

## Syntactic Context and Lexical Access

Michael K. Tanenhaus and Suzanne Donnenwerth-Nolan  
*Wayne State University, Detroit, Michigan, U.S.A.*

Recent studies demonstrating that multiple meanings of an ambiguous word are initially accessed even when only one reading is syntactically appropriate with the preceding context can be criticized on at least two grounds. First, many of the syntactic contexts used were not truly restrictive, and, secondly, subjects may not have had time to integrate the context before processing the ambiguous word. In the present study, subjects listened to a sentence ending in an ambiguous word and then made a lexical decision to a target related to either the appropriate or inappropriate reading. Contexts were completely restrictive, and a pause was introduced between the context and the ambiguous word. Multiple access still obtained, providing further support for the claim that lexical access is not guided by syntactic context.

### Introduction

In several important papers Forster (1976, 1979) has proposed that the language comprehension system is composed of a set of autonomous processing modules each of which performs a subset of the processes necessary for comprehension. A module functions autonomously in that when given an input it will always compute the same output regardless of the states or operations of other modules. Processing modules hypothesized by Forster include a lexical processor, a syntactic processor, and a message processor. Forster's proposals run counter to the heavily interactive flavour of a number of recent models of spoken word recognition. For example, in the cohort model developed by Marslen-Wilson (Marslen-Wilson and Welsh, 1978, Marslen-Wilson and Tyler, 1980) semantic and

---

Requests for reprints should be sent to Michael K. Tanenhaus, Psychology Department, University of Rochester, Rochester, New York 14627, U.S.A.

This research was partially supported by NSF grant IST-80-12439. A preliminary version of this paper was presented at the Midwestern Psychological Association Meetings held in Chicago, May 3-6, 1983. We wish to thank Dennis Elya for assistance in preparing materials and testing subjects and Gary Dell and Margery Lucas for helpful comments on the manuscript. We have also benefited from discussions with Mark Seidenberg about the lexical decision task. Suzanne Donnenwerth-Nolan is now at the Department of Psychology at New York University.

syntactic information combine with phonetic information during word recognition such that less phonetic input is needed to recognize a word when it is presented in context. Similar claims are made by Elman and McClelland (1984) in their recent extension to spoken language of the parallel interactive model originally developed by McClelland and Rumelhart (1981) for visual word recognition.

Evidence in support of Forster's claims comes from recent studies of the processing of ambiguous words in context. Swinney (1979) and Tanenhaus, Leiman, and Seidenberg (1979) conducted cross-modal lexical priming studies in which subjects responded to targets related either to the contextually biased or to the unbiased reading of an ambiguous word in a spoken sentence. In Swinney's study, the ambiguous word was preceded by a context in which only one reading of the word was pragmatically plausible (e.g., John saw several spiders, roaches and other *bugs*) and subjects made lexical decisions to targets related to either the plausible (insect) or implausible (spy) reading of *bug*. In Tanenhaus et al.'s study, an ambiguous word was preceded by a context in which only one reading was syntactically possible (e.g., They all *rose*), and subjects named targets related either to the appropriate (stood) or to the inappropriate (flower) reading. In both studies responses to targets related to either the biased or the unbiased reading of the ambiguous word were facilitated when the target immediately followed the ambiguous word, indicating that both meanings were initially accessed. When the target was delayed by several hundred msec, only targets related to the biased reading were facilitated. Thus multiple readings of ambiguous words appear to be initially accessed regardless of context, and context is subsequently used to select the appropriate reading.

The ambiguity results with pragmatically biasing contexts have since been replicated and extended in a number of studies, including Onifer and Swinney (1981), who demonstrated that multiple meanings are initially accessed regardless of whether the context biases the more or less frequent reading of an ambiguous word, and Lucas,<sup>1</sup> who demonstrated initial access of the unbiased reading in contexts where the preceding context alone was sufficient to facilitate lexical decisions to targets related to the biased reading.

