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THE EFFECTS OF CONTEXT ON LEXICAL AMBIGUITY RESOLUTION

by

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ABSTRACT

THE EFFECTS OF CONTEXT ON LEXICAL AMBIGUITY RESOLUTION

by

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The effects of context on lexical ambiguity resolution were examined in two experiments as a replication and extension of Simpson and Krueger (1991), who found evidence for selective access of word meanings. In a cross-modal naming paradigm, ambiguous words were placed in sentences that biased the dominant meaning, the subordinate meaning, or no meaning (neutral context) of the ambiguous word. Subjects named target words that were either related or unrelated to the ambiguous word after 0, 200, 600 ms S.O.A. (Experiment 1); or 0, 300, 700 ms I.S.I. (Experiment 2). In Experiment 1, no effects of context were found at any level of S.O.A. but there was an effect of dominance at 600 ms S.O.A., supporting a modular theory of lexical access. In Experiment 2, there were no effects of context on meaning access at any level of I.S.I. The results of these experiments are discussed in terms of recent theories of lexical ambiguity resolution.

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INTRODUCTION

Lexical ambiguities can provide an insight into human mental processes. By examining how a particular meaning of an ambiguous word is accessed, psychologists can gain insight into how words are stored in memory and how words with different meanings are accessed. Many English words have multiple meanings, but listeners have very little difficulty determining which meaning is appropriate. This lack of difficulty results from the disambiguating effects of sentential context.

Traditionally, there have been two broad theories about the nature of this process, multiple access and selective access. Multiple access theories posit that sentence context has no prior effect on the access from memory of the relevant meaning of an ambiguity. (Multiple access theories are also called exhaustive models because all possible meanings are exhaustively accessed before a decision is made.) These models are consistent with a highly modular view of the language processing system, with higher levels in the system having influence on selection only after all meanings of the ambiguous word have been accessed. In this case, semantic and syntactic information have no influence on the bottom-up processing of lexical information during sentence processing.

On the other hand, selective access theories propose that sentence context can directly influence which meaning of an ambiguous word is accessed. This influence is the result of the overall meaning of the sentence serving to

determine which meaning of the ambiguous word is appropriate given the meaning conveyed by the sentence. Thus, selective access theories support an interactive view of the language processing system, with higher levels in the system influencing the selection of appropriate meaning as the sentence is being processed. I will now review some studies that examine these issues.

Literature Review

Tanenhaus, Leiman & Seidenberg (1979) found support for a multiple-access model of meaning for noun-verb lexical ambiguities. Subjects listened to sentences and then named a visually presented target as quickly as possible (cross-modal naming). The last word in the sentence was both semantically and syntactically ambiguous: One meaning corresponded to a noun and the other to a verb (e.g. rose). The sentences provided contextual information that favored only one of the possible meanings of the ambiguous word. The target word's meaning could either be related to the meaning of the target biased by the sentence context, related to the meaning unbiased by the sentence context, or unrelated to either meaning. Target words appeared with either 0, 200, or 600 msec Stimulus Onset Asynchrony (S.O.A.). According to Tanenhaus et al.'s predictions, naming latencies should be faster for the target word related to the biased meaning of the ambiguous word relative to controls if context influences access of meaning. However, both meanings of the ambiguous word should show facilitation relative to controls if context exerts no influence on access of meaning.

Tanenhaus et al. (1979) found that target naming latencies varied not only with the congruency of the target word meaning and the meaning of the ambiguous word biased by the context, but also with the amount of time between presentation of the ambiguous word and target. At O msec S.O.A., there was facilitation for target words related to both contextually appropriate and inappropriate meanings of the ambiguous word. At 200 msec S.O.A., however, there was only facilitation for the target word related to the contextually appropriate meaning. They concluded that both meanings of an ambiguous word are accessed initially and one of the meanings is selected within 200 msec. They further posit that the selection is based on the meaning of the context. The results at 600 msec S.O.A. were complex. Targets related to the verb meaning of the ambiguous word were facilitated only when the context biased the verb meaning of the ambiguous word. However, targets related to both verb and noun meanings showed facilitation when the context was biased toward the noun meaning of the ambiguous word. This pattern suggests that the verb meaning of an ambiguous word is only minimally affected by context at 600 msec (Tanenhaus, et al. 1979). Thus, for verb ambiguities, both meanings are highly activated at some early stage,and later context plays a small role in choosing the appropriate meaning.

Swinney (1979) found similar results using the same cross-modal priming paradigm, but with lexical decision times instead of naming latencies as the dependent measure. Also, the alternative meanings of the ambiguous word

were always from the same syntactic category. In Experiment 1, subjects listened to sentences that contained either an ambiguous noun or an unambiguous control. The sentence context was either strongly predictive of one of the meanings of the ambiguous word, or provided no disambiguation. Following the auditory presentation of the sentence, subjects performed a lexical decision task on word and nonword targets presented at the onset of the ambiguous word (0 msec S.O.A.) Word targets were either related to the contextually appropriate meaning of the ambiguous word, related to the contextually inappropriate meaning, or unrelated to either meaning. Swinney (1979) found that even in the presence of a strongly biased context, both meanings of an ambiguous word are accessed, suggesting that lexical access is fairly autonomous from the influences of contextual information.

In Experiment 2, Swinney (1979) examined the time-course of activation for appropriate and inappropriate meanings of an ambiguous word. The target word appeared three syllables after the presentation of the ambiguous word; otherwise, all other procedures remained the same as in Experiment 1. Swinney found facilitation only for the contextually-related target word. Swinney thus concluded that, initially, lexical access is autonomous with respect to sentential context in that "the entire inventory of information stored for a lexical form is made available to the sentence comprehension device" (p. 657). A later postaccess decision process uses context to select the relevant meaning of the ambiguous word, and this process is complete three syllables after the

ambiguous word has been encountered.

Research by Seidenberg, Tanenhaus, Leiman and Bienkowski (1982) also largely supported a multiple-access view of meaning for ambiguous words. They distinguished between two classes of ambiguous words (noun-noun and noun-verb) and three types of contexts (priming, nonpriming, and neutral). Noun-noun ambiguous words are those that have two unrelated meanings that are both nouns, (e.g. bank), and noun-verb ambiguities are those that have two unrelated meanings where one is a noun and the other is a verb, (e.g. rose). Seidenberg, et al. defined priming contexts as those that contain a word that is highly associated with the biased meaning of the ambiguous word, and nonpriming contexts as those that bias the meaning of the ambiguous word through syntax or pragmatics but contain no semantic associates of the alternative interpretations. Thus, the overall meaning of the context serves to reduce the appropriateness of one of the meanings.

Seidenberg et al. found that for noun-noun and noun-verb ambiguities in neutral contexts, both meanings of the ambiguous word were accessed initially, but just one of the meanings was available 200 ms later. For noun-noun ambiguities in contexts that contained a word that was highly associated to a particular meaning of the ambiguous word, only that meaning of the ambiguous word was accessed, even at the earliest probe point. Seidenberg, et al. argued that this result is due to lexical priming. A word in a context that is highly associated with one of the meanings of the ambiguous word is linked by

preexisting associations within the lexicon. As a result, intra-lexical priming can restrict the search within the lexicon to those items related to the biased meaning. Seidenberg et al. found converging evidence for the lexical priming theory when they failed to find selective access for noun-noun ambiguities. They occurred in contexts that favored one meaning of the ambiguous word, but contained no semantically associated word. They continued to find multiple access for noun-verb ambiguities even in contexts that contained a semantically related word, indicating that noun-noun and noun-verb ambiguities are resolved differently.

