In addition, the test word named either the antecedent of the pronoun or the non-antecedent. Response times to the test words indicated that unambiguous pronouns, which have a unique antecedent, are interpreted very quickly - at least by the time the verb following the pronoun has been read. Conversely, ambiguous pronouns, which require inferences from general knowledge, are still unresolved at the end of the phrase containing the pronoun. The results suggest that the search for antecedents is initiated very quickly, but that selection of a unique antecedent may continue during the reading of subsequent words.

INTRODUCTION

The assignment of pronouns to appropriate antecedents is essential for successful comprehension. Such assignments typically require inferences based on general knowledge (e.g. Ehrlich, 1980; Hirst & Brill, 1980). Hence in the following sentence:

The mother punished her daughter because
she stayed very late at the party.

The pronoun she is linguistically ambiguous. Linguistic rules can only state that, in this sentence, neither the mother nor the daughter can be ruled out as potential antecedents for the pronoun. To interpret the sentence appropriately, the reader has to make inferences from general knowledge about some possible reasons for punishment, to infer that she refers to the

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daughter. Thus, despite the linguistic ambiguity of the sentence, the reader may use pragmatic inferences to derive a plausible and unambiguous interpretation of it. Of course, if the mother were replaced by the father (and her by him) in the sentence above, then the pronoun could be interpreted on linguistic grounds, without the need for pragmatic inferences. Indeed, it has been shown that linguistically ambiguous pronouns do take longer to comprehend than unambiguous pronouns (Ehrlich, 1980).

Despite the interest in the use of such inferences (e.g. Hirst & Brill, 1980), there has been little direct investigation of the time course for the retrieval and selection of an appropriate antecedent. The present experiments address this issue. In particular, they address the following questions: When a reader encounters a pronoun, how soon is retrieval of the antecedent initiated? And at what point in the sentence is a pronoun assigned to the antecedent, thus reflecting successful retrieval and interpretation?

These considerations raise the general question of the extent and kind of processing that may be carried out by a reader while a particular word is being read. Current research indicates that lexical retrieval of a word and some syntactic parsing occur while a word is being read (Frazier & Rayner, 1982; Swinney, 1979). However, in the case of pronouns, all that can be retrieved by reading the word itself is information about number and gender. To interpret a pronoun appropriately, a reader must access and integrate information from another portion of the text in order to select an antecedent that matches the pronoun in number and gender. If the pronoun is linguistically unambiguous, this will yield a unique antecedent. But if the pronoun is linguistically ambiguous, the selection of a single, appropriate antecedent can only be made by the use of inferences based on general knowledge. Thus, although the search for an antecedent may be initiated very quickly when a pronoun is encountered, the selection of a single, appropriate antecedent may not be completed until some point after the pronoun has been read. Further, we might expect that completion of assignment will take longer with ambiguous pronouns than with unambiguous pronouns.

Ehrlich & Rayner (1983) measured eye movements while sentences containing pronouns were being read. They found that with increasing distance between the pronoun and its antecedent there was an increasing delay in the time taken for pronoun comprehension to be completed. However, Ehrlich & Rayner only considered unambiguous pronouns, which may be interpreted without the need for pragmatic inferences. By contrast, Corbett & Chang (1983) investigated sentences containing ambiguous pronouns. They asked subjects to identify test words presented at the end of sentences containing linguistically ambiguous pronouns. Their results suggest that both the antecedent and the non-antecedent are activated at the end of the sentence. However, this result may be due to end-of-sentence integration effects, and not to a failure of successful interpretation of the pronoun.

The present experiments investigated the activation of antecedent information during the reading of the sentences containing either linguistically ambiguous pronouns or unambiguous pronouns. The basic procedure was as follows: Subjects were presented with a series of sentences.

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Each sentence appeared on a computer screen one phrase at a time. In the following example each phrase is on a new line:

John apologised to Anne
at the end of the class (1)
because he regretted (2)
having caused so much trouble.

There were 56 experimental sentences. In 28 of them the first noun phrase was the antecedent of the pronoun. These were called NP1 sentences. (See the example above.) In the remaining 28 sentences, the second noun phrase was the antecedent of the pronoun. These were called NP2 sentences, for example:

Anne scolded John
three times during the class (1)
because he dropped (2)
several books on the floor.

The presentation of the phrases was self-paced: Subjects pressed the space bar of the computer keyboard when they had read and understood the current phrase. Depression of the space bar removed the current phrase and replaced it with the next phrase of the sentence. At some point during the presentation of the phrases, when the subject pressed the space bar, instead of the next phrase coming up immediately, the subject saw a single capitalised word surrounded by asterisks (e.g. ***JOHN***). When presented with this word, the subject had to press one of two keys to indicate whether or not the word had already occurred in the sentence currently being read. This test word was either the antecedent (John in the sentences above) or the non-antecedent (Anne). The time taken to respond to it was the dependent variable. In the experimental sentences, the test word appeared either after the second phrase (position number (1) in the examples above) or after the third phrase (position number (2) in the examples above). These positions correspond to the EARLY and LATE conditions respectively. Thus, there were four experimental conditions: The test word was either the antecedent or the non-antecedent; and the test word position was either early or late. There were 76 filler sentences, 66 of which required "no" responses to the test word, and all of which varied the position of the test word. To encourage comprehension of the sentences, 40% of them were followed by a yes/no question.