Seidenberg, Tanenhaus, Leiman, and Bienkowski (1982) also found initial access of multiple meanings of ambiguous words in pragmatically biasing contexts. However, they also found that only the contextually biased meaning was accessed when the ambiguous word was closely preceded by one or more associatively related words (e.g., The *smoker* lit the *pipe*). The selective access obtained in these lexical contexts does not,

however, violate Forster's autonomy claims, since it can be attributed solely to intralexical processing—that is, processing that reflects the organization of the lexicon. Thus studies examining the effects of pragmatic context of lexical access suggest that listeners do not use their knowledge of the world to restrict access to one reading. Stanovich and West (1983) come to similar conclusions after a detailed examination of the effects of context on visual word recognition. They found only small facilitatory effects of congruent contexts, which they attributed to intralexical priming.

The evidence indicating that lexical access proceeds independently of syntactic context is not as convincing. Evidence for the access of multiple readings of ambiguous words in syntactically biasing contexts has been reported in only two published studies, Tanenhaus et al. (1979) and Seidenberg et al. (1982), and in Prather and Swinney<sup>2</sup> (1977). The Tanenhaus et al. and Seidenberg et al. studies are open to at least two criticisms, the first of which has to do with the materials used in these studies. Cowart<sup>3</sup> has pointed out that in many of the contexts used to bias the verb reading of the ambiguous word, the infinitive *to* was used to signal a verb context—as in the example, "They began to tire." However, the infinitive *to* can be homophonous with the adjective *two*. Cowart correctly notes that many of the contexts used by Tanenhaus et al. and by Seidenberg et al. may not have been truly biasing.

Secondly, it is possible that multiple access obtained in these studies because subjects did not have enough time to generate syntactic expectations prior to hearing the ambiguous word and not because syntactic context cannot guide lexical access. This is plausible because the contexts used in the Tanenhaus et al. (1979) and Seidenberg et al. (1982) studies were extremely short—often only two or three words. Ryder and Walker (1982) have questioned the generality of the Tanenhaus et al. results on these grounds. Moreover, studies of context effects in visual word recognition have consistently demonstrated stronger context effects when a brief pause is introduced between the context and the target word (see Mitchell, 1982, pages 112–114, for a review). Thus listeners may be able to use syntactic context to constrain initial lexical access of ambiguous words if they are given ample time to have processed the context.

These criticisms become important in view of two considerations. First, in contrast to pragmatic contexts, which can only reduce the plausibility of a possible meaning of an ambiguous word, syntactic contexts can completely rule out a possible reading as ungrammatical. For example, the

<sup>2</sup>P. Prather and D. Swinney (1977) Some effects of syntactic context upon lexical access. Presented at a meeting of the American Psychological Association, San Francisco, California.

<sup>3</sup>W. Cowart (1983). Reference relations and syntactic processing: evidence of a pronoun's influence on a syntactic decision that affects word naming. Distributed by Indiana University Linguistics Club.

<sup>1</sup>M. M. Lucas (1983). Lexical access during sentence comprehension: Context effects, frequency effects, and decision processes. Unpublished doctoral dissertation, University of Rochester.

word *train* in the sentence "They began to train" cannot refer to the vehicle because the syntactic rules of English do not allow the word following *to* to be a noun. In contrast, the word *bugs* in the sentence "He was afraid of bees, wasps and other bugs" *could* refer to electronic listening devices—although it would be strange for it to do so. Thus it can be argued that initial access of a reading of an ambiguous word that is syntactically inappropriate given the preceding context is stronger evidence for Forster's autonomy claim than evidence that pragmatically implausible readings are initially accessed.

Secondly, two recent studies have claimed to find evidence that syntactic context can guide lexical access. In one study, lexical decisions to nouns in Serbo-Croatian were faster when preceded by an appropriate preposition than when preceded by an inappropriate preposition (Lukatela, Kostic, Feldman, and Turvey, 1983). In the other study, lexical decisions were faster to a target word when it was preceded by a syntactically appropriate word—for example, *the laugh*—than when it was preceded by a syntactically inappropriate word—for example, *it laugh* (Goodman, McClelland, and Gibbs, 1981). Given these results, it is important to determine whether the results obtained by Tanenhaus et al. (1979) and Seidenberg et al. (1982) can be attributed to the two factors outlined above.