All of the research discussed to this point has assumed that the alternative meanings of an ambiguous word are equally salient. However, for many ambiguous words, one meaning is more frequent than the others. As a result, some ambiguous words have what is called a dominant and subordinate meaning, where the former is the most frequently occurring meaning and the latter is the second most frequent meaning. Some recent research has shown support for selective access of the dominant meaning of an ambiguous word even in contexts without lexical associates. In a cross-modal priming study, Tabossi (1988) had subjects listen to sentences and then make a lexical decision on a target word. Three conditions were employed. In the first condition, the sentence biased the dominant meaning of the ambiguous word without strong constraints on that meaning. The target word was either related to one of the meanings of the ambiguous word without denoting any

characteristic of it, or was a control (For example: During the walk, the boy noticed on the trees many *buds*, although it was already late in the season. The related and unrelated target words were Flower and Chair, respectively. Ambiguous word in italics.) In the second condition, the same context was used, but the target word either denoted a specific characteristic feature of one of the meanings of the ambiguous word or was a control (e.g. During the walk, the boy noticed on the trees many *buds*, although it was already late in the season. Delicate-Order, related and unrelated target words, respectively). In the third condition, the sentence biased the dominant meaning of an ambiguous word by making salient a particular characteristic of that meaning. In this case the target word was associated either with the dominant meaning, the subordinate meaning or unrelated (control) (e.g. In the spring, a light wind among the branches of the tree was sufficient to damage the first young *bud*, just opened. Flower- Precious-Order, dominant, subordinate, and control target words, respectively).

Tabossi (1988) found that in the first condition, lexical decisions were faster for both the appropriate and inappropriate meaning of the ambiguous word relative to the control. This pattern of results also held for Condition 2 where the target word denoted specific characteristics of one of the meanings. However, in Condition 3, Tabossi found that lexical decisions on target words that are related to the dominant meaning of the ambiguous word following sentences that bias and constrain the dominant meaning of the ambiguous word are faster than

target words related to the subordinate meaning of the ambiguous word or target words that were unrelated. Tabossi interpreted these results as showing selective priming of the dominant meaning of an ambiguous word when the ambiguity is embedded in sentential contexts that "render a central aspect of its dominant meaning particularly salient" (p. 333). These results also indicate that lexical access can be influenced by dominance and context, but the actual mechanism responsible for this type of priming has yet to be determined.

Duffy, Morris and Rayner (1988) found a similar pattern of results and interpreted them as favoring a reordered-access model of lexical access for ambiguous words instead of a selective-access or purely exhaustive model. In their study, subjects' eye movements were monitored as they read sentences containing lexically ambiguous words that were either equibiased (both meanings equally frequent) or non-equibiased. These ambiguous words appeared in sentences that had a disambiguating clause either preceding or following the ambiguous word. Duffy et al. used an eye movement paradigm to measure gaze durations (all consecutive fixations made on the target word beginning with the first fixation on the word and ending with the last fixation before the eyes moved to another word, p. 436) on the ambiguous word as well as on later parts of the sentence. For sentences that had a non-equibiased ambiguous word, the disambiguating clause always favored the less frequent meaning. Previous studies (Duffy and Rayner, 1986) had shown that gaze durations were longer for equibiased but not for non-equibiased ambiguous

words when they were preceded by a context that did not decide between the two meanings. Duffy et al. predicted, then, that if an autonomous access model is correct, gaze durations should be longer for both equibiased and nonequibiased ambiguous words when the disambiguating clause precedes the target word. However, if the reordered-access model is correct, gaze durations should differ depending on whether the ambiguous word is equibiased or non-equibiased. For equibiased ambiguities, when the disambiguating clause comes before the target word, the appropriate meaning should become available before the inappropriate meaning and should be incorporated into the sentence without any difficulty. As a result, the equibiased ambiguity will resemble a non-equibiased word when the dominant meaning is correct, with no difference in gaze durations for equibiased ambiguous words and their controls. However, with non-equibiased ambiguous words, when the disambiguating clause comes before the target word, because the clause supports the less frequent meaning of the ambiguous word, the less frequent meaning should become more available than normal and thus require the system to select between the two meanings. As a result, the non-equibiased ambiguities should resemble equibiased ambiguous words with longer gaze durations compared to their controls.

The pattern of gaze durations supported the reordered-access model. For equibiased words, gaze durations on the target word in the after condition (disambiguating information coming after the ambiguous word) were longer

compared to their controls, but in the before condition (disambiguating information coming before the ambiguous word), gaze durations on the target word and control were equivalent. For non-equibiased words, gaze durations were lengthened compared to controls in both the before and after conditions. Gaze durations in the disambiguating region were longer when they followed an ambiguous word compared to when they followed a neutral control word. Duffy et al. concluded that the pattern of results in the before condition best fit a reordered model of lexical access. In the case of the equibiased ambiguous words, the appropriate meaning becomes available first and is easily incorporated into the sentence without any competition from the inappropriate meaning. When the ambiguous word is non-equibiased, because the less frequent meaning becomes available sooner than normal, the system has to select between two meanings, resulting in the longer gaze durations. These results are incompatible with an exhaustive model that predicts that all meanings should become available for both equibiased and non-equibiased ambiguous words, thus resulting in longer gaze durations for both. Moreover, a purely selective-access model cannot account for the data because of the pattern of gaze durations in the post-target region of the sentence for non-equibiased ambiguous words in the before condition. Here, gaze durations on the ambiguous word were longer compared to controls. As a result, Duffy, et al. concluded that the reordered-access model best describes the data. All meanings of an ambiguity are accessed, but activation levels of alternative

meanings differ depending on the frequency of occurrence of the alternative meanings and the semantic bias in any prior context.

In a follow-up study, Rayner, Pacht and Duffy (in press) attempted to eliminate what they termed the subordinate-bias effect for non-equibiased ambiguous words (longer gaze durations on non-equibiased ambiguous words when the context favors the subordinate meaning) by increasing the contextual bias of the sentence in favor of the subordinate meaning. In Experiment 1, Duffy et al. attempted to influence the bias towards the subordinate meaning of non-equibiased ambiguous words by having subjects participate in a paired-associate task where an ambiguous word was paired with a word related to its subordinate meaning. Thus, the pair-associate task should help to promote the activation level of the subordinate meaning of the ambiguous word relative to the dominant meaning. Following the paired-associate learning task, subjects read sentences in which the context favored the subordinate meaning of an ambiguous word while their eye movements were monitored. Rayner et al. compared fixation times on the ambiguous word when the subject learned the paired-associate list compared to when they did not as well as fixation times on the ambiguous words relative to their controls for subjects that either had or had not performed the paired-associate list task. Rayner, Pacht and Duffy found that gaze durations did not differ for ambiguous words that were a part of the paired-associate list compared to ambiguous words that were not. Additionally, these gaze durations did not differ from non-ambiguous control words, indicating that

the dominant meaning was still competing with the subordinate for final selection (p. 18).

In Experiment 2, Rayner, Pacht and Duffy again attempted to eliminate the subordinate-bias effect by using a slightly different task. Concerned that the effects of having performed the paired-associate list task did not carry over to the episodically-dissimilar sentence-reading task, they designed a task where the subjects were biased towards the subordinate meaning of the ambiguous word while their gaze durations were measured. Subjects read a paragraph of text which biased the subordinate meaning of an ambiguous word that occurred towards the end of the paragraph. In some cases, the paragraph contained a prior occurrence of the ambiguous word also disambiguated towards its subordinate meaning. They then recorded gaze durations for the ambiguous word at both the earlier and later encounters and compared them to their controls. Rayner et al. found longer gaze durations on the ambiguous word at both occurrences relative to non-ambiguous controls, again indicating that the dominant meaning of the ambiguity was competing with the subordinate meaning for final selection. This research seems to support a view of lexical access that is exhaustive, but is influenced by frequency of meaning and prior context. Lexical access is exhaustive in the sense that until one meaning has been integrated into the sentence, all meanings are accessed. However, degree of activation of meaning is influenced by its frequency and by context, with higher frequency occurring meanings being activated sooner than lower ones when the

context biases the higher frequency meaning, and with both meanings being activated in a context that biases the lower frequency meaning. An important point here is that a selective access account was not supported because the subordinate bias effect was not eliminated.

