

Effects of Prior Context upon Lexical Access during Sentence Comprehension

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The effects of disambiguating prior contexts upon the processing of lexical ambiguities in sentences were investigated. Subjects listened to lexically ambiguous (or unambiguous control) sentences under one of three conditions: a neutral prior context, a disambiguating context occurring immediately prior to the ambiguity, or a disambiguating context occurring in a prior sentence. Subjects monitored for phonemes which occurred immediately after each ambiguous or control word. In the neutral context condition, reaction times were significantly longer following ambiguous words than following their controls. For both the immediate and distant context conditions, the ambiguity-control contrast was not significant. The results were interpreted as support for a model of sentence processing in which a prior disambiguating context serves to restrict access to readings for an ambiguous word.

When we understand what a person has said we do not understand just isolated words or even isolated sentences. Rather, the interpretation given a particular word or sentence is determined, in part, by the context in which it occurs. But, although there appears to be general agreement that context affects what interpretation is obtained, there is little agreement on how or when this effect is produced.

One basis for such context effects lies in the fact that many linguistic stimuli—most words, and many sentences—are ambiguous when taken in isolation. (This is, of course, equally

true of many nonlinguistic stimuli.) Study of the conditions under which one interpretation rather than another is selected for an ambiguous lexical item will hopefully lead us to discover something about the general processes by which contextual information is brought to bear on this selection.

There are two basic conditions which need to be distinguished in studying the influence of contextual cues upon lexical ambiguity resolution—one in which the disambiguating context precedes the ambiguity and one in which the context follows the ambiguity. In the latter condition, the sequence of processing events appears to be rather straightforward and, in many ways, is similar to conditions in which no biasing context occurs: Most likely, the several readings of the ambiguity are accessed, followed by access of the disambiguating context (if any is present) which is then used to aid in the selection of a single, related reading for the ambiguity. While the details of such a process are far

This research was supported in part by Research Fellowship 1-FOI-MH54551-01 from NIMH and by Grant OEG-0-72-3941 from NIE. The authors are indebted to Donald J. Foss for his valuable criticism, counsel, and advice and to Judith S. Evans for her comments and assistance with earlier versions of this manuscript. Requests for reprints should be sent to David A. Swinney, Psychology Department, Tufts University, Medford, Massachusetts 02155.

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from resolved, the current evidence clearly supports this basic sequence; the presence of a lexical ambiguity in a neutral sentence has been reliably shown to momentarily increase processing complexity (Foss, 1970; Garrett, 1970; Foss & Jenkins, 1973) and this increased processing load, presumably resulting from processing the several readings for the ambiguity, is quickly reduced when a disambiguating context occurs following the ambiguity (Lackner & Garrett, 1972; Caplan, Note 1).

However, the more interesting condition is the one in which the context precedes the ambiguity. There are two general classes of possible explanations for such context effects, and explanations of effects from other context conditions merely constitute a subset of these possibilities. Following Foss and Jenkins (1973), we will refer to the first of these as *prior decision hypotheses* (see also Conrad, 1974; Hogaboam & Perfetti, 1975; Schvaneveldt, Meyer & Becker, in press). These hold that a prior context biases the interpretive process before the ambiguity itself is encountered. Such processes may be thought of as affecting or directing access of readings for the ambiguity, perhaps allowing only a single reading ever to be accessed. This appears to correspond to the general notion of expectancy which has appeared in many theories of perception.

The second class of hypotheses may be characterized as *post decision hypotheses*. These hold that a prior context produces its effect in the same manner as a context which follows an ambiguity. That is, the prior context influences the interpretation of an ambiguity only after all readings are accessed; it aids in the selection of an appropriate reading to retain from those accessed, but does not affect the access process itself.

