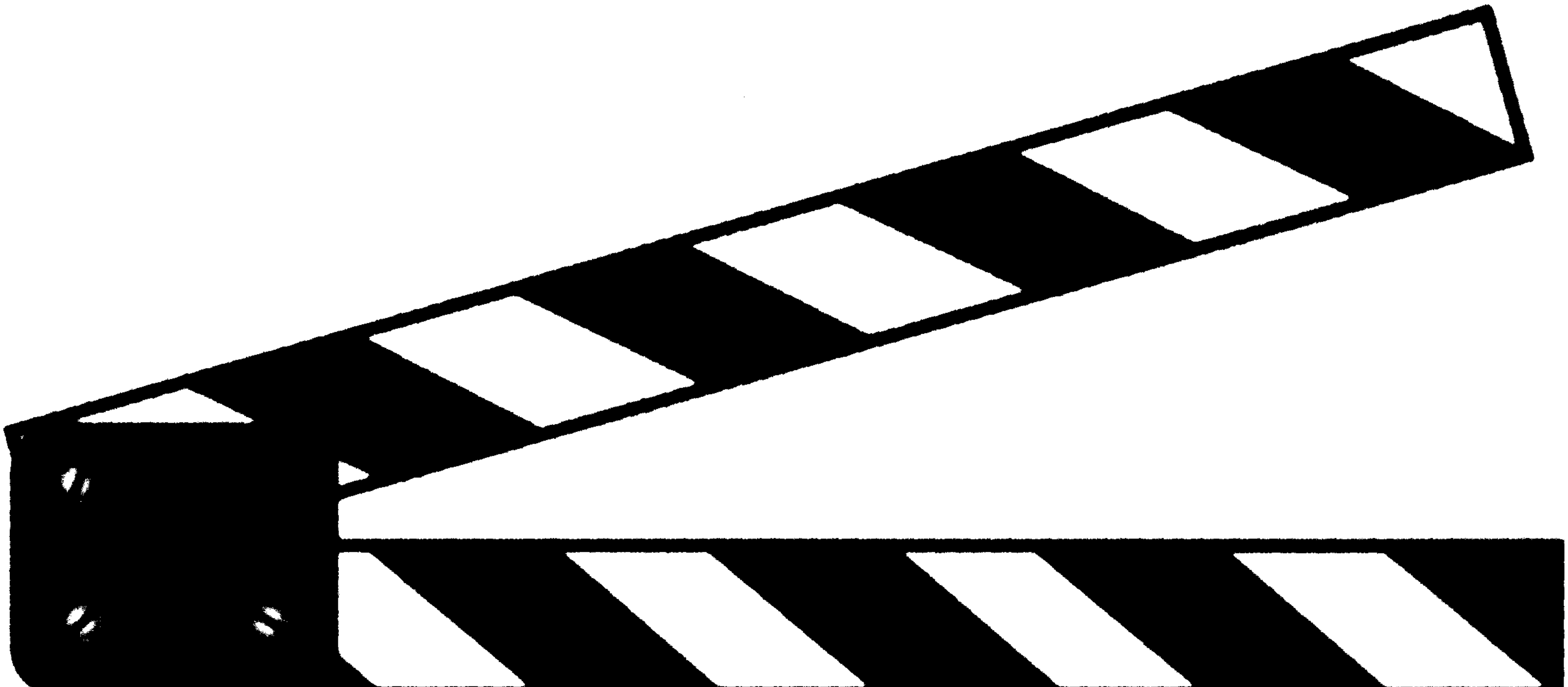
5-2002

Context effects and lexical ambiguity processing: an activation-based account

Frazier Orgain



Project Name: Orgain_Frazer_2002

Date: 6/29/15

Patron: DTP

Specialist: Jackie

Project Description: Master Theses

Hardware Specs:

CONTEXT EFFECTS AND LEXICAL AMBIGUITY PROCESSING:

AN ACTIVATION-BASED ACCOUNT

By

Frazer Orgain

B.S., Virginia Military Institute, 1999

A Thesis

Submitted to the Graduate Faculty

of the University of Richmond

in Candidacy

for the degree of

MASTER OF ARTS

in

Psychology

May, 2002

University of Richmond, Virginia

I certify that I have read this thesis and find that, in scope and quality, it satisfies the requirements for the degree of Master of Arts.

Ping Li, Thesis Advisor

Jane M. Berry

Beth Crawford

Abstract

Many studies have been conducted to test the effects of ambiguous words in sentence processing. There are two views: the *modularity hypothesis* and the *interactive hypothesis* that dominate this field of study. The effect of ambiguity has been tested in many ways, including gating, cross-modal priming, naming, and self-paced reading. This study utilizes the methods of self-paced reading with lexical decision and naming tasks to examine the hypotheses as they relate to the access period of lexical differentiation. Results indicate that context has an immediate effect, after which participants look to other factors to discern meaning of a sentence. Details are discussed according to a time course activation model.

Acknowledgements

I would like to thank Ping Li for the idea and support for this project. Before matriculation into the University of Richmond Cognitive Science Lab I had no idea that this was a research issue. Thank you for broadening my horizons and turning me into a research.

A special thanks goes to Lucy Medina and Kathy Reid for the collection of data. We suffered through the Beta version of E-prime and from the meager beginnings to the culmination of data collection.

And finally to my family. Mom and Dad, you have served as a cheering section for over a quarter century. This degree shines as proof of your undying support and everlasting love. And Corbin, you are the vessel from which I float. You bring me forth in effortless grace so that I may achieve great accomplishments. Without your steadfast support and unconditional love I could not find my way in the waters that seek to drown those unsure in direction. You have shown me the beacon for which to aim. I love you.

Context Effects and Lexical Ambiguity Processing: An Activation-based Account

Natural language provides many examples of ambiguity that we must discern for effective communication. A single sequence of words may render many interpretations. However, many of these situations often go unnoticed to a reader as it is assumed that context allows them to select among the various possibilities. One major research debate in language concerns whether the access and selection of a contextually appropriate meaning from among several possible definitions depends on the prior sentence context. Meaning also depends on how early the context can influence the access, selection, and integration processes. The study of lexical ambiguity affords the unique opportunity to examine the comprehension of words that have multiple meanings. It is a research area that has been studied for many years utilizing several techniques (Van Petten & Kutas, 1987; Small, Cottrell, & Tanenhaus, 1988; Li, Shu, Yip, Zhang, & Tang, 2001; Swaab, Brown, & Hagoort, 1998; Lucas, 1999). Most agree that there are a limited number of language processing subsystems: phonetic, phonological, lexical, syntactic, and conceptual (see Lucas, 1999 for an overview). Nevertheless, how these systems are related and organized is still under much debate.

Two competing hypotheses have emerged in the past thirty years with research from psychological, linguistic, and computational perspectives. The first proposes a modular view where language subsystems are encapsulated, operating independently of other cognitive systems (Fodor, 1983). Termed the exhaustive or multiple access hypothesis, it states that all meanings of an ambiguous word will be accessed momentarily following the occurrence of the word. Sentence context can then only help to select the appropriate meaning at a post-access stage. This hypothesis is based upon the premise that language processing is a modular, bottom-up method in which non-lexical, sentential information does not penetrate lexical access (Fodor, 1983).

In contrast, the context-dependent or selective access hypothesis declares that the contextually appropriate meaning of an ambiguous word can be selectively accessed early on if the preceding sentence context provides a strong bias to the appropriate meaning. This hypothesis assumes that language processing is operated by an interactive mechanism in which information can flow both bottom-up and top-down simultaneously and that lexical access and sentential context can mutually influence one another at a very early stage (McClelland, 1987). Higher order functioning can feedback upon the operation of lower subsystems (see Marslen-Wilson & Tyler, 1980 for complete discussion). In both multiple and selective access hypothesis, researchers believe that the time course of lexical ambiguity resolution reflects the general mechanisms of language understanding.

Three models (the exhaustive access, selective access, and ordered access hypotheses) have emerged prominently from past research in lexical ambiguity. The following sections will give a detailed description of the types of ambiguity, the methods in which researchers gained data in this area, the models of language processing, and the theories from which these models have arisen.

Types of ambiguity

The two main types of lexical ambiguity are syntactic and semantic. Syntactic ambiguity refers to the ambiguity across category, as in the case of a noun versus a verb. *Drill* can either be the act performed by a carpenter or the object used to complete the task. Since these words may be found in different categories in the brain, some researchers believe that this type of ambiguity is easier to discern than semantic lexical ambiguity (Small, et al., 1988). There are two types of semantic ambiguity: polysemy and homonymy. A polysome is a word whose several meanings are related. For example, when we speak of *foot* we can refer to the appendage attached to your leg or the end of the bed where your feet rest. Both meanings are related but not literally the same. Homonymy refers to words whose definitions are unrelated as shown in the case of *bat*: “The boy picked up the bat and walked to home plate” or “As he walked into a cave a bat flew over his head.” Both meanings are pronounced and spelled the same but they are semantically unrelated. The goal of the present research is to examine lexical access as it occurs across unrelated meanings, not categories. Therefore, this study focuses on the situations of semantic ambiguity.