Work by Sereno, Pacht and Rayner (1992) favored a reordered or integration model of lexical access. Concerned that subordinate meanings of ambiguous words could be treated as low-frequency unambiguous words, they compared ambiguous words to both high-frequency (HF) and low-frequency (LF) control words. They found that initial gaze durations on biased ambiguous words when the context biased the subordinate meaning of the ambiguous word did not differ from the amount of time they spent on LF controls. However, total fixation time on ambiguous words relative to controls differed significantly across the three conditions (longest in the ambiguous condition, shorter in the LF condition, and shortest in the HF condition). Thus, subjects were not treating ambiguous words as low-frequency unambiguous words. They concluded that when the subordinate meaning of an ambiguity is instantiated by context, subjects will spend more time processing the ambiguous word relative to controls matched for frequency, and that this pattern of results cannot be explained by a purely selective or exhaustive model of lexical access. The longer fixation times in the subordinate bias condition are explained by the reordered model as competition between the dominant and subordinate meanings because of the higher than normal activation of the subordinate meaning. On the other hand, according to

the integration model, because the dominant meaning is incorrectly integrated into the sentence, the longer gaze durations are the result of the reintegration of the subordinate meaning of the ambiguous word. Sereno, Pacht and Rayner go on to posit that the reordered model supports a more interactive view of the memory system, while the integration model favors a more modular view, with post-access ambiguity resolution.

Recent work by Tabossi and Zardon (1993) also suggests that both context and frequency of occurrence influence access of meaning for ambiguous words. In an experiment similar to Experiment 3 in Tabossi (1988) but with target presentation at 100 ms before the end of the ambiguity, they found that when context biases the subordinate meaning of the ambiguity, both meanings of the ambiguity were activated. This is an interesting finding because in this case, the effect of context causes both meanings to be highly active simultaneously which resembles multiple access and adds further support to the conclusions drawn by Sereno, Pacht, and Rayner (1988).

Simpson and Krueger, 1991

The research I have described thus far supports the reordered access model. However, in a recent study, Simpson and Krueger (1991) claim to have evidence for a purely selective-access model, even for subordinate meanings. Because my own research is an attempt to replicate and extend their work, I will review their research in some detail.

Simpson and Krueger begin by assuming that in the absence of preceding

biasing context, the dominant meaning of an ambiguous word is accessed before the subordinate meaning (in the case of non-equibiased words). In their experiment, subjects named targets after reading a sentence that appeared on a computer monitor. Sentences either biased the dominant meaning of the ambiguous word, the subordinate meaning of the ambiguous word, or were neutral with respect to meaning of the ambiguous word. Targets varied by either being related to the dominant or the subordinate meaning of the ambiguous word. Interstimulus interval (I.S.I.) was also varied: the target appeared at either 0, 300, or 700 msec after presentation of the ambiguous word. Sentence-type (dominant, subordinate, ambiguous) and I.S.I. were between-subject variables, and target dominance and relatedness were within-subject variables.

Simpson and Krueger (1991) found that for neutral sentences and at 0 msec I.S.I., only the dominant meaning of the ambiguous word was activated as seen in facilitation for targets related to the dominant meaning. However, at 300 msec. I.S.I., there was facilitation for both dominant and subordinate meaning related targets. Finally, at 700 msec I.S.I., again there was only facilitation for targets related to the dominant meaning of the ambiguous word. Simpson and Krueger concluded that in the absence of biasing context, the dominant or most frequent meaning of an ambiguous word will be accessed first and subsequently selected though the subordinate meaning is accessed (e.g. at 300 ms).

In biasing contexts, however, Simpson and Krueger (1991) found a striking pattern of results. If the context biased the dominant meaning of the

ambiguous word, facilitation occurred at all ISI's for targets related to the dominant meaning of the ambiguous word. Targets related to the subordinate meaning of an ambiguous word showed no priming. Moreover, the pattern of results reversed for sentences biasing the subordinate meaning of the ambiguous word. In these cases, targets related to the subordinate meaning of the ambiguous word showed priming whereas targets related to the dominant meaning of the ambiguous word showed no such priming. This pattern also held across the I.S.I. manipulation. Simpson and Krueger concluded that in some cases, contextual information can immediately affect the access of the appropriate meaning of an ambiguous word regardless of the frequency of that meaning. These conclusions are inconsistent with the other work described above, which shows clear effects of meaning dominance (Tabossi, 1988; Duffy, Morris, and Rayner, 1988; Sereno, Pacht and Rayner, 1992; and Tabossi and Zardon, 1993).

Criticisms of Simpson and Krueger (1991)

Although Simpson and Krueger (1991) claimed to show selective access of meaning for ambiguous words through sentence context in their paradigm, there are some concerns about the design used in their study as well as the implementation of their experiment which might account for their pattern of results.

In Experiment 1 of their study, sentence-context and I.S.I. were between-subject variables. Thus, subjects saw only one type of sentence: dominant

biased, subordinate biased, or ambiguous, at a particular I.S.I. (0, 300, 700 msec) on every trial. As a result, it is possible that subjects were able to form an expectation about what type of sentence and target they would receive, enabling them to develop the strategy of consciously accessing the appropriate meaning of the ambiguous word. This tendency was likely exacerbated by the absence of any filler items in the stimulus presentation lists. If subjects were able to adopt this type of strategy, Simpson and Krueger (1991) would be able to argue against a modular (multiple access) view of the memory system because in this case subjects would be using contextual information to select the appropriate meaning of the ambiguous word. However, the use of I.S.I. in their experiment suggests that maybe context was not influencing access, but that Simpson and Krueger were probing after some period in time when both meanings of the ambiguous word were accessed.

The second concern with Simpson and Krueger's (1991) manipulation is the manner in which the target word was presented and the use of I.S.I. Subjects read aloud a sentence that was presented to them on a computer screen. As the subject finished pronouncing out loud the ambiguous word, the experimenter pressed a button that presented the target word the subject was to name at one of the I.S.I. times. What makes this type of paradigm questionable is the fact that the 0 ms I.S.I. does not take into consideration naming latency and pronunciation duration. Because subjects had to pronounce the word before the target word appeared, on average, 400 to 500 ms (Siedenberg and

Waters, 1984) elapsed between the time when the subject first saw the ambiguous word and when he or she began pronouncing the target word. This latency was then followed by an average pronunciating duration of 400 to 600 ms before the experimenter pressed the button to present the target word. As a result, some 900 to 1,000 ms, on average, elapsed between the time when the subject first saw the ambiguous word and when the target word was presented in the 0 ms I.S.I. condition. Thus, Simpson and Krueger's earliest probe time probably does not tap into the earliest time at which lexical processing of the ambiguous word is occurring. This fact, in combination with the blocked presentation of context, leads to the possibility that subjects could consciously generate expectations concerning which meaning of the ambiguity would be probed.

Simpson and Krueger defended their use of 0 msec I.S.I. by the pattern of data for the ambiguous sentences. Because ambiguous sentences seemed to be following the same pattern of results at 0 msec I.S.I. as they did in an experiment by Simpson and Burgess (1985), where they used 16-750 msec S.O.A., they claimed that it is unlikely that they missed some earlier time when both meanings of the ambiguous word were accessed in the present experiment. However, this fact does not address the naming and pronunciation latency problem caused by this subject naming paradigm. Thus, it may be that using I.S.I. instead of S.O.A. and a subject-paced target presentation paradigm missed an earlier period during lexical ambiguity processing when both meanings are

simultaneously accessed.