Somewhat surprisingly, the available data do not strongly favor either class of hypothesis. The strongest experimental support for a prior decision hypothesis comes from a series of experiments by Meyer and his associates

(Schvaneveldt et al., in press; Meyer, Schvaneveldt, & Ruddy, Note 2; Meyer, Note 3). Their general experimental paradigm involves visual presentation of sequences of letter strings for which subjects make word-nonword judgments. Schvaneveldt et al., for example, presented three-word sequences in which the middle word was ambiguous and the first and last words were related to readings of the ambiguity. When the first and last words were related to the same reading (e.g., *heavy-light-weight*), reaction time to the last word was facilitated relative to a condition containing an unrelated last word. However, when the first and last words were related to different readings of the ambiguity (e.g., *dark-light-weight*), no facilitation was obtained. They interpreted this as suggesting that the first word caused only the related reading of the ambiguity to be activated.

It is, however, not clear whether or not, or how, the studies by Meyer and his associates bear on questions concerning context effects in normal language comprehension. It may well be that the characteristics of the word-nonword task encourage subjects to adopt special processing strategies of limited generality. Nonetheless, the results of these studies do suggest that there are some circumstances in which a prior context may be used to restrict access of lexical information about an ambiguity's readings.

Other experiments appear to lend more support to some form of post decision hypothesis. For example, Conrad (1974), using a variant of the Stroop task, presented subjects with sentences containing lexical ambiguities and prior disambiguating contexts. Each sentence was followed by the visual presentation of a word printed in colored ink, and reaction times to name the color of the ink were recorded. The word was either the ambiguous word from the preceding sentence, a word related to the reading of the ambiguity appropriate to the disambiguating context, or a word related to the inappropriate reading. Conrad found that the magnitude of

interference in color naming was the same for both appropriate and inappropriate words, suggesting that both readings had been accessed.

However, it, seems likely that Conrad's task was one which tended to draw subjects' attention to the presence of the ambiguous words and to their several readings. The experiment used a within-subjects design, each subject receiving all context-ambiguity pairings of each ambiguity. Much as in the Meyer studies, this may well have led the subjects to adopt strategies different from those involved in normal sentence comprehension. (A similar problem exists for the Hogaboam & Perfetti, 1975, experiment, which also appeared to support a post decision hypothesis.)

The most persuasive evidence for a post decision hypothesis comes from an experiment by Foss and Jenkins (1973). In an earlier experiment, Foss (1970) found that reaction time to monitor for a phoneme target which occurred shortly after an ambiguous word in a sentence was longer than that following an unambiguous control word. Assuming that the increased reaction time reflected an increase in processing load resulting from processing the ambiguity's several readings, Foss and Jenkins reasoned that if a prior decision hypothesis holds, then the presence of a context should cause the ambiguity-control differences to disappear. They presented subjects with sentences containing ambiguous or control words, half of which contained disambiguating contexts preceding the ambiguities or their controls, the other half containing neutral contexts. Monitor reaction times were significantly longer following the ambiguous words than following their controls, but there was no significant interaction between this effect and the context condition. Since the presence of a prior disambiguating context did not significantly reduce the ambiguity-control difference, the data appear to support the post decision hypothesis. A subsequent study by Cutler and Foss (Note 4), in which the number of words of disambigu-

ating context was varied, yielded essentially the same results.

Thus, the preponderance of evidence seems more consistent with a post decision hypothesis than with a prior decision hypothesis. That is, it would appear that a context preceding an ambiguity produces its effect (at least under some circumstances) in the same manner as a context which follows the ambiguity; it affects the selection of a reading from among those already accessed. The question which remains is whether or not the prior decision hypothesis has been given a fair and adequate test.

Logically, the situation is that of evaluating an existence claim. We know that there must be a process like that specified by the post decision hypothesis, for such a process must be involved in cases where the pertinent context follows the ambiguity. The question, then, is whether there is an additional process that can, at least under some conditions, be invoked when the context precedes the ambiguity. The general strategy when trying to find evidence for the existence of a process or property is to try to find the most favorable set of conditions for its appearance. We suggest that the available experiments have failed to do that.