Research Methods

It is important to examine the research methods utilized to explore lexical ambiguity because scientific history dictates that theory is wedded to methodology. To learn or improve upon theories results must either be duplicated or disputed. Research of language processing is no exception. Three methods are of primary interest to the current research. First, Grosjean (1980) conducted the pioneering work known as gating. This method uncovered the facility for persons to recognize a word when only half of the auditory information has been presented. It was a first look at the time course of word comprehension. Next, priming studies are of principal importance because one is able to present context followed by a target to examine participant’s recognition and reaction. Most current theories of lexical ambiguity stem from this discourse. And finally, self-paced reading is a basic method to most closely duplicate a person's online reading time. Several examples of self-paced reading were analyzed by Just, Carpenter, and Woolley (1982) and the best was selected to display the contexts in the current study.

The gating paradigm introduced by Grosjean (1980) has allowed for words to be presented piecemeal. Each word is presented repeatedly at increasing intervals until the entire word is heard. Grosjean's research had two main goals: study the on-line processing of spoken language and extend the current knowledge of the word recognition process (Cotton & Grosjean, 1984). During a test the subjects' task is to guess the stimulus being presented and report their level of confidence based on their answer. The main contribution of this research was the discovery that subjects are able to recognize a word in context with about only half of the acoustic information. This discovery leads one to realize the tremendous effect of context. This effect is the main concern of this thesis. Unfortunately, little work had been focused on the context of spoken sentence comprehension until Li (1996) conducted a study focused on this topic. Results, from Li (1996) suggest that speakers rely heavily upon semantic cues, which are consistent with previous untimed studies.

Priming studies involve two main stimuli: prime and target. The prime is either a full sentence (Onifer & Swinney, 1981 and Simpson & Krueger, 1991) or a single word (Simpson, 1981). After presentation of these primes, the target is presented. The target is generally a single word whereupon the participant must respond according to the criteria of the study. The form of response is in one of two methods: lexical decision or naming. The lexical decision paradigm requires the participant to make an affirmative or negative response to the question: "Is the target a word or a non-word?" That is, if the target is a word, they press a 'yes' button but, if the target is a non-word, they press a 'no' button.

Naming is another method that can be used to tap into semantic priming. When the participant sees the target word, their task is to say the word as quickly as possible into a microphone. This type of study allows for examination of phonology as well as access. The lexical decision and naming tasks are the primary methods utilized in this thesis and are discussed completely in the section: Models of Ambiguity Processing.

Finally, self-paced reading is the last method pertinent to this study. Using this type of presentation permits data collection concerning the length of time one needs to comprehend individual words and sentences. Just, Carpenter, and Woolley (1982) conducted a study to examine three methods of self-paced reading: a cumulative condition, a moving window condition, and a stationary window condition. All conditions required subjects to respond by button press to see the next word. The cumulative condition displayed words as would be seen in normal text one after the other, leaving the preceding words on the screen until the end of the passage. Just et al quickly identified a problem with this paradigm. Subjects would press the button repetitively and then read the words that were displayed. This discrepancy is an obvious drawback to a system designed to time the comprehension of individual words, not groups of words. The second method examined the moving-window technique and produced improved results. Here words were again presented one at a time but they did not remain on the screen when the subject responded by a button push. Instead, there were dashes that preceded and replaced the content words on the screen. Finally they tested the stationary-window condition where words were presented in succession in the same area on the screen.

All three conditions were compared to eye-fixation research since eye-fixation is thought to most closely represent natural reading. Of the three presentation techniques the moving-window condition correlated with eye-fixation the most, stationary-window a close second, and the cumulative condition a distant third. It is important to note, however, that the mean reading time for each word in the three conditions was 462 ms, as opposed to 239 ms in the eye-fixation study. Also, the eye-fixation studies found that readers did not fixate on all of the words in a sentence: 83% on content words and only 39% on function words such as "the."

Models of Ambiguity Processing

As discussed earlier, ambiguity research has been divided by a dichotomy between the modular and the interactive views. Most previous tasks have been designed to compare exhaustive and context dependent models. Due to the inability of these models to account for all of the variables associated with ambiguity, a third was developed. Currently there are three models of lexical ambiguity processing: exhaustive access, selective access, and ordered access. Each of the below-mentioned models has its strengths. However, the anomaly seems best described by a hybrid model that allows for stipulations sensitive to the frequency of the meanings in context (Simpson, 1984).

Exhaustive access

The exhaustive or multiple access model proposes that lexical processing is a modular, bottom-up method where all meanings are accessed first and the context can only work at the post-access stage (Onifer and Swinney, 1981). This explanation of lexical access has had the most supportive evidence and has been the most popular for many years. A number of studies have shown that immediately following an ambiguity, all meanings are momentarily available, though the appropriate one is selected for elaboration later on (Lucas, 1987; Onifer & Swinney, 1981; Seidenberg, Tanenhaus, Leiman, & Bienkowski, 1982; Swinney, 1979; Tanenhaus, Leiman, & Seidenberg, 1979; Till, Mross, & Kintsch, 1988). Those that prefer this theory make one basic assumption. In the absence of any strongly biasing context, all meanings of a word are accessed, at least momentarily. Even in the presence of a strongly biasing context, all meanings of an ambiguity are still accessed, according to this theory.

Many studies have been conducted to show the effect of multiple access. One conducted by Onifer and Swinney (1981) utilizing the cross modal priming technique leads to evidence for this argument. They employed a technique where subjects listened to and comprehended sentences containing ambiguous words. Simultaneously, a string of letters were presented on a computer screen to which participants were required to make a lexical decision concerning whether the letter strings were words or non-words. The sentences presented auditorily were biased to the dominant or subordinate meaning of the ambiguous word presented visually. The results indicate that both meanings of the ambiguous word were facilitated when presented simultaneously with the target word. The data provide a straightforward argument for the exhaustive access model: that is, all meanings were accessed momentarily following the ambiguity irrespective of the relative frequency or the semantic context in which the words occur. Most important, this study provides the critical case that distinguishes this hypothesis from others. Here the lexical access for words related to the secondary, less frequent interpretation of the ambiguity were facilitated, thus indicating that the secondary meaning had been accessed, at least momentarily, in the presence of context biased toward the more frequent meaning (Onifer & Swinney, 1981). Therefore, the data do not support the selective access hypothesis put forward by other authors.

At some point during the decision of word meaning, a person must determine what meaning an ambiguity obtains. This model allows for this process only after the access stage. It is at this post-access stage where a priori knowledge (frequency) and context can aid the unique judgment of parallel semantics according to the deliberate meaning. Time course of activation within various meanings of ambiguous words is thus quite important to establish the nature of the post-access decision process. This point is explained in the second experiment included in the article by Onifer and Swinney (1981).

Experiment 2 examined the activation of the primary and secondary meanings in a new set of ambiguities both immediately following the ambiguity in the sentence and 1.5 seconds following the occurrence of the ambiguity in the sentence, thus examining the post-access stage of lexical processing. In the conditions where the target was presented immediately following the ambiguity, the results replicated experiment one: both primary and secondary meanings were facilitated independent of context. However, in the cases where the word was presented 1.5 seconds after the occurrence of the ambiguity a difference was found. Only the contextually appropriate meaning showed facilitation at this point.

In both cases these experiments provide strong support for the exhaustive access model of lexical access. The first experiment shows that lexical access is autonomous and independent of contextual information. In addition, lexical access seems to be an automatic process that is driven by the acoustic/phonetic form of the word only. Experiment 2 evaluates the addition of frequency and context at the post access stage. Here the subjects were able to differentiate between the ambiguous meanings. It appears that the time course for semantic gathering is complete at 1.5 seconds following the occurrence of a word.

Selective access

The selective access or context dependent hypothesis asserts that lexical processing is an interaction process restricted to the appropriate meaning of an ambiguous word in context. When the context sufficiently biases toward a certain meaning, only that definition becomes activated (Conrad, 1974; Li & Yip, 1996, 1998; Lucas, 1984; Seidenberg, 1982; Simpson & Krueger, 1991). According to this theory, the ambiguous nature of the word does not have to be resolved because the context primes only the appropriate meaning (Simpson, 1984). The study conducted by Simpson and Krueger (1991) is the best representation of this model. It is an improvement upon Simpson's 1984 article where the methodological constraints were under dispute.

In that experiment subjects listened to sentences ending in homographs and followed by the target presented for lexical decision (Simpson, 1984). The facilitation of the target was recorded for related and unrelated words. Several obstacles and objections to this interpretation are present as unequivocal support for the interaction of semantic and lexical processing. First, several recent studies have shown that the use of the lexical decision task may not only affect lexical access but influence the decision stage (Lorch, Balota, & Stamm, 1986; Seidenberg, Waters, Sanders, & Langer, 1984; West & Stanovich, 1982). The sentence context could cause a relation to the target. If the context is highly biased, the subject could predict that the target is a word. Therefore the subject could make faster lexical decisions for the appropriate target even in the absence of any contextual influence on the access of that meaning.