The present study eliminated the problem with the materials in these studies by pronouncing the infinitive *to* with reduced stress, that is, as "tuh." While stressed *to* can be either an infinitive or an adjective, unstressed *to* can only be an infinitive. Thus the sentence "They began tuh fall" is acceptable spoken American English while "They counted tuh books" is not. In order to give subjects time to process the context, a condition was added in which a pause of approximately 400 msec was inserted between the context and the ambiguous word. The pause was introduced by silently mouthing the ambiguous word before it was pronounced aloud.

## Method

### Subjects

Thirty-two Wayne State University undergraduates participated as subjects in order to satisfy a course requirement.

### Materials

The experimental sentences were generated from sentence sets built around 48 ambiguous words with unrelated noun and verb meanings (e.g., *tyre*). Four sentences were generated for each set: a sentence in which the sentence-final ambiguous word was a noun by virtue of the preceding syntactic context, a sentence in which the ambiguous word was a verb, and two control sentences constructed by replacing the ambiguous word by a syntactically appropriate word

of similar length and frequency. Examples of noun and verb contexts and their controls are given in (1) and (2). The full set of materials is given in the Appendix.

1. a. John began to tire.  
b. John began to laugh.
2. a. John bought a new tyre.  
b. John bought a new shoe.

Each sentence set was paired with a target related to one of the readings of the ambiguous word (e.g., SLEEP). A third variable was added by either recording each sentence normally or inserting a pause before the final word of the sentence. In the pause conditions, the speaker silently mouthed the final word before pronouncing it aloud, resulting in a pause of about 400 msec between the context and the sentence-final word. The eight sentences produced by combining type of context (noun or verb) pause and type of final word (ambiguous or control) were counterbalanced across eight presentation versions. The experimental sentences were intermixed with 60 filler sentences; 54 of the filler trials were paired with non-word targets, the remaining with word targets.

### Procedure

Four subjects were assigned to each of the eight presentation versions. Each presentation version was preceded by 20 practice trials. Subjects heard the sentences binaurally over stereo headphones. A timing tone inaudible to the subject was placed at the end of each sentence. The tone initiated presentation of a target stimulus that was rear-projected using a Gerbrands three-channel projection tachistoscope at a visual angle of approximately 1.2° vertically and 5.6° horizontally. Lexical decision times were recorded from the onset of the target. In order to ensure that subjects were attending to the sentences comprehension questions were asked following 25% of the trials.

## Results

ANOVAS with subjects and items as random factors were used to analyse the data. For each subject, outlier scores greater or less than 2.0 SD from the subject's mean were replaced by the 2.0-SD cutoff score. Four factors were used in both the subject and item analyses: pause, target relatedness, syntactic appropriateness, and list. Pause referred to whether or not the sentence-final word was preceded by a silent pause; target relatedness referred to whether or not the target word was related to one of the meanings of the sentence-final word—all targets following ambiguous words were considered related, and all target words following control words were considered unrelated; and syntactic appropriateness referred to whether or not the target word was related to the syntactically appropriate or inappropriate reading of the ambiguous word or its control. These three factors were crossed with both subjects and materials. List was nested within subjects and materials.

Condition means and error rates are presented in Table 1. There was no indication of a speed-accuracy trade-off, and error rates were approximately equal across conditions. In all conditions, lexical decisions were facilitated when the target word followed an ambiguous word. This

Table 1  
Mean Lexical Decision Times in msec for Each Condition

Syntactic Appropriateness	Target Relatedness		Facilitation in msec
	Related	Unrelated	
	No Pause		
Appropriate	778 (2)	798 (6)	20
Inappropriate	772 (5)	799 (4)	27
	Pause		
Appropriate	781 (6)	798 (4)	17
Inappropriate	784 (4)	812 (5)	28

Note: Error rates in percentages as presented in parentheses.

was reflected in a significant effect of target relatedness in both the subject and item analysis,  $F_1(1, 24) = 8.11$ ,  $p < 0.01$ , and  $F_2(1, 40) = 13.13$ ,  $p < 0.01$ . Syntactic appropriateness did not approach significance in either the subject analysis,  $F_1(1, 24) = 1.25$ , or the item analysis,  $F_2(1, 40) < 1.0$ . The presence of the pause had no significant effects,  $F_1(1, 24) = 1.25$  and  $F_2(1, 40) = 1.73$ , and no interactions with pause approached significance.