Experiment 1

The purpose of the present experiment was two-fold. First, this experiment was a replication of Simpson and Krueger (1991) using their stimulus materials and a more controlled cross-modal priming paradigm. This paradigm allowed for more precise control of target presentation using S.O.A. instead of I.S.I. and alleviated the need for experimenter-paced presentation of the target. Additionally, the design of the experiment addressed the potential blocked context problem. Subjects were randomly presented each of the three types of sentence contexts (dominant, neutral, and subordinate). The second purpose was to test the more recent theories of lexical access as put forth by Tabossi (1988), Tabossi and Zardon (1993), and Rayner, et al. (1988, 1992) with the results of Simpson and Krueger and the present experiment.

In Experiment 1, subjects listened to a sentence played through a speaker and named a target presented on a computer screen. Sentence context either biased the dominant, subordinate, or neither meaning of the ambiguous word and targets were either related or unrelated to the dominant or subordinate meaning of the ambiguous word. Sentence context and what I will call target relation (related/unrelated) and target ambiguity strength (dominant/subordinate) varied within subjects, and S.O.A. (0, 200, and 600 msec) varied between subjects. Moreover, filler sentences occurred within all presentation lists.

Using this experimental paradigm, if Simpson and Krueger (1991) are correct and biasing context can allow selective access of a particular meaning of an ambiguous word, then we should find a similar pattern of facilitation of targets related to the biased meaning of the ambiguous word in the dominant biased and subordinate biased sentence context conditions at all S.O.A. levels.

According to the multiple-access theory which does not incorporate a mechanism to deal with the frequency of the alternative meanings of an ambiguous word, both meanings of the ambiguous word will be accessed and at some later time, selection of the appropriate meaning--mediated by sentence context--will occur. Thus, I should find facilitation for targets related to both meanings at 0 msec S.O.A., and only facilitation for targets related to the appropriate meaning of the ambiguous word at some later time. Again, because the notion of dominant and subordinate meaning of ambiguous words is irrelevant in this theory, the same pattern of results is predicted for both of the biasing context conditions.

According to a reordered multiple-access theory of lexical ambiguity which does make assumptions about the effects of meaning dominance, both meanings of the ambiguous word should be accessed in a neutral context and at 0 S.O.A, with the dominant meaning having a higher activation level (level of facilitation) than the subordinate meaning. At some subsequent selection point, the dominant meaning should be selected with activation of the subordinate meaning falling off. Thus, at longer I.S.I.'s, targets related to only the dominant

meaning should show facilitation.

In the dominant meaning biasing context condition, at 0 msec S.O.A., both meanings of the ambiguous word will be accessed, again with the dominant meaning having a higher level of activation. At the period of selection, only the dominant meaning will show activation. This situation will be evident in facilitation for target words related to both meanings in the former condition, and only the dominant meaning in the latter condition.

In the subordinate meaning biasing context condition, targets related to both dominant and subordinate meanings will show facilitation at 0 msec S.O.A. However, because sentence context is posited to aid in the selection of the appropriate meaning of the ambiguous word, at some selection time later, there should be some competition between dominant and subordinate meanings. This competition would be the result of the subordinate meaning consciously remaining active while the dominant meaning retains its a priori activation. This pattern of results could result in inhibition of target naming at some time later than 0 msec S.O.A. with context effects ultimately resulting in activation of only the subordinate meaning. Rayner and his colleagues (1988) have shown such competition between dominant and subordinate meanings of ambiguous words in their studies.

Method

Subjects. One hundred and eight introductory psychology students at Michigan State University participated as subjects in this experiment. Subjects

received partial credit in their introductory psychology courses for their participation and all were native English speakers and had normal or corrected to normal vision and hearing.

Apparatus. Response times to pronounce the target word were recorded by a 486-33 IBM-PC clone micro computer with a VGA monitor. Digitized speech sentences were presented to the subjects through a speaker using the Computerized Speech Laboratory (CSL) from Kay Elemetrics Corporation interfaced with the computer. Subjects used a button-box also interfaced with the computer to start each trial. A voice-activated relay responded to subjects' naming of the target word through a unidirectional microphone (Shure Prologue) supplied by CSL.

Materials. Thirty-two experimental sentences were used from the Simpson and Krueger (1991) study. In that study, 32 ambiguous words were selected from the homograph association norms of Nelson, McEvoy, Walling and Wheeler (1980). Two associates were selected for each ambiguous word, one representing the dominant and one the subordinate meaning. Three sentences were created for each ambiguous word. One sentence biased the dominant meaning of the word, another the subordinate meaning, and a third biased neither (neutral). For the unrelated target condition, sentences were paired and the related target words were interchanged between members of the pair. Four additional experimental sentences were created to match the 32 experimental trials from the Simpson and Krueger study to bring the total number of

experimental sentences to 36, a number divisible by the number of within subject conditions. All of these sentences were equated for length and complexity, and target words were balanced for length and frequency of occurence. These sentences and their target words are included as Appendix A.

Seventy-two filler sentences were created where the last word in the sentence was not obviously ambiguous. These sentences were equated in length and complexity with the experimental sentences. For half of the filler sentences, a related target word was paired with the last word in the sentence and for the other half, an unrelated target word was paired with the last word in the sentence. Ten practice trials were created similar to the filler sentences. The last word in each of the practice trials was a neutral non-ambiguous word. Half of the sentences had a related and half had an unrelated target word (see Appendix A).

The 118 sentences were recorded by a native English male speaker and digitized at a sampling rate of 10 KHz. A tag was placed at the onset of the last word of each sentence using a waveform editor. The tag was used by the computer as the point at which to display the target word on the monitor depending on what S.O.A. had been selected for that subject. The tag was inaudible to the subject.

Procedure. Subjects were tested individually. Subjects sat in front of the computer monitor, microphone, button-box and small speaker used to play the digitized sentences. The experimenter read the instructions, explaining to them

their task for the experiment. They were told that they would hear a sentence being played through the speaker and were to pronounce the word that appeared on the computer monitor as quickly as possible without sacrificing accuracy.

During each trial of the experiment, subjects saw a prompt instructing them to press a button on the button box to begin each trial. Next, a sentence was played through the speaker and subjects listened to the sentence while looking at the computer monitor. When the target word appeared on the computer monitor, subjects pronounced the word as quickly as possible into the microphone. The target word appeared in the center of the monitor in capital letters. Reaction time was measured from onset of the target word until the subject pronounced the target word. After pronouncing the word, subjects were again prompted to press a button on the button-box to proceed to the next trial. If the subject did not pronounce the target within 5 seconds, the target word disappeared, and the subject was prompted to push the button for the next trial. Subjects were run in a practice block of ten trials to familiarize themselves with the task and procedure. After the practice trials, the experimenter answered any questions the subjects had about the procedure and then the subject proceeded to the 108 experimental trials. After the experiment, subjects were debriefed by the experimenter and thanked for their participation in the experiment. The entire session lasted about 20 minutes.

Design and Analysis. The design of the experiment was a 3 (Sentence

context) X 2 (Target relationship) X 2 (Target ambiguity strength) X 3 (Stimulus onset asynchrony) factorial. Sentence context (neutral, biased dominant and biased subordinate), target relationship (related and unrelated), and target ambiguity strength (dominant and subordinate) were within subject variables. Stimulus onset asynchrony (0ms, 200ms and 600ms) was a between subjects variable. Each subject heard three sentences in each of the 12 within subject cells and all 72 of the filler items at one particular S.O.A. An Omnibus ANOVA that included all factors was conducted on mean naming latencies.