The second major controversy of the Simpson (1984) article was the time course of lexical access. Onifer and Swinney (1981) have shown that immediately following the presentation of the ambiguous word both meanings were accessed simultaneously, but only one remained after an elapse of 1500 ms. The problem stems from a delay of 150 ms between the end of the context and the onset of the lexical decision target in the Simpson article. It is therefore believed that the data was influenced not by the immediate activation process but by the selection processes occurring after all meanings had been retrieved.

In rebuttal, Simpson and Krueger (1991) defended their findings to squelch these objections. Their first change was to eliminate the lexical decision task. As an alternative the subjects were asked to name the target. Secondly, they were careful to ensure that context effects could not be traced to intralexical associations. Finally, three sentence-to-target intervals were used so that time course of meaning acquisition could be assessed. Subjects read sentences with a homograph at the end and then named the target presented at a interstimulus interval (ISI) of 0, 300, 700 ms. If the modular view was prominent, the data would show that subjects are better able to differentiate the meanings of the homographs. But, the data suggest an effect of ISI between dominant and subordinate sentence meanings and related and unrelated targets.

In the ambiguous sentences at the 0 ISI, there was a 37 ms facilitation for the dominant targets. Subordinate targets showed no priming. This difference leads to the conclusion that, at this interval, only the more frequent meaning is accessed. The same would be true at the ISI of 700 ms. There was a 29 ms facilitation of the dominate target while no priming was shown for the subordinate. However, there was an interesting discovery at the middle ISI of 300 ms. Both the subordinate and dominant targets showed a 30 ms priming effect indicating that both homograph meanings were activated at this interval. In the ambiguous sentences there was facilitation across the intervals of the dominant meaning of the target. However, the activation of the subordinate meaning is quite different. At both ISIs of 0 and 700 ms results show that the more frequent meaning influences the acquisition of the target, but at 300 ms the subordinate reaches a facilitation equal to the dominant.

In the biased sentences both types (biased to dominant and subordinate) led to a context dependent pattern of facilitation. Only the meaning that was biased by the context was facilitated regardless of ISI. There was a 23 ms prime for the dominant target while there was none for the subordinate. The opposite was found for the subordinately primed sentences. In this context the target was primed 22 ms while the dominant indicated no effect. The results suggest that sentence context can restrict access to the appropriate meaning of a homograph.

This study proposes that when the context provides no specific clues as to which meaning should be maintained, the most frequent is selected, just as it is when there is no context. In consideration of the results about the nonbiasing context, they find that the homogeneity across ISI leads to the assumption that the effects of context are immediate and are not the result of a selection process following activation of all meanings. Nevertheless, we must consider the possibility of multiple access at the ISI of 300 ms.

The data suggest that both meanings are facilitated but lends itself toward the possibility of a modular representation of semantic space. However, it is unlikely that we use different strategies for language acquisition at different processing times. If that were true the subordinate meaning of the homograph would be activated initially, then deactivated (0 ms ISI), reactivated (300 ms ISI), and finally deactivated again (700 ms ISI). This does not seem to be effective use of the language processor. It seems that the most feasible explanation of the study is that the strongly biasing sentences restricted access to the single meaning of a homograph which was consistent with that context, and that they did so immediately.

A second experiment in the Simpson and Krueger (1991) article was completed to dispute the theory that the context dependent pattern of the first experiment was due to direct priming of the target. If that were the case, when the new primes (unambiguous control words) replaced the homographs, the results should be replicated in Experiment 2. They found that the difference was not significant and that there was no evidence that the priming effects in the first experiment were due to direct influence of the context.

These results are contrary to much of the existing research conducted to show that there is a period of multiple access followed rapidly by selection of the appropriate meaning. However support is found in other research (e.g., Li & Yip, 1996, 1998; Duffy, Morris, & Rayner, 1988; Neill, Hilliard, & Cooper, 1988; Simpson, 1981; Tabossi, 1988; Van Petten & Kutas, 1987) that the effect of context is an immediate one where both meanings are activated only after several hundred milliseconds. Therefore, this study confirms that the context effect seen with biased sentences acts at a very early stage of meaning activation.

Ordered Access

The third and final model that explains lexical access is the ordered access model. Those in favor of this model (Forster & Bednall, 1976; Hogaboam & Perfetti, 1975; Holmes, 1979; Rayner, Pacht & Duffy, 1994) emphasize that ambiguous word meanings are not encountered with equal frequency and thus lexical acquisition of these words should be comprehended accordingly. The model proposes that word meanings are retrieved in a serial, self-terminating search. The most frequent meaning is activated first and evaluated based on context. Only if the definition is not congruent with the word, will the processor evaluate the second most frequent meaning of the word. This process is continued until the correct definition is activated.

Simpson and Burgess (1985) designed an experimental procedure that best examines the general position of the ordered access model. They conducted three experiments in their study utilizing the same method of priming. The prime, presented first, was either of the dominant meaning or the subordinate and the target, presented second, was either related or unrelated. The first two studies were identical except for the stimulus onset asynchrony (SOA). Experiment 1 employed three SOAs of 16 ms, 100 ms, and 300 ms and Experiment 2: 300 ms, 500 ms, and 750 ms SOAs. If all meanings of an ambiguous word are initially retrieved, then dominant and subordinate associates should show equivalent amounts of facilitation, relative to targets primed by unrelated words, at very short SOAs. On the other hand, if lexical access is ordered according to frequency, then we should see a facilitation of the dominant meaning even at the shortest SOA.

In Experiment 1 all three SOAs revealed an effect of dominance and relatedness. There was an interaction at only the shortest interval (16 ms). The results suggest that when an ambiguous word is presented without context, its dominant meaning is available almost immediately, whereas activation of the less frequent meaning develops more slowly. The dominant meaning has an initial advantage that diminishes after 100 ms. The second experiment indicates that this advantage is regained at SOAs longer than 300 ms. All three SOAs revealed a main effect of dominance and relatedness, but only the 750 ms SOA had a significant interaction. Results indicate that the first experiment illustrated a tendency to move from an ordered access model to an exhaustive access model. The opposite is true for Experiment 2. In this study one cannot argue that all meanings of a word are eventually activated – that is, the lexical access for ambiguous words is exhaustive. However, the extent to which time and frequency restrain this activation is under debate. It appears that frequency of meaning is utilized twice: in the initial stages and again after meanings have been exhausted.

Experiment 3 was performed to examine whether the selective attention to the primes meaning at SOA of 750 ms was due to an active, forward process of the dominant meaning or rather to the decay of the subordinate meaning. Significant main effects of dominance and relatedness again were found. The only condition to show facilitation relative to the neutral stimulus was the related-dominant condition. Lexical decisions were longer in regard to unrelated and to related-subordinate targets than to targets preceded by the neutral prime. This suggests that the process by which the appropriate meaning is selected is an active one. Concurrently, the latency is not due to the more rapid decay of another definition. The strategy employed by the subjects is to direct their attention to information that is consistent with the frequent meaning. This is to say, the subordinate meanings of words are treated as unrelated. Even if the subjects are told to avoid the dominant meaning they can not redirect their attention to the subordinate. As such, this study exemplifies the ordered access model where the subordinate meaning can be accessed only if the context is heavily biased toward that meaning.

Another approach to ambiguity research was conducted by Rayner, Pacht, and Duffy (1994). They conducted two experiments to examine which model of processing best explains natural reading. The primary concern of the first experiment was to determine whether a prior encounter with a subordinately biased homonym would facilitate the access of that word when repeated in context. The prior encounter was a word pair: the homonym (ex. bank), and an associated word biased to the subordinate meaning of the homonym (ex. river). After participants had memorized the list of associations, they were asked to read sentences containing the homonyms. In experimental sentences contexts were biased to the subordinate meaning of the homonym. Data were collected for eye gaze duration for the sentences taking special notice to the homonym. As a result, the prior knowledge of subordinate associations failed to facilitate the participants' gaze upon the homonyms. Thus, Rayner et al. (1994) propose that this result serves to support the ordered access hypothesis where the most frequent meaning of a word is examined before other meanings can be considered. Consequently, the data provide no support for the selective access hypothesis: even when presented with the subordinate association, that meaning does not take precedence over the dominant when later seen in context. However, these assumptions are derived even though the difference could be a result of the paired association conflicting with context, a case in which the participants could see these tasks as functionally and semantically unrelated.

In Experiment 2 Rayner et al. (1994) created a variant of the previous paradigm to rebut the methodological enigmas from Experiment 1. Instead of simple pairings of a homonym with a subordinate association, entire paragraphs were constructed with the homonym embedded. This was to make certain participants comprehended the subordinate bias. After reading these paragraphs, the participants would read sentences with the homonyms inserted to examine eye gaze duration, just as Experiment 1. Even though the subordinate bias was inherently stronger in Experiment 2, there was no evidence for the subordinate bias effect.