Whether or not the effect predicted by the prior decision hypothesis occurs seems likely to depend upon the nature of the relationship between the context and the ambiguity. There is, unfortunately, no well-developed scheme for describing such relationships. We suggest, however, that there are at least two aspects of the relationship which are likely to be important. One, which we will refer to as the selectivity aspect, is the ability of a context to be used as a basis for selecting an appropriate reading from among possible readings of an ambiguity *after* those readings are known. The main consideration here seems to be the ability of a context to eliminate readings from consideration, perhaps on a basis such as conflicting semantic characteristics. For example, *gas* appears to be highly

selective for one reading of *pipe*. On the other hand, *black* appears not to be selective for any reading of *pipe*.

More important, however, is a second aspect of the context-ambiguity relationship: the ability of a context to *predict* one reading even before the possible readings are known. This relationship is based on the notion that access to information for a lexical item includes, in some form, access to information about closely related words and concepts. For example, if one considers the set of words or readings associated with a context word like *wooden*, it seems unlikely that any reading of *bat* would enjoy a prominent place in that set, even though *wooden* is clearly selective of the "baseball" reading and eliminates the "flying mammal" reading once *bat* is known. *Baseball*, on the other hand, appears to exhibit a rather stronger predictive relationship with one reading of *bat*.

It seems reasonable to suppose that if a prior decision process operates at all, it will operate only when the context bears a strong predictive relationship with one reading of the ambiguity. While we do not know how to assess such relationships rigorously, inspection of the materials used in the experiments to date suggests that many, if not most, of the context-ambiguity pairings used have held only weak predictive relationships. In fact, many appear to involve only weak selective relationships.

The present experiment was designed to evaluate the effects of prior disambiguating contexts under conditions as favorable to demonstrating the existence of a prior decision effect as we could devise. To this end, we attempted to construct context-ambiguity pairings exhibiting strong predictive (and, where possible, selective) relationships.

A secondary consideration concerned the temporal relationship between context and ambiguity. It seems reasonable, as Foss and Jenkins (1973) suggest, that this variable would modulate the effectiveness of a prior context. Meyer et al., (Note 2) found that

contextual facilitation in the word-nonword task diminished as the interval between context and target increased, asymptoting at 4 sec. While it seems reasonable that a close temporal relationship between context and ambiguity might facilitate the occurrence of a prior decision effect, as suggested by the Meyer data, it is possible to construct an argument that temporal proximity would prevent such an effect. If we assume that some time is necessary for the processing of the context itself, then, when the context immediately precedes the ambiguity, the context may not have been sufficiently processed in time to exert any influence on the access process for the ambiguity. It is interesting to note that several of the experiments which have failed to find evidence of the prior decision effect have used contexts which immediately preceded the ambiguity.

A final consideration concerned the effects of syntactic processing upon these context effects. Evidence has been accumulating for some time that the clause, or deep-structure sentoid, is an integral unit in comprehension processing (see, e.g., Bever, Lackner, & Kirk, 1969; Caplan, 1972). If, as Caplan's (1972) results suggest, material from a completed clause is shifted out of working memory, then a context in a clause prior to that containing the ambiguity might not be available to affect access of the ambiguity's readings in the manner predicted by the prior decision hypothesis. On the other hand, if, as Bever, Garrett, and Hurtig (1973) suggest, decisions about the lexical readings and syntax of a clause are not resolved until the end of that clause, then a context must necessarily be in a clause prior to that containing the ambiguity in order to affect the access of its readings.

To evaluate these possibilities, the materials were constructed such that identical disambiguating contexts could occur either immediately prior to the ambiguity or, more remotely, in a prior clause. Processing load was assessed immediately following the ambiguities (or their unambiguous controls)

with the phoneme monitor task. In the absence of a disambiguating context, monitoring reaction time should be longer for sentences containing ambiguous words than for ones containing unambiguous control words. The prior decision hypothesis predicts that this difference will disappear in the presence of a prior disambiguating context.

METHOD

Design and Materials

Thirty sets of sentence pairs (two sentences presented sequentially) were constructed, each pair having six variations. The six variations were characterized by two factorially combined variables: Ambiguity and Prior Context.