Results

Mean naming latencies at each S.O.A. are shown in Table 1. Errors in which the subject incorrectly named the target word never occurred. Trials that were eliminated were those on which the subject made an extraneous noise before pronouncing the target word which triggered the voice key, as noted by the experimenter, or those trials on which the subject pronounced the target word in less than 250 ms or more than 1500 ms. The analyses are based on 98.6% of the data.

Insert Table 1 Here

There was a main effect of S.O.A., $F(2,105)=6.7858$, $MSe=56155$, $p<.005$. Naming latencies to targets decreased as S.O.A. increased: 568 ms, 530 ms, and 510 ms for 0, 200, and 600 ms S.O.A., respectively. There was a also main

effect of context, $F(2,2)=9.7606$, $MSe=1839$, $p<.005$. Naming latencies to targets were fastest in the dominant context condition (530 ms), slower in the subordinate context condition (535 ms) and slowest in the neutral context condition (543 ms). There was also a main effect of target relation, $F(1,2)=11.2517$, $MSe=1962$, $p<.005$. Naming latencies were faster for related targets (532 ms) than for unrelated targets (540 ms). Finally there was a main effect of target ambiguity strength, $F(1,2)=8.7447$, $MSe=2005$, $p<.005$. Targets related to the dominant meaning of the ambiguous word had faster naming latencies than targets related to the subordinate meaning of the ambiguous word, 532 ms and 540 ms, respectively. The 3-way interaction of target relation x target relation strength x S.O.A. was significant, $F(2,105)=3.4147$, $MSe=2089$, $p<.05$. As can be seen in Figure 1, at 0 and 200 ms S.O.A., the target related to the meaning biased by the subordinate context shows greater priming than the target related to the meaning biased by the dominant context. However, at 600 ms, the target related to the meaning biased by the dominant context shows more priming than the target related to the meaning biased by the subordinate meaning. No other interaction was significant (all $F's < 1$).

Additional ANOVA's were conducted for each level of S.O.A. At 0 ms S.O.A., there were no significant main effects and no significant interactions, indicating that the 9 ms difference in priming between subordinate meaning related targets and dominant meaning related targets as shown in Figure 1 was not significant. At 200 ms S.O.A., there was a significant main effect of target

relation, F(1,35)=8.3226, MSe=1203, p<.005. Naming latencies were faster for related targets (524 ms) than for unrelated targets (534 ms). There were no significant interactions, indicating that the 7 ms difference in priming between the subordinate meaning related targets and the dominant meaning related targets as shown in Figure 1 was not significant. At 600 ms S.O.A., there was a significant main effect of target relation strength, F(1,35)=11.266, MSe=1611, p<.05. Naming latencies were faster for targets related to the dominant meaning (503 ms) than for targets related to the subordinate meaning (516 ms). There were no other significant main effects. There was also a significant interaction of target relation x target relation strength F(1,35)=4.1964, MSe=1315, p<.05. By 600 ms, the 14 ms difference in priming between dominant meaning related targets and subordinate meaning related targets is significant, suggesting that only the dominant meaning is accessed. There were no other significant interactions.

Discussion

The results of Experiment 1 contradicted the earlier findings of Simpson and Krueger (1991) in that there was no evidence for selective access. According to the selective access theory, a particular meaning of an ambiguous word can be accessed in an appropriately biased context. Thus, in this experiment, the dominant target should have shown priming in contexts that primed the dominant meaning across all S.O.A. conditions. Likewise, the subordinate target should have shown priming in contexts that primed the

subordinate meaning in all S.O.A. conditions. Whereas Simpson and Krueger found this pattern of results in their experiments, there was no effect of context at any of the S.O.A. conditions in the present experiment. Even though at 600 ms, the dominant meaning showed priming over the subordinate, this effect was seen for both the dominant and subordinate contexts. Thus, it appears that all of the effects were dependent on the dominance of meaning of the ambiguous word. At 0 and 200 ms S.O.A., there was no significant difference in priming for the dominant or the subordinate target. However, at 600 ms, the dominant related target was significantly faster than the subordinate related target. This pattern of data at 600 ms suggests an effect at the lexical level of representation.

The pattern of data does not fit well into a reordered theory of lexical access, either. According to this theory, for nonequibiased ambiguous words, the dominant meaning should show facilitation in ambiguous contexts, followed in time by the subordinate meaning. Subsequently, the appropriate meaning is selected based on some post-access process as determined by the meaning of the sentence. In this experiment, however, there was no differential activation of target words in the ambiguous context condition at any of the S.O.A. conditions.

The pattern of data in Experiment 1 favors a multiple access model of ambiguity resolution account. As stated earlier, a multiple access model predicts that context will have no effect on meaning access at earlier stages of processing, with the appropriate meaning being selected later. This was the

pattern of facilitation found in Experiment 1 where at 0 ms S.O.A., there was no activation for either the dominant or the subordinate target, with a rise in facilitation over time so that both targets showed some facilitation at 200 ms S.O.A. Finally, only the dominant target showed facilitation at 600 ms S.O.A. The overall pattern supports a modularity effect because of the lack of an effect of context and only an effect of dominance at 600 ms S.O.A.

However, there is an important difference between the procedures used in this experiment and in previous priming studies of lexical ambiguity. In previous experiments (Seidenberg, et al. 1979; Tanenhaus et al. 1979; Simpson and Krueger, 1991), researchers used what was really I.S.I. instead of S.O.A. even though they referred to the manipulation as S.O.A. In their experiments, the marker used to trigger presentation of the target word was located at the end of the ambiguous word. Thus, the period of time between the ambiguous word and the target word was not synchronous with the onset of the ambiguous word. In other words, 0 ms S.O.A. in these experiments meant that the target word was presented immediately following presentation of the ambiguous word. In contrast, 0 ms S.O.A. for the present experiment meant that the ambiguous word began and the target word appeared on the monitor at the same time.

An analysis of the average duration of the ambiguous words used in this experiment found that they lasted between 500 and 600 ms. Consequently, the 600 ms S.O.A. manipulation in this experiment was closer to the 0 ms "S.O.A." used in the Simpson and Krueger experiments, and the earlier S.O.A. conditions

were tapping into the processes of ambiguity resolution that take place before the end of the word.

There may be several reasons for why I failed to replicate Simpson and Krueger, 1991. As stated, there were no interaction effects between context and target dominance or target strength, nor was there an interaction between target relation and target strength at 0 ms or 200 ms S.O.A. However, because the subject was actually trying to pronounce the target word during the time that the ambiguous word was being spoken, interference between naming the target word and listening to the spoken ambiguous word could have occurred, resulting in the lack of any context effects. There was an interaction between target relation and target strength at 600 ms S.O.A. The finding that there was an effect of target dominance only at the 600 ms S.O.A. condition indicates that it takes some period of time for the dominant meaning to be accessed but may indicate a difference in access by the end of the ambiguous word. Thus, it could be that dominance of the target plays an early role in meaning access with context effects occuring at some later time.

Finally, in Experiment 1, it was possible that subjects were not paying close attention to the sentences before pronouncing the target word. In the experiment, subjects listened to the sentence as it was played through the speaker. However, there were no checks to make sure that subjects were not ignoring the sentence, thereby adopting the strategy of just saying the target word as quickly as they could when it was presented on the monitor. If this

strategy was adopted by subjects, it becomes difficult to examine the effects of sentence context.