Critique of Past Research

The methodologies of previous studies seem to be the most disputable point. When a word is presented in isolation, is that enough prime for the subject to presuppose the context that was intended? I believe that this assumption is erroneous considering that studies have exhibited the differences in processing single words compared to full sentences (Forster, 1979; Schuberth, Spoehr, & Lane, 1981). Forster (1979), specifically points to the differences between these methods.

If you consider the prime in these experiments by themselves, you can see a considerable difference. When a sentence is presented that will bias the subject to comprehend an intended meaning, the technique is employed at the beginning of the sentence. From that point until the time of the ambiguous prime (when data are recorded), several hundred milliseconds could pass, allowing critical comprehension time to elapse. Simpson and Burgess think that they can account for the seemingly exhaustive access period of subject evaluation.

When the time lines are compared between the Simpson and Burgess article and the composition written by Onifer and Swinney, we find a very interesting difference. Taking into consideration the difference between the onset of the sentence and the time when reaction latency is begun, the latter article allows for a couple of hundred milliseconds to elapse. These crucial milliseconds could be the time when the intended definition of the prime is accessed even before the onset of the prime. If this were true, it would be in direct accord with the first article in that the time course of activation seems to take an immediate selective access procedure followed by exhaustive access at about 300 ms after the prime. I believe the time from the onset of the sentence to the point when reaction latency is begun accounts for this period of selective access.

Upon further consideration of the timelines in these studies, we find another discrepancy. Onifer and Swinney utilized a 0 ms and a 1500 ms delay for the onset of the target. To examine the access stage of lexical differentiation these intervals are too extreme. One cannot effectively examine the issue of access at these times, since the access stage is undeniably over.

Furthermore, upon close examination of the Rayner et al. (1994) paper one finds a very important discrepancy. They did not directly examine the effects their paradigm would have in the dominant context. Even so, they drew their conclusions as if participants reviewed the dominant definition as a possibility before proceeding to the lesser frequent subordinate. Whether or not the prior experience of the homonym was a pair or in a paragraph has no bearing. The fact remains, only a comparison of the homonym and a control can be made. No comparison of how one would interpret the sentence had it been biased toward the dominant meaning can be discussed. The design of the present thesis is not only able to compare how one comprehends the homonym and a control word, but it allows comparison of dominant vs. subordinate and dominant vs. control. This design is a marked improvement upon that of previous discourses.

The experiments designed in this study address the issue of context as it affects time course activation to meanings of ambiguous sentences. As an improvement upon the Simpson and Burgess (1985) article, context is primed by complete sentences rather than single words. And in consideration of Simpson and Krueger (1991), unambiguous words are utilized as controls. The following studies are designed to analyze the access period of language processing and to identify the model that best exemplifies this process.

Pilot Experiments

Experiment 1

This study was a preliminary trial of the experimental research designed to examine lexical access. All experiments that follow are variations of this original paradigm.

Method

Participants. This study was completed with a random sample of 23 students at the University of Richmond. They were fulfilling the requirement of research participation for the Introductory to the Psychological Sciences course.

Materials. Twenty-two written homonyms were selected that have the same spelling and pronunciation, each with at least two different meanings according to the

Longman Dictionary of Contemporary English (Longman, 1995). Semantic ambiguities are the focus thus syntactic ambiguities were avoided for this study. Each homonym (22) was embedded in two types of sentences: those biased toward the dominant (ex. 1) meaning and those biased to the subordinate (ex. 2) meaning (a total of forty-four experimental contexts). The homonym was placed as the last word of the third sentence, thus the first three sentences act to sufficiently bias to the selected context.

1. After dinner Joe went outside to play on the field with his friends. John threw a baseball to him. Then he saw a *bat (glove & bird).*
    a. He picked it up and walked to home plate.
    b. It flew over his head and out of site.
1. On Monday there was not a cloud in the sky. John stood outside and stared at the stars most of the night. He saw a *bat (bird & glove).*
    a. It flew over his head and out of site.
    b. He picked it up and walked to home plate.

The final sentence/target either was related (1a & 2a) or was unrelated (1b & 2b). Each subject saw one of the four possibilities for each context when completing the experiment. 40 filler sentences were also created that followed the same sentence structure and length but not content. Upon completion of the task participants were asked to answer a simple questionnaire about the content of the sentences. This added to make sure participants did not go through the questions blindly.

Design. The participants were divided into four groups so that each homonym formation could be examined by separate participants. The sentences were arranged so that none of the participants saw the same sentence or the same homonym twice.

Apparatus. The participants were presented with these homonyms by computer. The computer program E-prime was used to generate the experiment. E-prime was developed by Psychology Software Tools (PST) designed for experimental psychology. Experiments are created graphically, by dragging and dropping objects onto procedural timelines and setting their respective properties (Psychology Software Tools, 2000). Participants will use the response box to move through each word of the sentences after which reading latencies will be recorded for the final sentence (PST Serial Response Box, model #200a).

Procedure. The sentences were presented by the moving window technique, left justified. The *moving window* technique allows each word to be presented individually and in succession. This method requires the participant to read, decode, and signal for the next word using a button. At this time the word disappears and the next word appears. Participants were told that each word would appear individually except for the final sentence. They were instructed to read as quickly as possible while comprehending the sentences. The fourth sentence appeared as a whole so that the respondents latency could be recorded for the entire target. Five practice trials were built in to familiarize the participant with the task. The experiment required 35 minutes to complete.

Results. A 2 (context type) x 2 (target type) ANOVA was conducted to assess main effects and interaction of the data. The result suggests that there is a significant main effect of Target Type, $F(1,22) = 44.44$, $p<.001$, and main effect of Context Type, $F(1,22) = 4.87$, $p<.05$. There was no interaction effect between the two variables. This result indicates that the sentences that are consistent with the previous context elicited significantly faster reaction times than sentences that are inconsistent with the previous context. However, the response latencies had a range of 1021ms to 5098ms, values that cannot be used to argue for or against the targeted hypothesis. The range of the reaction latencies indicates that the target needs to be of abbreviated proportion. The access period of lexical processing is complete at a very short interval. Therefore to examine this process the target must be shortened. Instead of a full sentence, as used here, a single word would produce more useful data.

Experiment 2

With regard to prior clear results using naming studies, this experiment was designed to incorporate the task into the established design of Experiment 1. The target would be comprised of a single word rather than a whole sentence to achieve the abridged latency. To further examine the postulate of time-course activation of word meaning, two intervals were established, 0ms and 500ms.

Method

Participants. A sample of 38 volunteers were employed to complete this task. They were respondents to flyers posted around the University of Richmond campus. Those who completed the study were paid ten dollars for their time. The sample was composed of students attending summer school. They were divided into two groups, 0ms (n=18) and 500ms (n=20) ISI.. These groups were divided into four sections so that each context could be examined in each of the four possibilities.

Materials. The same 44 sentence contexts and 22 homonyms were used for this study. Target words were selected from the University of South Florida Homograph Norms for each homograph (Nelson, McEvoy, Walling, & Wheeler, 1980). Each participant would see one of the four conditions where the context was biased toward the dominate or subordinate followed by the most highly associated word for that meaning. For example, in the case of 'bat' the two most frequent meanings are 'stick' and 'animal,' thus the two most associated words to these meanings are 'ball' and 'cave' respectively.

Design. Three independent variables were controlled in each of the ISI conditions: 2 (context type) x 2 (prime type) x 2 (target type).

Apparatus. The participants saw the sentences on the computer, presented by the E-prime software. Sentences appeared as before, left justified and individually. The targets were presented center justified, boldface, and in blue type following the context sentences. The response latency was recorded by means of the PST Serial Response Box (model #200a) through a table mounted microphone attached to the voice-activated relay.

Procedure. Participants were seated in front of the computer, explained the procedure, and given a chance for any questions. After reading the instructions they proceeded to eight practice trials where they were familiarized with the task. They would use the spacebar to progress from word to word and then speak the target word into the microphone. E-prime was manipulated to create the 0 or 500 ms ISI. The experiment took 25 minutes to complete.

Results. ANOVA across the independent variables reveal no significant effects at the 0 ms ISI. However analysis at the 500 ms ISI revealed a main effect, $(1, 19) = 10.4$, $p<.05$ with a 46 ms facilitation of the target consistent with the context of the sentences. But these results are thought to be highly unreliable. The version of the E-prime software used at the time of this experiment (Beta 1, RC2) had a programming bug that prevented accurate recognition of a voice stimulus. Many subjects were required to repeat the word in order for the computer to register the response. Thus response latencies were long and erratic. The latest version of E-prime (Version 1) has corrected for this problem.

Experiment 3

The constraints of the previous study led to the utilization of the lexical decision task. Again we wanted to replicate the effect of the time-course of activation so 0 ms and 500 ms ISI were employed. Eliminating the voice recorder allowed for accurate recording of response latencies.

Method

Participants. Introductory Psychology students (N=35) were again utilized for this study who were fulfilling research participation hours. The students were separated into two groups: 0 ms ISI (n=15) and 500 ms ISI (n=20).