The Ambiguity variable was comprised of two conditions: inclusion of either an ambiguous word or an unambiguous control word which was roughly synonymous with one reading of the ambiguity. These words were all nouns and always appeared in the predicate of the second sentence of each sentence pair. Ambiguous and control words appearing in the same sentence were matched for frequency, using the Kucera and Francis (1967) norms, and for length in syllables.

The Prior Context variable was comprised of three conditions: either *no* disambiguating context, an *immediate* disambiguating context, occurring in the second sentence of the pair, one to three syllables before the ambiguity, or a *distant* disambiguating context, identical to the immediate context, but occurring in the first sentence of the pair, 10-40 syllables prior to the ambiguity. All disambiguating contexts were judged by two judges to represent strong predictive relationships to one reading of their associated ambiguities. They generally also exhibited strong selective relationships with the same readings.

Thirty-eight subjects from the same population as those in the main experiment were asked to give the first interpretation they thought of upon hearing the sentence-

pair versions containing ambiguities but no disambiguating contexts. The Maximum proportion for any one reading was .68, indicating that, in the absence of a disambiguating context, the ambiguities were all relatively unbiased.

The phoneme monitor target for each sentence pair was a word-initial phoneme in the same clause as, and never more than two words following, the ambiguity. The target was the same for all six variations of each sentence pair, but varied across the different pairs.

The six variations of one sentence pair are presented in Table 1. The ambiguous (or control) word in each is italicized, as is the phoneme monitor target.

Six tape recordings were made from these materials. Each contained one variation of each of the 30 sentence pairs, the six variations being equally represented on each tape. All tapes also contained identical filler sentence pairs, randomly interspersed among the test sentence pairs. For 20 of the filler pairs, a monitor target occurred near the beginning of the second sentence of the pair. In an additional 20 filler pairs, the monitored-for target never occurred. Both types of fillers were included to prevent anticipation of the target locations in the test sentence pairs.

A 1000-Hz signal was placed on the tape coincident with the onset of each monitor target. These signals, inaudible to the subjects, were used to start the timing mechanism which recorded monitoring reaction times.

In sum, each tape contained 70 sentence pairs, 30 of these being experimental sentence pairs, the remainder being filler pairs. The experimental pairs were arranged across tapes in a mixed between-within design with two within-subjects variables (Ambiguity vs Control and No Context vs Immediate Context vs Distant Context) and one between-subjects variable (Groups). The latter resulted from the counterbalancing of the assignment of sentence pairs to conditions across tapes.

TABLE I
SAMPLE SENTENCE-PAIR VARIATIONS

Disambiguating context	Ambiguity condition	
	Ambiguous	Unambiguous
None	Rumor had it that, for years, the government building had been plagued with problems. The man was not surprised when he found several <i>bugs</i> in the corner of his room.	Rumor had it that, for years, the government building had been plagued with problems. The man was not surprised when he found several <i>insects</i> in the corner of his room.
Immediate	Rumor had it that, for years, the government building had been plagued with problems. The man was not surprised when he found several spiders, roaches, and other <i>bugs</i> in the corner of his room.	Rumor had it that, for years, the government building had been plagued with problems. The man was not surprised when he found several spiders, roaches, and other <i>insects</i> in the corner of his room.
Distant	Rumor had it that for years the government building had been plagued with spiders, roaches, and other problems. The man was not surprised when he found several <i>bugs</i> in the corner of his room.	Rumor had it that for years the government building had been plagued with spiders, roaches, and other problems. The man was not surprised when he found several <i>insects</i> in the corner of his room.

Subjects

Ninety undergraduates from The University of Texas at Austin participated in partial fulfillment of a psychology course requirement. Fifteen subjects were randomly assigned to each of the six groups. As there was a potential of five responses per condition, it was decided a priori to eliminate any subject who yielded fewer than two scores for any condition. Eight subjects were eliminated on this basis, and each was replaced by the next subject tested.