Experiment 2

Experiment 1 was a failed attempt to replicate Simpson and Krueger's (1991) experiments. However, it cannot be ruled out that I failed to replicate Simpson and Krueger because of the difference in the S.O.A. manipulation. Consequently, Experiment 2 examined the effects of context on lexical ambiguity resolution using I.S.I. instead of S.O.A. In this experiment, markers were placed at the end of the ambiguous word, and I.S.I.'s of 0, 300 and 700 ms were used as in Simpson and Krueger's experiments. Additionally, because it cannot be ruled out that subjects were not paying close attention to the sentences before pronouncing the target word, an additional task whereby subjects were randomly prompted to repeat verbatim the previous sentence was used. The design, materials and procedure were the same as Experiment 1.

Method

Subjects. One hundred and eight introductory psychology students at Michigan State University participated as subjects in this experiment with the restriction that they did not participate in the first experiment. Subjects received partial credit in their introductory psychology courses for their participation and all were native English speakers and had normal or corrected to normal vision and hearing.

Apparatus. The apparatus used in this experiment was the same as that

used in Experiment 1.

Design and materials. The design and materials used in this experiment were the same as in Experiment 1, except the tag used to present target words was placed at the end of the last word in the sentence so that I.S.I. could be manipulated. Also, a cue was randomly added to 35 of the 108 trials (31%) that prompted the subjects to repeat a sentence occasionally throughout the block of experimental trials.

Procedure. The procedure was the same as in Experiment 1. As before, on each trial, subjects listened to a sentence and then named the target word out loud. After pronouncing the word, subjects were either prompted to press a button on the button-box to proceed to the next trial, or were prompted to repeat, to the best of their memory, the sentence they had just heard. The experimenter recorded whether the subject correctly recalled the sentence. Subjects ran a practice block of ten trials to familiarize themselves with the task and procedure. Of the ten practice trials, two trials required that the subject repeat the sentence. After the practice trials, the experimenter answered any questions about the procedure before the subject proceeded to the 108 experimental trials. After the experiment, subjects were debriefed by the experimenter and thanked for their participation in the experiment. The entire session lasted about 30 minutes.

Results

Mean naming latencies at each I.S.I. for the Omnibus ANOVA for Experiment 2 were obtained and are shown in Table 2. Errors in which the

subject incorrectly named the target word did not occur. Subjects who failed to recall a quarter of the repeated trials were replaced. Trials were eliminated if the subject made an extraneous noise before pronouncing the target word which triggered the voice key, as noted by the experimenter, or if the subject pronounced the target word in less than 250 ms or failed to pronounce the target word in less than 1500 ms. The analyses included 98.2% of the data.

Insert Table 2 Here

Unlike Experiment 1, there was no main effect of I.S.I., $p > .05$. However, as in Experiment 1, there was a main effect of context, $F(2,105)=3.974$, $MSe=2765$, $p < .05$. Naming latencies to targets were equivalent in the subordinate context condition and the dominant context condition (513 and 516 ms; $p>.05$), and slower in the neutral context condition (523 ms, $p<.05$). Thus, it appears that having some type of meaningful sentence speeds up naming of a target. There was also a main effect of target strength, $F(1,2)=9.0575$, $MSe=1622$, $p < .005$. Dominant targets (514 ms) were named faster than subordinate targets (521 ms), regardless of the context of the sentence or the relationship of the target to the ambiguous word. While none of the interactions were significant, the interaction of context X target relation was marginal, $F(2,4)=2.4350$, $MSe=2392$, $p = .08$. In the neutral context, there was more priming (unrelated-related target) than in the dominant context, or the

subordinate context (12, -2, and 1.22 ms, respectively). There also was a marginal interaction of context X target strength, $F(4,2)=2.6145$, $MSe=2399$, $p = .07$. In the neutral and dominant contexts, dominant targets were named faster than subordinate target (12.54 ms and 9.57 ms, respectively). In the subordinate context, dominant targets were named slower than subordinate targets (-1.92 ms). This pattern, however, held for both related and unrelated targets.

Discussion

Again, the results of Experiment 2 failed to replicate the findings of Simpson and Krueger (1991), even when the timing parameters more closely matched those used in their experiments. Using I.S.I. instead of S.O.A., there was no evidence of only the appropriate meaning biased by the sentence being accessed; thus, there was no support for a selective access account of lexical ambiguity resolution. The main effect of context suggested that when some information about a particular meaning of the ambiguous word is given, responses to name a target word are quicker. However, this speeded naming occurs for both related and unrelated targets, as well as for dominant and subordinate targets. While dominant targets were named faster than subordinate targets, this effect did not vary with target relation. Thus unrelated dominant targets were named just as quickly as related dominant targets.

The lack of priming for the appropriate meaning also carried over across all I.S.I. conditions, suggesting that the contexts used may not have been

sufficient to restrict access to only one meaning of the ambiguous word.

General Discussion

Simpson and Krueger (1991) found support for a purely selective access model of lexical ambiguity resolution. In their experiments using nonequibiased words, when the dominant meaning was biased by the sentence, there was only facilitation for the target word related to the dominant meaning of the ambiguous word. When the subordinate meaning of the ambiguous word was biased by the sentence, there was only facilitation for the target word related to the subordinate meaning of the ambiguous word. What makes these findings so interesting is the lack of facilitation of the dominant meaning in the presence of a context that biases the subordinate meaning of the ambiguous word.

The experiments reported here were an attempt to replicate the findings of Simpson and Krueger (1991) using a more controlled cross-modal priming experimental paradigm which permitted greater control over target word presentation. In Experiment 1, subjects listened to a sentence being played through a speaker and pronounced a target word presented to them on a computer monitor. Target words were either related to the dominant or subordinate meaning of the ambiguous word in the sentence and appeared at either 0 ms, 200, or 600 ms S.O.A. Unlike Simpson and Krueger, when the dominant meaning of the ambiguous word was biased by the sentence, targets related to both the dominant and the subordinate meanings were facilitated. In

fact, there was no evidence of context mediating which meaning of the ambiguous word was accessed across all levels of S.O.A. used in this experiment. However, as indicated by the pattern of results at 600 ms S.O.A., dominance may play an early role in accessing meaning of the ambiguous word, followed later by context effects.

Experiment 2 was an additional attempt to replicate the earlier findings of Simpson and Krueger (1991), using timing parameters closer to those used in their experiments. Also, because there was a concern that subjects may have not been paying attention to the sentences, an additional task of having subjects randomly repeat the sentence was used. This task presumably caused subjects to process the sentences more carefully. Using I.S.I. instead of S.O.A., I again found no evidence of context mediating which meaning of an ambiguous word was accessed. However, the main effect of context suggested that when some information about a particular meaning of an ambiguous word is given, target word (both related and unrelated) naming latencies are faster. Nevertheless, Experiment 2 failed to provide any information about how context may influence access of meaning of an ambiguous word.

Replication of Simpson and Krueger (1991) was prompted not only because of their findings supporting a selective access theory of lexical ambiguity resolution, but also because of the experimental paradigm they used. In their experiments, subjects read a sentence presented to them on a computer monitor and when they had finished pronouncing the last word in the sentence

(which was the ambiguous word), an experimenter pressed a button that presented the subject with the target word they were to pronounce. This type of task, I argued, did not provide the same amount of control over timing as cross-modal priming or eye-movement monitoring tasks because of naming and pronounciation latencies. In their task, subjects were presented with the target word as much as one second after initially viewing the ambiguous word. Thus, it remains unclear whether or not subjects initially accessed both meanings of the ambiguous word and by the time they were presented with the target word, context had aided in the selection of the appropriate meaning. Using the same stimuli and a cross-modal priming paradigm, I failed to replicate their findings.

A possible reason for this failure to find selective access of the appropriate meaning of an ambiguous word may be due to the timing parameters used in this experiment. Having more precise control over when the target word is presented may have uncovered periods of time when context has no effect over access of meaning. Assuming that the target presentation times used by Simpson and Krueger would have tapped into the periods of time when there are differential effects of contexts, their effects may be due to the lack of control over when the target is actually presented.