Materials. The same context sentences were used in this study as the previous two. The targets were maintained except for the legal non-words. The non-words were adapted from an article compiled to norm non-words for experimental research (Seidenberg, Petersen, MacDonald, & Plaut, 1996). These non-words appeared in 7/8 of the filler sentences and were placed according to a random number chart.

Apparatus. Participants used the spacebar to move through the sentences and the lexical decision latencies were recorded utilizing 'Yes' or 'No' keys on the PST Serial Response Box. Response latencies from the onset of the target to the participants response were recorded.

Procedure. Before the program was started, the experimenter explained the task to the participants. They were told to read the sentences as quickly as possible while comprehending the context. Their second task was to determine whether the string of letters that followed the sentences was a 'word' or a 'non-word.' To do this press 'Yes' for a word and 'No' for a non-word on the response box. All participants completed the experiment individually. Before the experiment commenced they were familiarized with the procedure by eight practice paragraphs that followed the pattern of sentence presentation. The whole experiment took about 30 minutes.

Results. A 2 (target type) x 2 (context type) x 2 (prime type) ANOVA was conducted for the 0 ms ISI study. The analysis yielded no statistically significant effects. But the 500 ms ISI extension disclosed a significant main effect of Target Type, $F(1,19) = 4.43$, $p<.05$. Compared to the 0 ms ISI results, this experiment suggest that the sentence context played a role in the access of appropriate meanings only at an interval of 500ms, but not at the very initial stage of 0 ms. To verify this, I conducted a 4-way ANOVA, treating ISI as a between-subject independent variable. The main effect of ISI was statistically significant, $F(1, 34) = 64.02$, $p < .001$.

Discussion

The results obtained from these studies seem to be standard in the sense that they show the time course of context effects which unfold in sentence processing. One could draw inferences from the results that perhaps the access of a contextually appropriate meaning is completed only after an initial multiple access, given that context effects are not observed at the 0ms ISI. However, as discussed earlier, I consider lexical ambiguity processing not as an "either-or" phenomenon (either multiple access or selective access) but rather as a process of continuous activation of word meanings. My hypothesis is that different meanings of the ambiguous word will be activated to different degrees largely dependent on the constraints of context and frequency of use. Nevertheless the typical design used in the lexical ambiguity literature, as is the case with the current study, prevents one to address the issue of continuous activation.

Thesis Experiments

Considering the significant amount of research that has been conducted to examine context effects and the processing of lexical ambiguity in sentences, the present studies serve to look at the contrasting hypothesis in a new perspective. In particular, I argue that it is not necessary to assume either a strict multiple-access view nor a strict selective access hypothesis. Different meanings of an ambiguous word may become activated to different degrees, depending on the constraints of context, the relative frequency of meanings, the grammatical classes and semantic relatedness of different meanings, and the number of potential competitors within a meaning. This argument is corroborated with an examination of the relative frequency of homograph meanings and activation degrees in this study. Future studies of the other lexical and grammatical factors in this perspective can further increase our understanding in this area.

The constraints of previous and historical methodologies have prevented analysis of the issue of continuous activation. To overcome this problem a regression analysis is used across the ISI conditions. The response latencies were paired with the University of Alberta (UA) norms of relative meaning frequency for homographs (Twilley, Dixon, Taylor, & Clark, 1994)(See page 28 for detailed discussion). The proportion of responses associated with a homonym (the P-measure), along with the overall ambiguity of homographs therein (the U-measure), will be used as predictor variables for the new latency scores in the analysis. The expected result would be that the P-measure (proportion of association), sentence context, and U-measure (Overall ambiguity) will significantly predict the degree of activation of each meaning within an ambiguous word (See detailed discussion in *Materials*).

Experiment 1 - Lexical Decision

This study utilizes the lexical decision task to examine the access period of ambiguity processing. To examine access at a shorter interval E-prime was manipulated to display a 300 ms ISI instead of the 500 ms ISI utilized in the pilot studies. Previous research suggests that we should see full access at this earlier stage.

Method

Participants. The participants were 41 undergraduates participating for course credit in an introductory psychology class in the fall semester 2001. For eligibility to participate students must have reported no reading disabilities and speak English as their first and most proficient language. Participants were randomly assigned to one of two groups: 0 ms ISI (N=21) and 300 ms ISI (N=20) conditions.

Materials. The sentences outlined in Appendix A were utilized for this experiment. 22 ambiguous words were selected and contexts were discerned according to their more frequent (dominant) meaning and a less frequent (subordinate) meaning according to the CELEX Lexical Database (1995). The structure for all groups of sentences was constant. Three context sentences of similar lengths were created to bias to either the dominant meaning or the subordinate meaning of the homonym. The homonym (prime) was presented as the last word of the third sentence.

After display of the prime, the subjects' task was to make a lexical decision about the target. The target was a string of letters presented in one of three forms: A word related to the meaning of the homonym in context, a word unrelated to the homonym in context, or a non-word (ex. SKIB). The non-words were selected from those normalized by Seidenberg, Peterson, Macdonald, and Plaut (1996). Non-words were presented in 7/8 of the filler sentences only. The remaining filler sentences contained normed real words (Balota, 1999). The target words were selected from the University of Alberta (UA) Norms as the most frequently associated word to the homonym according to context (Twilley, Dixon, Taylor, and Clark, 1994).

The UA norms were derived from a study conducted to compile the most complete and accurate list of homonym associative norms to date. The study contained 566 homonyms with an average of 192 subjects per homograph. Subjects were given a list of homonyms and asked to write the first word they thought of after reading it. The response varied greatly, hence they were categorized as to overall themes. For example: if *ball* was presented and one subject wrote *base* and another wrote *bat* they were grouped according to the category, baseball. Of that category the most frequently written word would represent that category. The categories according to the frequency of occurrence were recorded for the top three meanings of the homonym.

This manner of categorization allowed for the calculation of numeric proportions for each group and word. The P-measure is the primary association to the homonym, derived by: the number of responses to a word divided by the total number of responses for the homonym. The M-measure is defined as the homonym's categorized associative meaning. It is calculated as: the number of responses in a category divided by the total number of responses to the homonym. Lastly, the U-measure is the overall ambiguity of a homonym. It is determined by dividing the total number of responses for the homonym from the number of individual responses. This can be thought of as how many definitions (density) a homonym has.

The sentences were designed so that each homonym appeared in four situations: two biased in the dominant meaning (context 1) and two in subordinate (context 2). Each of these was followed by a related (1a and 2a) or an unrelated target (1b and 2b).

1. Bob has been a construction worker for over 20 years. Every day of the week he works with large machines. His favorite is the *crane*.

   a) LIFT b) BIRD

2. Greg is an animal rights activist. He spends most of his time trying to save the wetlands. The other day he saw a *crane*.

   a) BIRD b) LIFT

In the other four sentences an unrelated control word (e.g. hose) replaces the homonym that is matched for frequency of total use according to the Celex database (Center for Lexical Information, 1995). No one participant saw the same context or homonym twice.

The sentence structure permitted three independent variables to be manipulated:

(a) *Context type*: The three preceding context sentences were (1) biased to the dominant meaning of the homonym, or (2) biased to the subordinate meaning of the homonym.

(b) *Prime type*: The prime, the last word of the third sentence (shown above in italics) was (1) the homonym related to the context therein, or (2) a control word matched for frequency to the homonym.

(c) *Target type*: The target (above lift or bird) was either (1) related to the dominant meaning of the homonym, or (2) related to the subordinate meaning of the homonym in context.

Apparatus. E-prime was used to create and run the experiment. Subjects pushed the keyboard spacebar to move through the sentences and then made the lexical decision on the PST serial response box model #200a. Yes and No labels were placed on two of the five buttons on the response box hardware to enable the lexical decision. A computer with a 1.7 GHz Intel Pentium 4 processor with 256 MB of RAM was employed to run E-prime. The sentences were displayed on a 17' trinitron monitor (model VX720). Display rate was set at optimal.

Procedure. Participants were seated in the testing room where they were explained a brief outline of the study according to informed consent guidelines. If agreement of participation was met, the participant and investigator signed the informed consent form (Appendix B). To continue students were asked: "Is English your first language?" and "Do you have any diagnosed reading disorders?" If the answers were "Yes." and "No." respectively, participant was asked to sit in front of the computer where formal instruction and procedure began.

The investigator would then read the directions to the subject allowing a time for questions (Appendix C). The instructions detailed that each word will appear individually requiring the push of the spacebar to see each successive word. After reading the sentence the participant will see a word shown in blue. When this word is presented the second task is to determine if that string of letters is a word or a non-word as quickly as possible. The directions will be repeated on the screen for clarity (Appendix D). They were not to begin until the experimenter has left the room. There were eight practice sentences before the experiment began.

Upon completion of the experiment participants were asked to answer questions about the content of the sentences (Appendix E1-E4). These questions were to ensure that the participant read the sentences and did not press the button blindly. The experiment took 35 minutes to complete.