Procedure

The subjects listened through headphones to the 70 binaurally presented sentence pairs. For each pair, the subjects heard a trial number, followed by a specification of the target phoneme for that pair. This was followed by the word "ready," which was then followed by the sentence pair. The subjects were instructed to listen to the sentences and to press a button as soon as they heard a word beginning with the specified target phoneme. Following each trial, they were also instructed

to indicate, on a five-point scale, how closely they felt the two sentences of the pair were related. This task was included to help ensure that the subjects would attend closely to both sentences in a pair.

At the end of the experimental session, subjects were questioned concerning whether or not they had noticed the presence of ambiguities in the materials. These data were used in a post hoc analysis, described below.

RESULTS

Six mean reaction times were computed for each subject, one for each of the six experimental conditions. Reaction times longer than 2200 msec were omitted from these computations; previous research has suggested that such lengthy reaction times often reflect a reprocessing of the sentence or response to a phoneme other than the target (see Foss & Jenkins, 1973).

Table 2 presents the means of the mean reaction times for the six conditions, collapsed across groups. It is apparent that, in the conditions with no disambiguating con-

TABLE 2

MEAN REACTION TIMES, IN MILLISECONDS, FOR THE SIX CONDITIONS OF THE AMBIGUITY-BY-CONTEXT INTERACTION

Ambiguity condition	Context condition		
	None	Immediate	Distant
Ambiguous words	556	527	517
Nonambiguous words	514	540	495

text, the mean reaction time for sentences containing ambiguities is longer than for their unambiguous controls. Further, this difference appears to be far larger than the ambiguous-control differences for either the immediate or the distant context conditions. Inspection suggests, then, that the results correspond to the prediction derived from the prior decision hypothesis.

An analysis of variance revealed that the main effect for the context variable was significant, $F(2, 168) = 5.42, p < .01$, indicating that reaction times differed significantly among the three context conditions. The main effect for ambiguity was not significant, $F(1, 84) = 3.48, p > .05$. More important, however, is the fact that the ambiguity-by-context interaction was significant, $F(2, 168) = 4.08, p < .025$, indicating that the ambiguous-control difference was larger for the no context condition than for the other two context conditions. This interaction was still significant when analyzed using *min* $F(2, 114) = 3.18, p < .05$, indicating that the interaction obtains both across subjects and across materials.

The main effect for groups was not significant, $F(5, 84) = 1.85, p > .05$. There were, however, two significant interactions involving this variable-groups by ambiguity, $F(5, 84) = 9.09, p < .01$, and groups by ambiguity by context, $F(19, 168) = 5.04, p < .01$. These effects, particularly the latter, are primarily attributable to differences in the magnitude of the context-by-ambiguity interaction for

different groups. Comparison of context and ambiguity effects across groups involves comparing reaction times obtained on different sentence pairs and, hence, to different phoneme monitor targets. Savin and Bever (1970) and Foss and Swinney (1973) have both shown that reaction times typically vary widely for different phoneme targets. Consequently, the fact that these interactions were significant is neither surprising nor cause for concern.

It is, of course, the nature of the ambiguity-control differences in the three context conditions that is of primary concern, for the prior decision hypothesis predicts a difference for the condition with no disambiguating context and no difference for the immediate and distant context conditions (assuming, of course, that the two are equally effective). To examine these predictions, planned *t* tests were performed on the ambiguity-control comparison for each context condition. For the no context condition, reaction times were significantly longer for the ambiguous sentence pairs than for their controls, $t(89) = 2.30, p < .025$. This replicates the ambiguity effect found in previous experiments and indicates that the ambiguities used here were capable of producing the effect. For the immediate and distant context conditions, reaction times were not significantly longer for the ambiguous pairs than for the control pairs, $t(89) = -.20$ and 1.57 , respectively.