An additional reason why I failed to replicate the findings of Simpson and Krueger (1991) may be because of the change in modality in the present experiments. In Simpson and Krueger's work, subjects read aloud the sentence, and then read aloud the target word. In the present experiments, subjects

listened to the sentence and then read aloud the target word. While many experiments examining lexical ambiguity resolution have used such a cross-modal priming paradigm (Seidenberg, et al, 1983; Tannenhaus, et al 1979; Tabossi, 1988), it is possible that the discrepancy in the results can be accounted for by the discrepancy in the tasks. In other words, in the present experiments, cognitive processes involved in the auditory domain are not the same as those involved in visual processing used in Simpson and Krueger's experiments. This differences in cognitive processing may be qualitative in that during reading, as in the Simpson and Krueger task, subjects are forced to process the context of the sentence, while listening to a sentence may allow for less processing of the context of the sentence. Consequently, the lack of priming of the appropriate meaning of an ambiguous word could be because of the auditory processing of the sentences.

Finally, an additional difference between the two studies lies in the design of the studies. Simpson and Krueger (1991) manipulated context and I.S.I. as a between subjects variable while I manipulated context as a within subjects variable and S.O.A. and I.S.I. as between subjects variables. Because in the Simpson and Krueger's study subjects saw only one type of sentence context, they had the greatest chances of developing a strategy for naming the target word, namely, there is an ambiguous word at the end of each sentence, and the appropriate meaning of that ambiguous word is occasionally biased by the sentence. This design is the strongest test of modularity because it allows

subjects the opportunity of recognizing a pattern in the trials of the experiment and if possible, influence which meaning of the ambiguous word is accessed. Simpson and Krueger interpreted their findings as evidence against a modularity view because they found facilitating for only the appropriate meaning of the ambiguous word as determined by sentence context (selective access). In the present experiment, because sentence context was a within subjects manipulation, it is difficult to determine whether or not the effect of context was simply diluted in the present case and subjects were not able to take more advantage of them, or if there is simply no effects of context on the *access* of the meanings of an ambiguous word and that context aids in *selection* of the appropriate meaning.

Although the data in my experiment did not support it, a reordered-access account (Duffy, et al., 1988) probably remains the most favorable theory of lexical ambiguity resolution given the results of other studies. According to this theory, the dominant meaning of an unequibiased ambiguous word is accessed quickly, and is instantiated in to the sentence if it is appropriate. Under these conditions, no trace of the subordinate meaning may exist because of the quick access of the dominant meaning, and this can look like selective access of the dominant meaning. The results of the present Experiment 1 are consistent with the rapid access of the dominant meaning. When the subordinate meaning of an unequibiased ambiguous word is biased by the sentence, activation levels of the subordinate meaning increase enough to compete with the activation level of

the dominant meaning. This competition between the dominant and the subordinate meanings slows down the selection process of a particular meaning of the ambiguous word.

For equibiased ambiguous words in a neutral context, again there is competition between the different meanings of the ambiguous word because of equal levels of activation. However, when one meaning is biased by the sentence, the activation level of that meaning increases so that it is access before the other meaning. This quicker selection of the appropriate meaning can resemble selective access of that meaning. In conclusion, the present experiments failed to replicate the findings of Simpson and Krueger (1991). Context did not mediate access of meaning of an ambiguous word. Unfortunately, while the results did not support a selective access account, they also did not support a reordered access account (Duffy, et al. 1988) of lexical ambiguity resolution.

Table 1

Mean Reaction Times (RT) in ms for S.O.A. X Target Ambiguity Strength X Target Relation X Context.

0 ms S.O.A.

	Dominant Related		Subordinate Related	
	Related	Unrelated	Related	Unrelated
Dominant	554	565	562	574
Neutral	572	573	572	585
Subordinate	563	561	559	579
M	563	566	564	579

200 ms S.O.A.

	Dominant Related		Subordinate Related	
	Related	Unrelated	Related	Unrelated
Dominant	520	523	513	526
Neutral	526	539	532	552
Subordinate	531	532	527	534
M	523	531	524	537

600 ms S.O.A.

	Dominant Related		Subordinate Related	
	Related	Unrelated	Related	Unrelated
Dominant	491	497	520	513
Neutral	494	518	524	525
Subordinate	515	516	507	509
M	500	510	517	516

Table 2

Mean Reaction Times (RT) in ms for I.S.I. X Target Ambiguity Strength X Target Relation X Context.

0 ms I.S.I.

	Dominant Related		Subordinate Related	
	Related	Unrelated	Related	Unrelated
Dominant	524	521	538	526
Neutral	529	551	537	558
Subordinate	529	530	522	521
M	527	534	532	535

300 ms I.S.I.

	Dominant Related		Subordinate Related	
	Related	Unrelated	Related	Unrelated
Dominant	509	510	512	525
Neutral	496	515	530	520
Subordinate	513	502	502	507
M	506	509	515	517

700 ms I.S.I.

	Dominant Related		Subordinate Related	
	Related	Unrelated	Related	Unrelated
Dominant	502	502	518	506
Neutral	503	506	508	523
Subordinate	505	507	505	517
M	503	505	510	515

Appendix A

Experimental Sentences	Dominant Related	Subordinate Related
1. The princess took a carriage to the ball.	BOUNCE	DANCE
We decided on the size of the ball.		
The boy reached up to catch the ball.		
She stored her letters in the wooden chest.	BODY	TREASURE
The young man had a very large chest.		
The man was having pains in his chest.		
2. I tied up the papers with a band.	MUSIC	RUBBER
We all agreed that we liked the band.		
We like to listen to the marching band.		
I scratched my hand against the rough bark.	DOG	TREE
I was surprised by its very strange bark.		
I was scared by his very loud bark.		
3. With his gun, Johnny shot the hairy bat.	BASEBALL	FLY
While in the basement, Johnny found a bat.		
Johnny proudly swung his wooden bat.		
We went out for dinner on our date.	MONTH	GIRL
I'm sure that will be a good date.		
A great leader was killed on this date.		
4. The man got a cramp in his calf.	COW	LEG
The man looked carefully at my injured calf.		
The man fed corn to the hungry calf.		
This is a broken and rusty old spring.	SUMMER	COIL

This really is not a very good spring.

This has been a cold and rainy spring.

5. The princess rode home in her silver coach.	TEAM	HORSE
We liked the looks of the new coach.		
We won and gave a prize to our coach.		
The men took their positions on the diamond.	GOLD	CIRCLE
The two men discussed the size of the diamond.		
The man gave his wife a beautiful diamond.		
6. I cheated by dealing from the bottom of the deck.	SHIP	PACK
There was something wrong with the deck.		
The men were told to mop the deck.		
They finally asked me to join the club.	STICK	GROUP
The people were very interested in the club.		
His head was hurt by the heavy club.		
7. The school children walked outside for the drill.	HOLE	FIRE
I think we need to have a drill.		
To help make the chair he used a drill.		
The grass had grown over a whole foot.	TOE	INCH
They thought that it would be a foot.		
I received a bad cut on my foot.		
8. I like to watch football games in the fall.	DOWN	LEAVES
I hope you don't have a bad fall.		
I tripped on the curb and had a bad fall.		

The cowboy thought he had the winning hand.	ARM	CARDS
The thought the man had a nice hand.		
The man bowed and kissed the lady's hand.		
9. The questions on that test were too hard.	SOFT	EASY
I don't like it because it's too hard.		
She cooled the metal until it was hard.		
I was stuck in the chest by his sharp horn.	BLOW	DEER
The man showed us a very old horn.		
They called us to dinner by sounding a horn.		