The three context sentences were presented utilizing the moving window/self-paced reading paradigm. This method required the participant to read, decode, and signal for the next word. The sentences appeared serially, on one line from left to right, centered vertically on the screen. Upon termination of a sentence, the next word would appear at the left of the screen at the same altitude. This method is determined to be quite familiar considering the common use of streaming banners and tickers. After reading the third sentence the target would appear on the screen in capitals, center justified, and in blue to distinguish it from among the body sentences. Thereupon the latency for comprehension was determined for the correct determination of word or non-word.

Analysis. Two 2 (prime type) x 2 (context) x 2 (target type) analyses of variance were run to determine the main effects and the interactions of the independent variables. Prime type (homonym or non-ambiguous word controlled for frequency), context (dominantly biased or subordinately biased), and target type (consistent with the context or inconsistent with context) were all between-subjects variables. In both the 0 ms ISI and the 300 ms ISI sample prime type was significant $F(1,220) = 18.1$, $p < .009$ and $F(1,220) = 19.8$, $p < .008$ (see Table I & III). This shows that the control word matched for frequency increased the latency required for the subject to discern the meaning. There is also an interaction at 0 ms ISI of prime type and context $F(1,440) = 38.8$, $p < .003$ (Table I & III). These data suggest that a person is quickest to respond when presented with the dominant context coupled with the ambiguous word. However when the dominant context is paired with the control, they are slowest to respond. There were two other significant effects in the 300 ms ISI condition: the main effect of target type, $F(1,210) = 35.9$, $p < .003$ and the interaction between context and target type, $F(1,420) = 6.9$, $p < .05$ (Table I & III). From the table, it is clear that subjects are quickest to respond when presented with the dominant contexts with the related target. Consequently, subjects are slower to respond when presented with the dominant context with the unrelated target, suggesting that the dominant and more frequent context of the sentences has forced the acquisition of any other definitions below its resting potential (see Discussion). On the other hand, when the dominate context is presented with the unrelated target, subjects are quicker to respond when compared to the subordinate context and the related target. This interaction suggests that readers rely most heavily upon sentence context to acquire the meanings of words.

To further inspect the data a second set of analyses of variance were conducted where prime type was eliminated to allow examination of the homonyms' effect only. At the 0 ms ISI, context had a main effect, $F(1,212) = 5.6$, $p < .02$ and at 300 ms, dominance had a main effect $F(1,212) = 4.3$, $p < .05$ (Figure I & II). No other effects in this examination were significant.

A series of regression analyses were conducted without the control prime type for each predictor to determine their unique contribution to reaction time. Not surprisingly the significant effects in the analysis of variance (context in 0 ms ISI and dominance for 300 ms ISI) were significant predictors. In the shorter interval condition context was the only factor of significant predictive power. The UA measure for the proportion of association (P measure) was also a significant predictor of lexical access that uniquely explains 2% of the variance.

Discussion

Across the ISI conditions subjects were slower to respond where the control word was present rather than the homonym. This is an important result that shows the effect the prime word has on the lexical decision task. The effect was not present in previous studies because a semantically related word to the context was adopted. In the 0 ms ISI condition the interaction between prime type and context is of particular interest. The data suggest that when a participant is presented with a dominant context and the unrelated prime they are slowest in response to the target. This also suggests that when a subject reads the most frequent context for an expected word and if they are concurrently not presented that word, it is unusually hard for them to retrieve that meaning. In other words, the stronger and more frequent context of the sentences has served to inhibit other interpretations of presented words. Thus the processing of one meaning pushes another below its resting level of activation and makes it more difficult to semantically retrieve (Simpson & Adamopoulos, 2002).

The significant effects after the removal of the control primes are also of primary interest. Here one can see that the effect of context is immediate and only after some time does one look for other means to classify definitions. In the 300 ms ISI condition, the effects of context were less robust than in the 0 ms ISI condition. Therefore, a subject is less dependent upon context at this later stage. Instead participants are able to examine a priori knowledge of associative strength and semantic relatedness to discern the meaning of a homonym in context. The data from the regression analysis of the 300 ms

ISI condition serve to corroborate this predication. Therefore, I conclude that the results do not conform to the multiple access hypothesis.

However, these models fail to explain specific differences between certain conditions when we examine the data without the control primes. For one, the models cannot account for the difference between latencies for the related targets. In the 0 ms ISI condition those targets appearing after dominant contexts containing dominant primes showed a 27 ms facilitation, compared to the targets that were preceded with the subordinate context and dominant prime for that context. If the data were to support the context dependent hypothesis, there should be no facilitation to reaction time. That is, reaction times in these situation should be the same because any context should facilitate its related target.

To properly explain this phenomena one must consider frequency upon context as a possible solution: one does not entirely rely upon context and one does not rely entirely upon frequency. If a person were to follow either of these directions, the aforementioned paradigm would exhibit no facilitation. Thus it would appear that the human language processor examines frequency of a word as it applies to context therein.

For example, from the previous example on page 25 the homonym *crane* is examined. The first context presents Bob as a construction worker that biases the context to the more frequent, heavy machinery definition of crane. With combination of this context coupled with the homonym *crane* and the dominant target *lift*, subjects are quickest to respond. However, with the other combination consisting of the subordinate context united with the homonym and the dominant target for this context *bird*, subjects are comparatively slower to respond. If respondents were purely context dependent there would have been no difference between these responses.

Further inquiry prompts another question of model applicability. If the current data were to support the ordered access hypothesis, subjects would respond quicker to *lift* in the subordinate context rather than *bird.* That is, they would respond to the most frequent definition and then the lesser frequent meanings in a serial fashion; but, in fact, they responded quicker to the target most closely associated with the subordinate meaning of the homonym *crane* (bird). This result, when discussed concurrently with the previous criticism of the context dependent hypothesis, leads to the conclusion that a subject examines the meaning of words with respect to frequency upon context. This model of processing proposes that one views the frequency of meaning to a word as it applies to context. This seems to be the best explanation of language processing, as it allows for examination of all available information (a priori and context) to determine the intended meaning of a word in context.

Experiment 2 - Naming

Method

Participants. 32 Students were randomly selected from the class of Introductory Psychology, and the students received credits to fulfill class requirement. Standards for inclusion and exclusion were the same as Experiment 1. This study also examined the two conditions of 0 ms ISI (N=16) and 300 ms ISI (N=16).

Materials. The same sentences and targets were used for this study as Experiment 1, with the exception of the non-words. The non-words were replaced with normalized real words (from Balota, 1999).

Apparatus. E-prime was again used to create and run the experiment. The keyboard spacebar was utilized to see each successive word. The vocal response latency was recorded by a Radio Shack® Hands-free headset microphone (serial number 33-3012) attached to the response box. This allowed for the participants' head movement while maintaining a constant distance from the microphone. The headset fit snuggly around the head and over the ears with the microphone positioned to the corner of the mouth. The software was manipulated to allow voice activation and produce the 0 and 300 ms ISIs between the prime and the target.

Procedure. The participants were seated and given instructions about the experiment as before, with exception of the task: say the target word into the microphone as quickly as possible (Appendix F). During the experiment period the investigator sat in the room with the subject to note incorrect and invalid responses (Appendix G1-G4). The paradigm was designed so that the target would disappear immediately following the participants' response. If the word did not extinguish when the word was spoken it was deemed as invalid response and marked accordingly. This was done to guard against the undesired effects noted about the previous naming study (see page 21). In addition a mark could be made for the trials where the participant said the wrong word. This was also deemed to be an invalid response and not used in analyses.

Results. The statistical measures performed for the analysis of this study were the same as for the lexical decision study. However, the results are unclear. Notably, prime type for this task did have a significant effect upon the reaction times just as the previous study $F(1,156) = 3660.2$, $p < .001$ for the 0 ms ISI and $F(1,154) = 215.4$, $p < .001$ for the

300 ms ISI (see Table II & IV). But no other effects in the analysis of variants or regression were significant.

Discussion

Participants were slower to respond in the cases where the target was preceded by an unrelated prime, but there is a general homogeneity across all other variables in this task. It has been argued that the naming task has been less dependent upon the conditions of a study than any other paradigm (Hino & Lupker, 1996; and Kwantes & Mewhort, 1999). Some believe that requiring the participant to say the word requires access of phonology, thus proceeding past the process of lexical access to selection and integration. Therefore, the tasks must be functionally dissimilar. However, Balota and Chumbley (1984) claim that naming latencies are better measures of lexical access than lexical decision. The latter requires a decision process while the former should be more sensitive to effects during the access period. However, other research suggests that both the naming and lexical decision tasks produce data that are consistent with eye fixation studies (Schilling, Rayner, & Chumbley, 1998). Furthermore, a study conducted by Forster and Chambers (1973) indicates that the range of reaction latencies between naming and lexical decision tasks is simply explained by the different response parameters involved. They examined these tasks according to oral variants. In the naming task participants were asked to say the word on the screen as quickly as possible, but the lexical decision task involved an oral response of "Yes" or "No" to words or non-words. Consistent with the data in this thesis, the naming latencies were quicker than the lexical decision latencies, even though both were recorded from oral responses. Forster and Chambers believe that the difference is a result from both tasks taking place independently after lexical search has been completed. Therefore, word naming and lexical decision time are quite closely related even though a person can pronounce a word more quickly than the process of applying rules for the lexical decision. It is considered that the naming and lexical decision paradigms are useful techniques for use in determining the time course of lexical access.