The test words in the late position occurred after the phrase containing the pronoun; hence the speed of recognition should indicate whether or not the pronoun's antecedent has been activated. The test words in the early position occurred before the pronoun, and hence served as controls against which to measure the effects of reading the pronoun.

One assumption underlying the use of this task is that the time taken to recognise the test words reflects their presence or absence in the reader's currently active working memory. (See, for example, Ratcliffe, Hockley & McKoon, 1985). A second assumption underlying the measurement of recognition

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times is that the primary task for the reader is the interpretation of the pronoun (and hence the sentence). Thus, the effects of this primary task will also be reflected in the time taken to recognise the test words.

EXPERIMENT ONE: UNAMBIGUOUS PRONOUNS

In experiment one, unambiguous pronouns were used. With these sentences, we would expect that the antecedent would be retrieved relatively quickly after the pronoun has been read, and certainly by the end of the phrase containing the pronoun. Thus, when the test word is the antecedent, recognition times should be faster than when the test word is the non-antecedent, but only in the late condition. The results are shown in Table 1. Table 1 also shows the percentage of recognition errors in parentheses.

Analyses of variance on the recognition times indicated that, overall, test words in NP2 sentences were recognised faster than test words in NP1 sentences. $F1=4.45$, $df=1,31$, $p<.05$; $F2=3.39$, $df=1,54$, $p<.07$. The only other significant result was an interaction between type of test word (antecedent vs. non-antecedent) and position of test word (early vs. late). $F1=4.5$, $df=1,31$, $p<.05$; $F2=3.12$, $df=1,54$, $p<.08$. Observation of Table 1

TABLE 1: MEAN RECOGNITION TIMES (IN MSECS) AND RECOGNITION ACCURACY FOR ANTECEDENT AND NON-ANTECEDENT PROBE WORDS FOR THE TWO TYPES OF SENTENCE IN THE TWO PROBE POSITIONS (Unambiguous Pronouns)

	Early				Late			
	Antecedent		Non-Antecedent		Antecedent		Non-Antecedent	
	RT	PC	RT	PC	RT	PC	RT	PC
NP1 Sentences	1014	(6.7)	1020	(2.7)	1011	(8.5)	1052	(4.5)
NP2 Sentences	1000	(2.7)	982	(6.3)	978	(1.3)	1035	(8.0)
Means	1007	(4.7)	1001	(4.5)	994	(4.9)	1043	(6.2)

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indicates that, with both types of sentence, recognition times to the antecedent test words are faster than recognition times to the non-antecedent test words, but only in the late position. Thus the results support the initial prediction. Unambiguous pronouns, which can be interpreted without the use of inferences, appear to be fully interpreted by the time the verb following the pronoun has been read. This seems to render the non-antecedent less accessible. Hence, the basic finding supports the view that the search for an antecedent is initiated very quickly. The selection of a unique antecedent is completed by the time one word after the pronoun has been read.

However, this observation was only made on unambiguous pronouns. Since ambiguous pronouns invariably require the use of inferences from general knowledge for the selection of a unique antecedent, we might expect that this process would be completed less quickly than with unambiguous pronouns. Experiment two investigated this issue.

Observation of the errors in Table 1 presents a slightly different picture. Most errors seem to occur with the antecedent test word in NP1 sentences and with the non-antecedent test word in NP2 sentences. (The first noun phrase in both cases). Analyses of variance indicated that this was, indeed, the case. The only significant effect was an interaction between type of sentence (NP1 vs. NP2) and type of test word (antecedent vs. non-antecedent). $F_1=21.6$, $df=1,28$, $p<.01$; $F_2=10.76$, $df=1,48$, $p<.01$. (Three subjects were excluded from the F_1 analysis because they made no errors. Three sentences were excluded from the F_2 analysis because they elicited no errors). Thus it appears that there are more errors when the first noun phrase is the test word. One interpretation of this finding is that there is a greater likelihood that the first noun phrase will have been forgotten by the time the test word appears.

EXPERIMENT TWO: LINGUISTICALLY AMBIGUOUS PRONOUNS

Experiment two used linguistically ambiguous pronouns. Thus, in the example sentences above, John was replaced by Joan, and the pronoun was changed to she. In prior pilot work, the first three phrases of each sentence were presented to five independent judges. In all the experimental sentences, the intended antecedents were unanimously selected as the referents of the pronouns by these judges. Thus, despite the linguistic ambiguity, there was complete consensus on the interpretation of each pronoun by the end of the phrase containing the pronoun. The pronouns were, therefore, "pragmatically" unambiguous. Nevertheless, with these sentences, the pronouns cannot be interpreted without the use of pragmatic inferences.