Separate ANOVAS were also conducted on the lexical decision times in the inappropriate conditions, because the critical prediction made by the autonomy hypothesis was that syntactically inappropriate readings of ambiguous words would be accessed. These analyses revealed a significant effect of target relatedness in both the subject and item analyses,  $F_1(1, 24) = 7.69$ ,  $p < 0.01$ , and  $F_2(1, 40) = 8.77$ ,  $p < 0.01$ . Thus targets related to the syntactically inappropriate reading of the ambiguous word were clearly facilitated. The effect of pause was not significant in either the subject or the item analysis,  $F_1(1, 24) = 2.22$ ,  $p = 0.14$ , and  $F_2(1, 24) = 1.33$ . The interaction between pause and target relatedness did not approach significance, both  $F_1$  and  $F_2 < 1.0$ .

## Discussion

The results demonstrate that listeners access multiple readings of an ambiguous word even when one of the readings is syntactically inappropriate. These results replicate those obtained by Tanenhaus et al. (1979) and Seidenberg et al. (1982). The importance of the present study is that it eliminates a materials problem in these studies, and it demonstrates that multiple access obtains in a restrictive syntactic context even when subjects are allowed ample time to process the context fully. The results thus provide strong support for the autonomy of lexical access.

How then can the present results be reconciled with those obtained by Goodman et al. (1981) and Lukatela et al. (1983)? Recall that in both of these studies subjects made lexical decisions to target words that were

preceded by a context word. Lexical decisions were faster when the context and target word formed a syntactically legal sequence than when they formed an illegal sequence. One likely explanation has to do with the nature of the lexical decision task. The lexical decision task is generally assumed to be a relatively pure measure of lexical access. When a target word is presented, the subject waits until a lexical entry has been identified and responds "Yes." If no entry is identified within a certain response deadline, the subject responds "No." This model of lexical decision, labelled a "direct knowledge" model by Tanenhaus, Carlson, and Seidenberg (in press) seems implausible for several reasons. First, it is unclear why lexical access should provide immediate knowledge of whether or not we have been presented with a word. The lexical processor was not structured, after all, to make lexical decisions. More importantly, the direct knowledge model seems to run into empirical problems. It cannot naturally account for why lexical decisions are relatively slow compared to other lexical tasks, such as deciding whether or not a word belongs to a specified category or reading a word aloud. It also has difficulty explaining why lexical decisions are so easily subject to strategic influences given the widespread and reasonable assumption that lexical access is an automatic process. For example, the type of non-word distractor used influences the speed with which subjects make lexical decisions, the magnitude of context effects, and even the types of information that subjects appear to use in making lexical decisions (Shulman, Hornak, and Sanders, 1978). Lexical decisions are also influenced by a number of other variables, many of which are not clearly lexical. For example, lexical decision latencies for a word are influenced by its concreteness as well as by the ease with which a context for the word can be imagined (Schwanenflugel and Shoben, 1982).

An alternative to the direct knowledge account for lexical decision takes seriously the idea that the lexical decision task involves a decision stage. According to this view, developed by Forster (1979) and by Stanovich and West (1983) and elaborated in Seidenberg and Tanenhaus (in press), lexical decisions are made by a central processor, which has access to the outputs of different components of the language comprehension system, including information made available as a consequence of lexical access. Lexical decision is conceptualized as a signal detection task in which the subject must discriminate between words (signals) and non-words (noise) that can vary along a number of dimensions, including orthographic structure, phonological structure, and meaningfulness. Subjects adopt different decision criteria based on the dimension(s) along which the words and non-words can most rapidly be discriminated. Thus lexical decision is easily subject to strategic influences.

When words are presented in context, the subject has another dimension on which to base the lexical decision, whether or not the word makes sense in context. Given that lexical processing makes available sufficient information for lexical decisions to be made, why would contextual congruity