General Discussion

The main purpose of the present study was to examine the access period of lexical differentiation and to determine the model that best describes this process according to the time course of the activation. The historical methodological controversies (Onifer & Swinney, 1981 vs. Simpson, 1981) have been the primary concern for many years. It was posited that the differences between these studies were due to constraints of material presented to the participant. Onifer and Swinney (1981) utilized full sentence contexts to examine lexical access. Their data suggested an initial period of multiple access followed by a period where the subject would focus upon context. The opposing view held by Simpson (1981) was procured by data collected from single word contexts with ambiguities. With this method he found that participants tended to follow a selective access period where meaning was attained immediately with aid from context.

The arguments of the two investigators are valid by themselves in that results are wedded to method. The present study adds to our understanding of this phenomenon with use of full sentence contexts. The data in the lexical decision task display a clear relation between response latencies and context at the shortest interval. Consequently, the effect of context is substantial and immediate. Only at the later interval does one reach acquisition with aid from a priori sources: dominance, association, and frequency. Therefore the present research most closely supports the selective access hypothesis.

This theory maintains that only the contextually appropriate meaning of an ambiguous word is accessed (Simpson, 1984). In fact a more frequent context can inhibit the access to a subordinate meaning of an ambiguous word (Simpson & Adamopoulos, 2002). These two studies stand to establish the significant effect of context, but one cannot overlook the position of the ordered access model. There, the meaning of a word is activated only by its frequency (Forster & Bednall, 1976; Hogaboam & Perfetti, 1975; Holmes, 1979; Simpson & Burgess, 1985). That is, even in the case where a sentence is biased toward the subordinate meaning of a homonym, a person will access the dominant meaning first before consideration can be made to the lesser subordinate. In this study we find evidence to combat this view. Even though not significant the data suggest that subjects are slower to recognize the dominant target when presented with the subordinate context. Therefore, it appears the subordinate context has pushed the dominant meaning of the homonym below its resting potential. This situation also suggests neither model can explain lexical access.

The present evidence lends to a new model: *frequency upon context*. Here one does not examine context in isolation or frequency unconditionally. To access the meaning of the word the processor examines the context to disambiguate a decision and then examines the suggested meanings according to frequency.

Conclusion

In their strongest forms all models make very striking distinctions about how the human language processor operates. Multiple access is clearly not an efficient mean to disambiguate words presented in isolation or in context, and, as mentioned, the other models exhibit analytic dilemmas not easily confuted. It seems most effective to utilize the a priori knowledge we gain with development when receiving the messages others express whether orally or in script.

All models inevitably have their shortcomings but the three historical paradigms are at the ends of a multi-dimensional spectrum. First, as previously stated, theory is wedded to methodology. The design variance of the aforementioned articles is dramatic. There is certain to be a difference between words presented in isolation (Simpson & Burgess, 1985) or in sentence context (Onifer & Swinney, 1981). This difference could unquestionably account for the contrast in results for the two procedures. There is no way to tell the definitive moment when a subject is able to use context to disambiguate the prime under inspection. Therefore, it is impossible to design a completely accurate response time latency study for this purpose. This study utilizes the most knowledge available from current research to examine this split second period of lexical access. Nonetheless, given the history and the intrinsic fascination with this research for its solitary capacity to probe an otherwise functionally untestable phenomenon, this enterprise is a small stepping stone offered along the path leading toward understanding lexical ambiguity processing.

References

Balota, D.A., Cortese, M.J., & Pilotti, M. (1999). Item-level analyses of lexical decision performance: Results from a mega-study. In Abstracts of the 40th Annual Meeting of the Psychonomics Society (p. 44). Los Angeles, CA: Psychonomic Society.

Celex Lexical Database, Release 2 (1995). Centre for Lexical Information: Max Planck Institute for Psycholiguistics, Nijmegen.

Cotton, S., & Grosjean, F. (1984). The gating paradigm: A comparison of successive and individual presentation formats. *Perception & Psychophysics:* 35, 41-48.

Conrad, C. (1974). Context effects in sentence comprehension: A study of the subjective lexicon. *Memory & Cognition:* 2, 130-138.

Duffy, S.A., Morris, R.K., & Rayner, K. (1988). Lexical ambiguity and fixation times in reading. *Journal of Memory and Language:* 27, 429-446.

Fodor, J.A. (1983). *Modularity of mind.* Cambridge, MA: MIT Press.

Fodor, J.A. (1989). *The modularity of mind: An essay on faculty psychology.* Cambridge, MA: MIT Press.

Forster, K.I. (1979). Levels of processing and he structure of the language processor. In W.E. Cooper & E. Walker (Eds.), *Sentence Processing: Psycholinguistic studies presented to Merrill Garrett.* Hillsdale, NJ: Erlbaum.

Forster, K.I., & Bednall, E.S. (1976). Terminating and exhaustive search in lexical access. *Memory & Cognition:* 4, 53-61.

Grosjean, F. (1980) Spoke word recognition processes and the gating paradigm. *Perception & Psychophysics:* 28, 267-283.

Grosjean, F. (1996). Gating. *Language and Cognitive Processes:* 11, 597-604.

Hogaboam, T.W., & Perfetti, C.A. (1975). Lexical ambiguity and sentence comprehension. *Journal of Verbal Learning and Verbal Behavior:* 14, 265-274.

Holmes, V.M. (1979). Accessing ambiguous words during sentence comprehension. *Quarterly Journal of Experimental Psychology:* 44, 13-35.

Just, M.A., Carpenter, P.A., & Woolley, J.D. (1982). Paradigms and processes in reading comprehension. *Journal of Experimental Psychology: General:* 111: 228-238.

Li, P. (1996). The temporal structure of spoken sentence comprehension in Chinese. *Perception & Psychophysics:* 58, 571-586.

Li, P., Shu, H., Yip, M., Y. Zhang, & Y. Tang. (2001*). Lexical ambiguity in sentence processing: Evidence from Chinese.* In M. Nakayma (ed.) Crosslinguistic Sentence Processing. Stanford, CA: Center for the Study of Language and Information Publications.

Li, P. & Yip, M. (1996). *Lexical ambiguity and context effects in spoken word recognition: Evidence from Chinese.* In G. Cottrell (ed.) Proceedings of the 18th Annual Conference of the Cognitive Science Society (228-232). Hillsdale, NJ: Erlbaum.

Li, P. & Yip, M. (1998). Context effects and the processing of spoken homophones. *Reading and Writing: An Interdisciplinary Journal:* 10, 223-243.

Longman Dictionary of Contemporary English (1995). Harlow Publishing Co. New York: NY.

Lorch, R.F. Jr., Balota, D.A., & Stamm, E.G. (1986). Locus of inhibition effects in the priming of lexical decisions: Pre- and postlexical access? *Memory & Cognition:* 14, 95-103.

Lucas, M.M. (1984). Frequency effects on the processing of ambiguous words in sentence contexts. *Language and Speech:* 30, 25-46.

Lucas, M.M. (1987). Frequency effects on the processing of ambiguous words in sentence context. *Language and Speech:* 30, 25-46.

Lucas, M.M. (1999). Context effects in lexical access: A meta-analysis. *Memory & Cognition:* 27, 385-398.

Marslen-Wilson, W., & Tyler, L.K. (1980). The temporal structure of spoken language understanding. *Cognition:* 8, 1-71.

Neill, W.T., Hilliard, D.V., & Cooper, E. (1988). The detection of lexical ambiguity: Evidence for context sensitive parallel access. *Journal of Memory and Language:* 27, 279-287.

Onifer, W. & Swinney, D.A. (1981). Accessing lexical ambiguities during sentence comprehension: Effects of frequency of meaning and contextual bias. Memory & *Cognition:* 9, 225-236.

Psychology Software Tools (2000). *E-prime Version 1.*

Schuberth, R.E., Spoehr K.T., & Lane, D.M. (1981). Effects of stimulus and contextual information on the lexical decision process. *Memory & Cognition:* 9, 68-77.

Seidenberg, M.S., Tanenhaus, M.K., Leiman, J.M., & Bienkowski, M. (1982). Automatic access of the meanings of ambiguous words in context: Some limitations of knowledge-based processing. *Cognitive Psychology:* 14, 489-537.

Seidenberg, M.S., Waters, G.S., Sanders, M. & Langer, P. (1984). Pre- and postlexical loci of contextual effects on word recognition. *Memory & Cognition:* 12, 315-328.

Seidenberg, M.S., Petersen, A., MacDonald, M.C., & Plaut, D.C. (1996). Pseudohomophone effects and models of word recognition. *Journal of Experimental Psychology: Learning, Memory, and Cognition:* 22, 48-62.

Simpson, G.B. (1981). Meaning dominance and semantic context in the processing of lexical ambiguity. *Journal of Verbal Learning and Verbal Behavior:* 20, 120-136.