If the use of these inferences involves the retrieval of both potential antecedents which are checked for pragmatic plausibility, then we might expect that the activation of these two alternatives would interfere with the recognition of the test words (see, e.g. Corbett, 1984). The inferencing required to determine the interpretation of the pronoun is likely to interfere

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TABLE 2: MEAN RECOGNITION TIMES AND RECOGNITION ERRORS FOR ANTECEDENT AND NON-ANTECEDENT PROBE WORDS FOR THE TWO TYPES OF SENTENCE IN THE TWO PROBE POSITIONS (Ambiguous Pronouns)

	Early				Late			
	Antecedent		Non-Antecedent		Antecedent		Non-Antecedent	
	RT	PC	RT	PC	RT	PC	RT	PC
NP1 Sentences	1001	(2.6)	988	(4.6)	1009	(9.2)	994	(5.1)
NP2 Sentences	926	(4.1)	973	(4.1)	990	(5.6)	1043	(6.1)
Means	963	(3.4)	980	(4.3)	999	(7.4)	1018	(5.6)

with the secondary task of identifying the test word. Hence recognition times should be slow in the late position (after the pronoun) relative to the early position (before the pronoun). Table 2 shows the results. Again, the percentage of recognition errors are presented in parentheses.

Analyses of variance on the data in Table 2 indicated that, as predicted, test words in the late position took longer to recognise than test words in the early position. $F_1=16.84$, $df=1,27$, $p<.01$; $F_2=5.56$, $df=1,54$, $p<.05$. Analyses of the error data also support the prediction. For both types of sentences, it was more difficult to identify the test word when it occurred in the late position as opposed to the early position: More errors of recognition occurred when the test word occurred late rather than early. $F_1=14.1$, $df=1,22$, $p<.01$; $F_2=7.5$, $df=1,52$, $p<.01$. (Five subjects were discarded from the F_1 analysis because they made no errors. One sentence was excluded from the F_2 analysis because it elicited no errors). An analysis on the number correct rather than the number of errors yielded the same significant finding. The effect of test word position on the recognition times appears larger in the NP2 sentences than in the NP1 sentences. However, the interaction between test word position and type of sentence is only significant in the subjects analysis ($F_1=4.73$, $df=1,27$, $p<.05$), and not in the sentences analysis ($F_2 < 1$).

The data in Table 2 also suggest an overall benefit in recognition times for antecedent test words relative to non-antecedent test words.

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However, this difference was not reliable. $F_1=2.07$, $df=1,27$; $F_2=1.11$, $df=1,54$. It is possible, though, that such a benefit for antecedent test words is confined to the NP2 sentences. However, the interaction between type of sentence and type of test word was only marginally significant. $F_1=3.09$, $df=1,27$, $p<.09$. $F_2=2.90$, $df=1,54$, $p<.09$.

Thus the pattern of results supports the view that ambiguous pronouns are not comprehended as readily as unambiguous pronouns. This is the case even though the prior pilot studies indicated that the sentences were always given the intended interpretation. It thus appears that the inferencing required to select a unique antecedent continues while subsequent words in the sentence are being read.

DISCUSSION

Overall, the results of Experiment 1 suggest that the interpretation of unambiguous pronouns is completed quite rapidly, and this reflects the ease with which the antecedent can be retrieved. Thus, initiation of the search process must begin very quickly since, with these unambiguous pronouns, comprehension appears to be complete by the time the verb following the pronoun has been read. Conversely, the results of Experiment 2 suggest that the interpretation of ambiguous pronouns is still unresolved when the verb following the pronoun has been read. In this instance, therefore, it appears that interpretation of the pronoun continues while subsequent words are being read. However, there are two points that remain unresolved by these experiments. The first concerns the precise point in the text when the assignment of an unambiguous pronoun is completed. The present Experiment 1 only tested for the activation of antecedent information after the verb. It may well be the case, though, that assignment is completed as soon as an unambiguous pronoun (which requires a minimal search for an antecedent) is encountered. However, it is also possible that these unambiguous pronouns are comprehended by means of inferences from general knowledge, even though such inferences are logically unnecessary for the selection of a unique antecedent. (See, for example, Hirst & Brill, 1980; Stevenson & Vitkovitch, to appear). Hence, there may also be some delay in the completion of assignment for these unambiguous pronouns. The second point is that it remains unclear exactly how long it takes for ambiguous pronouns to be fully comprehended. All we can say from Experiment 2 is that the process is not completed when the verb following the pronoun has been read. Investigation of these two issues is currently in progress.

In general, these results support the proposition that processing is not completed immediately whenever the retrieval of relevant information is sufficiently complex (for example, when there is a need for inferences as in Experiment 2, or when a lengthy search process is required as in Ehrlich and Rayner, 1983). In these circumstances, we are likely to find cases where the processing continues while subsequent words are being read. More generally, it may well be the case that processing time increases whenever higher order integrative processes are involved; processes, for example, which are

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necessary to construct a discourse model. There is no reason to suppose that such higher order processes, which are necessary for the full comprehension of a particular word, will be completed while that word itself is still being read.

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