10. My mother poured water into her steam iron.	STEEL	SHIRT
Let's decide what to do with this iron.		
The box was made of very thick iron.		
I made a mistake by pressing the wrong key.	LOCK	TYPE
I don't think that is the right key.		
I could not get in with the wrong key.		
11. The girl carefully traced the shape of the letter.	NOTE	ALPHABET
The girl proudly showed her mother the letter.		
Oh his trip my friend sent me a letter.		
I lifted it easily because it was light.	DARK	HEAVY
Mary thought that the chair was very light.		
I liked the color because it was light.		
12. Everyone thinks that man is a real nut.	SHELL	CRAZY
This time I decided to pick a nut.		
I sat down and ate a toasted nut.		
The worker built a ten foot wire pen.	WRITE	PIG
He showed us a very well made pen.		
The teacher made a mark with her pen.		

13. I won the leading part in the play .	GAME	ACT
We were all very surprised by the play.		
We scored six points on a pass play.		
The tired woman asked for some more punch.	HIT	DRINK
I was very surprised by the punch.		
I was knocked out by his very hard punch.		
14. I held my ears because of the loud ring.	FINGER	BELL
He wanted to give the girl a ring.		
She loved to wear her beautiful new ring.		
I opened the letter by breaking the seal.	ANIMAL	SHUT
The woman said it was a good seal.		
My favorite circus act is the trained seal.		
15.I rolled up my sleeve to get the shot.	GUN	DOCTOR
I was very worried about the shot.		
I was scared because I heard a loud shot.		
I made the rounds on my night watch.	TIME	LOOK
They got mad because I sat on my watch.		
The rich man looked at his gold watch.		

16. He blew water at the crowd through his trunk. CAR ELEPHANT

I thought he would carry it in his trunk.

I put all of my suitcases into the trunk.

The dinner was in honor of the famous star. SKY MOVIE

We all loved to look at the beautiful star.

We looked up high to see the shining star.

17. The media is about to announce the
members of his cabinet. KITCHEN GOVERNMENT

Everyone was impressed with the new cabinet.

Jake went to the lumber store to select
the wood for his cabinet.

On their school vacation, the accounting
club toured the mint. TASTE MONEY

No one was particularly impressed with the mint.

Whit liked the drink until she discovered it
was made with mint.

18. Robert was excited that he would get to
tour the car plant. FLOWER BUILDING

Jason was surprised by the size of the plant.

I liked the colors in the pot she gave me for
my new plant.

I went for a jog along the muddy bank. MONEY WATER

Billy was not happy with the destruction to the bank.

We all thought it was an odd place to build the new bank.

Appendix B

Filler Sentences

Related Target Condition	TARGET WORD
1. The teacher went to the beach with her sister.	BROTHER
2. Those scared young boys ate the poison.	SERUM
3. The licensed fishermen were allowed to catch seven fish.	LURE
4. The attendant kept all of the passengers calm.	SERENE
5. John's house was destroyed by the high winds.	BLOW
6. The excited parents decided to name the baby Jack.	BOX
7. She accepted the offer from her boss.	JOB
8. The decorations were taken down and stored away.	FAR
9. The survivors blamed the company for the lack of lifeboats.	WATER
10. Keith had the most money left after our vacation.	TRIP
11. The company made sleepwear out of non-certified fabric.	CLOTH
12. The tower is not a good place for a restaurant.	FOOD
13. The best insurance agents will offer you a better rate.	PRICE
14. The patients discovered there was a serious emergency.	DANGER
15. The cars were parked close to the convention center.	BUILDING
16. The parents agreed about the benefits of the program.	COMPUTER
17. Many students will be attending the charity dance.	MUSIC
18. The players were excited about making the team.	CLUB
19. The dentist learned new procedures for removing teeth.	WHITE
20. The instrument fell and got scratched.	CUT
21. The ballerina was not satisfied with the dance sequence.	ROUTINE
22. The plant did not thrive in the dry air.	BREATHE
23. We were elated that the magazine was accepted for publication.	BOOK

24. The princess loved wearing the beautiful jewelry.	RING
25. The secretary always started her day by drinking coffee.	CAFFEINE
26. There was an obscene message written on the blackboard.	CHALK
27. The photograph was stored between plates of glass.	WINDOW
28. None of the textbooks could answer the student's questions.	ANSWER
29. The door withstood the incessant pounding of the man.	ADULT
30. Many raincoats are made of material that is not waterproof.	DRY
31. The highrise on the hill crumbled during the earthquake.	SHAKE
32. The group left messages on all around campus.	SCHOOL
33. The guitarist hoped shake up the music industry.	BUSINESS
34. The couple's young daughter is a delight.	JOY
35. The aspiring author had yet to write a word.	LETTER
36. The boating trip had been arranged very quickly.	FAST

UNRELATED TARGET CONDITION	TARGET WORD
1. The bus driver was sick of the hot days.	GROOM
2. His daughter chose to attend a midwestern college.	BEACH
3. The woman moved to Chicago because of her job.	AREA
4. The old man distinctly remembered the war.	HOUSE
5. Joan remembered the days when parking on campus was easy.	EAR
6. The new computer was very powerful and efficient.	BIKE
7. Brenda threw a party that no one attended.	PAPER
8. Montana is the fourth largest state in this country.	JOLLY

9. Jake was working nights and losing sleep.	HAPPY
10. The woman expected her parents to arrive early.	SUNNY
11. The man claimed to have seen the Beatles.	SPEAK
12. The librarian ordered a second copy of the book.	DOUGHNUT
13. The high school football team finally lost a game.	WINTER
14. The morning fog burns off quickly when the sun rises.	JUMP
15. Overdrilling in California's geothermal fields is a great concern.	WELFARE
16. The old actress remembered so many stories.	JUNK
17. Greenland is the largest island in the world.	HOPE
18. The chess club's advertisement got no response.	SABLE
19. The man hadn't spoken to his friend in months.	KING
20. The woman enjoyed bowling on Sundays.	BOOM
21, Jack Lemmon won an Oscar for his role.	READ
22. His wife shot him because he was evil.	QUESTION
23. Jill ate at the new restaurant on Main street.	DISK
24. New manufacturing ideas are now used in many companies.	SCAN
25. The boy crossed the road and played in the field.	MELODY
26. Johnny looked up the phone number in the book.	GHOST
27. I did not want to run for class president.	HOST
28. Bill went to school with a headache this morning.	TELEVISION
29. Michael liked to punch the refrigerator.	VEHICLE
30. Football players wear short sleeves so players can't grab them.	LAUGH
31. Susan dreamed of being a movie star.	BLINK
32. The young man cried at the end of the movie.	ROAST

33. The student had to write all weekend.	CLIP
34. We bought new speakers last night.	PROFESSOR
35. I have to call Jason tonight.	FENCE
36. It rained cats and dogs this morning.	DISK

Appendix C

Practice sentences

RELATED TARGET CONDITION	TARGET WORD
1. Eight feet of snow fell on the city.	TOWN
2. The inauguration of the President is always held in January.	MONTH
3. The Earth is closest to the Sun in January.	CALENDAR
4. Bill and Ted didn't think time travel was very pleasant.	NICE
5. Sam's cat hissed whenever I came to the house.	HOME

UNRELATED TARGET CONDITION	TARGET WORD
1. Deja vu is the feeling of having been somewhere before.	AFTER
2. John F. Kennedy's funeral was modelled after Lincoln's.	MUSIC
3. Elton John wrote a song about Marilyn Monroe.	ANKLE
4. My eyes ached after staring at the stars.	CAMP
5. Jimmy was afraid his mother would smell smoke.	COMMENT

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