Thus, the results are consistent with the prior decision hypothesis: In the absence of a disambiguating prior context, occurrence of an ambiguity produces an increase in processing load; in the presence of a disambiguating prior context, however, this effect disappears. Further, the disappearance of the ambiguity effect occurs both when the context immediately precedes the ambiguity and when it is considerably further removed.

We may note in passing that Foss and Jenkins (1973) have suggested that the processing of ambiguities might be different for those subjects who were aware of their

presence and for those who were not. Their own data lent no support to this conjecture, and neither do ours. Twenty-seven subjects reported having been aware at some point that some of the sentences contained ambiguities: the remaining 63 reported that *they* had been unaware of this fact throughout the experiment. While the subjects who were aware responded somewhat faster than those who were not, the patterns of reaction times for the six conditions were remarkably similar for the two groups. This fact was borne out by an unequal-N analysis of variance in which the ambiguity-by-context interaction was significant, $F(2, 176) = 3.49, p < .03$, but the awareness-by-ambiguity-by-context interaction did not approach significance, $F(2, 176) = .28$.

DISCUSSION

The present results have yielded an effective demonstration of the existence of a prior decision effect: At least some types of prior disambiguating contexts can eliminate the processing load effect typically obtained following an ambiguity. Thus, it appears that there are situations in which contexts place selective constraints upon the information which is accessed for an ambiguous word.

As we argued in the introduction, this effect appears to involve processes different from those used when the disambiguating context follows the ambiguity. In addition, the fact that previous experiments have failed to obtain the effect merely underlines the point that only certain of the possible types of disambiguating prior contexts will produce a prior effect. The distinction drawn earlier between strong predictive contexts and contexts which are merely selective is, at best, only vaguely suggestive of the nature of the necessary and sufficient conditions for the occurrence of this effect. However, one distinction to consider in building a model of this process is related to the difference between information that is directly and immediately accessed by a

search based on a word's phonetic code and other information that may be derived directly and by inference, once that access process has occurred. For example, the fact that most doctors are more than 2 ft tall can be derived from general knowledge about doctors. But, it seems unlikely that this is the sort of information that is directly and regularly available upon accessing the meaning of the word doctor. It seems likely that only semantic information which is directly and immediately accessed for a context word and which is related to similar information about the ambiguous word is likely to produce the effect we have found here.

Relatedly, whatever the nature of the necessary context-ambiguity relationships for semantically directed lexical access, the present data suggest that it can be produced by a single word of context. Many of the contexts in this experiment were single words, and inspection of the data suggests that these contexts yielded the same effects as did multiword contexts. It seems likely that increasing the number of context words will increase the likelihood that any one of them would hold the necessary relationship with the ambiguous word, but it seems unlikely that increasing the number of context words, each of which was individually insufficient, could produce the effect (cf. Cutler & Foss, Note 4).

Our results indicate that the prior decision effect can be obtained both when the context immediately precedes, and is in the same clause as, the ambiguity, as well as when the context precedes the ambiguity by a considerably greater period of time and occurs in a previous sentence. The effectiveness of the distant context is somewhat surprising in view of Meyer et al.'s finding that contextual facilitation was minimal for intervals of over 4 sec. The discrepancy most likely lies in the difference between a situation in which one is dealing with isolated words and a situation which more closely approximates connected discourse. Intuitively, we suspect that neither the amount of time (within some limits, of

course) nor the number of structural decisions that intervene between the pertinent context and the ambiguity is of prime importance in producing this effect during sentence comprehension. What seems more likely to be of importance is whether or not the hearer treats the material containing the context as relevant to that containing the ambiguity; under such circumstances, such as might occur under conditions involving a common topic, it seems likely that processing strategies will call for the interaction of material in the manner suggested by the prior context effect.

In sum, the present experiment has demonstrated the existence of an effect whose existence was in doubt. While we do not yet know much beyond the general nature of context-ambiguity relationships which produce this effect, and the apparent fact that it is relatively long-lived and independent of structural decisions, we do know that questions addressed to further description of the conditions under which the effect obtains are worth asking.

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(Received May 5, 1976)