Simpson, G.B. & Adamopoulos, A.C. (2002). Repeated homographs in word and sentence contexts: multiple processing of multiple meanings. *On the consequences of meaning selection.* D.S. Gorfein (Ed.) Washington, DC: American Psychological Association.

Simpson, G.B. & Burgess, C. (1985). Activation and selection processes in the recognition of ambiguous words. *Journal of Experimental Psychology: Human Perception and Performance:* 11, 28-39.

Simpson, G.B. & Krueger, M.A. (1991). Selective access of homograph meanings in sentence context. *Journal of Memory and Language:* 30, 627-643.

Small, S., Cottrell, G., & Tanenhaus, M. 1988. *Lexical ambiguity resolution: Perspectives from psycholinguistics, neuropsychology, and artificial intelligence.* San Mateo: Morgan Kaufmann Publishers.

Swaab, T.Y., Brown, C., & Hagoort, P. (1998). Understanding ambiguous words in sentence context: electrophysiological evidence for delayed contextual selection in Broca's aphasia. *Neuropsychologia:* 36, 737-761.

Swinney, D.A. (1979). Lexical access during sentence comprehension: (Re)consideration of context effects. *Journal of Verbal Learning and Verbal Behavior:* 18, 645-659.

Tabossi, P. (1988). Assessing lexical ambiguity in different types of sentential contexts. *Journal of Memory & Language:* 27, 324-340.

Tabossi, P. (1996). Cross-modal semantic priming. *Language and Cognitive Processes:* 11, 569-576.

Tanenhaus, M.K., Leiman, J.M., & Seidenberg, M.S. (1979). Evidence for multiple stages in the processing of ambiguous words on syntactic contexts. *Journal of Verbal Learning and Verbal Behavior:* 18, 427-440.

Till, R.E., Mross, E.F. & Kintsch, W. (1988). Time course of priming for associate and inference words in a discourse context. *Memory & Cognition:* 16, 283-298.

Twilley, L.C., Dixon, P., Taylor, D., & Clark, K. (1994). University of Alberta norms of relative meaning frequency for 566 homographs. *Memory & Cognition:* 22, 111-126.

Van Patten, C., & Kutas, M. (1987) Ambiguous words in context: An event-related potential analysis of the time course of meaning activation. *Journal of Memory and Language:* 26, 188-208.

West, R.F. & Stanovich, K.E. (1982). Source of inhibition in experiments on the effect of sentence context on word recognition. *Journal of Experimental Psychology: Learning, Memory, and Cognition:* 8, 385-399.

Table I

Cell Means for the Lexical Decision Task

	Dominant*		Subordinate*	
Prime Type	Related**	Unrelated**	Related**	Unrelated**
		0 ms ISI		
Homonym	741 (49)	766 (58)	716 (46)	774 (75)
Control	818 (29)	804 (43)	817 (51)	792 (55)
		300 ms ISI		
Homonym	739 (108)	763 (125)	791 (138)	772 (115)
Control	826 (166)	843 (138)	902 (186)	868 (149)

* Context type
** Target type

Note: Numbers in parenthesis indicate standard deviation.

Table II

Cell Means for the Naming Task

	Dominant*		Subordinate*	
Prime Type	Related**	Unrelated**	Related**	Unrelated**
	0 ms ISI			
Homonym	591 (64)	581 (69)	580 (49)	601 (61)
Control	784 (64)	783 (34)	781 (57)	780 (66)
	300 ms ISI			
Homonym	519 (88)	530 (40)	551 (60)	545 (68)
Control	633 (43)	637 (56)	637 (56)	659 (73)

* Context type
** Target type

Note: Numbers in parenthesis indicate standard deviation.

Table III

Analysis of Variance for the Lexical Decision Task

Source	*df*	*F*	*p*
		O ms ISI	
Prime (P)	1	18.13	.008**
Context (C)	1	3.38	.126
Target (T)	1	1.09	.343
P x C	1	38.78	.002**
P x T	1	0.005	.944
C x T	1	0.64	.459
P x C x T	1	0.77	.420
error	880		
		300 ms ISI	
Prime (P)	1	19.75	.007**
Context (C)	1	0.08	.794
Target (T)	1	35.95	.002**
P x C	1	0.21	.661
P x T	1	1.06	.351
C x T	1	6.92	.047*
P x C x T	1	0.07	.808
error	840		

*$p < .05$. **$p < .01$.

Table IV

Analysis of Variance for the Naming Task

Source	*df*	*F*	*p*
		O ms ISI	
Prime (P)	1	3660.20	.000**
Context (C)	1	0.26	.633
Target (T)	1	0.01	.925
P x C	1	0.18	.692
P x T	1	0.38	.564
C x T	1	0.36	.573
P x C x T	1	0.37	.568
error	632		
		300 ms ISI	
Prime (P)	1	215.45	.000**
Context (C)	1	1.04	.365
Target (T)	1	4.52	.101
P x C	1	0.67	.460
P x T	1	0.55	.498
C x T	1	0.00	.999
P x C x T	1	1.54	.283
error	624		

$^{**}p < .005$.

Figure Caption

Figure I

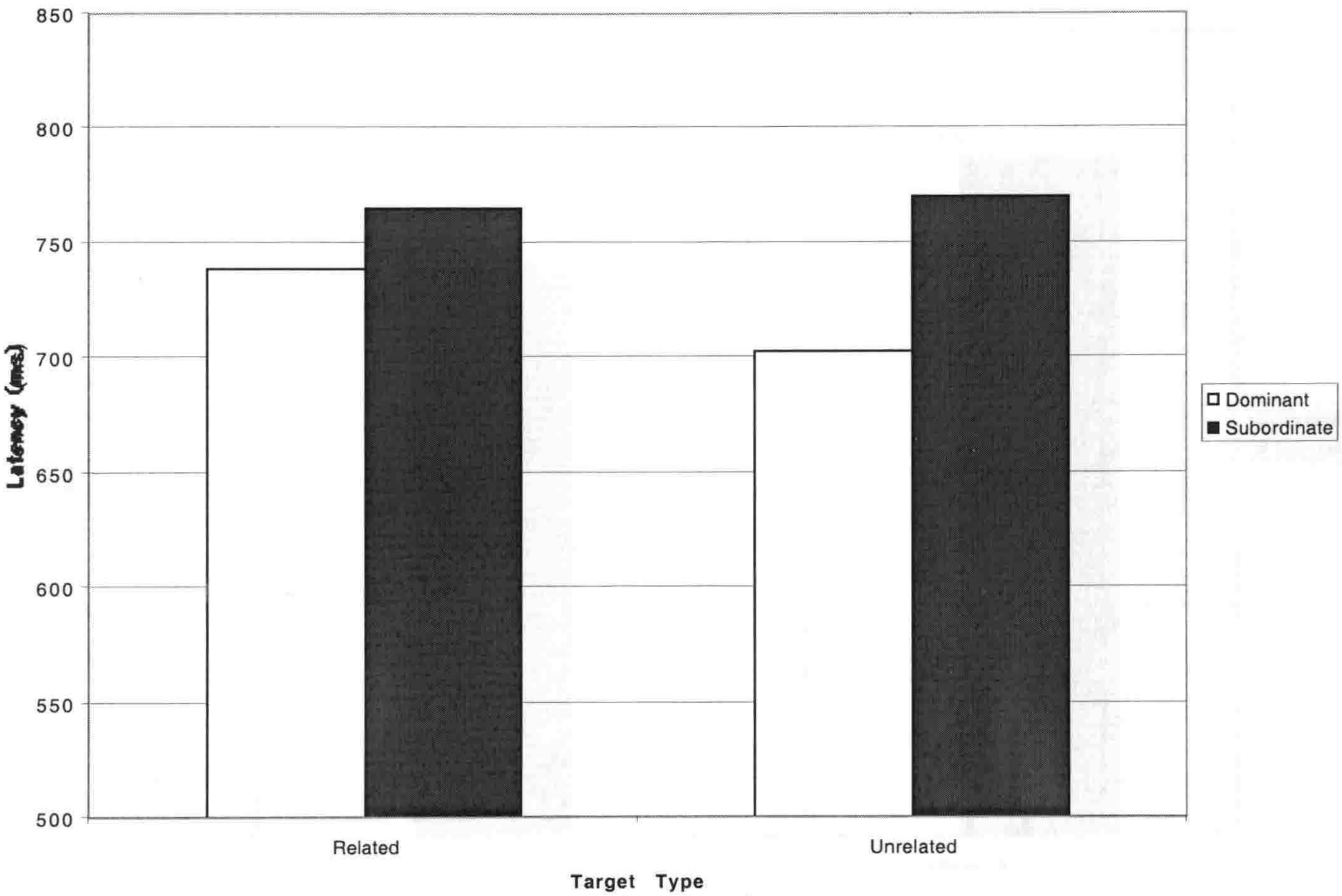

850
800
750
700
650
600
550
500
Latency (ms)
Related
Unrelated
Target Type
Dominant
Subordinate

Figure II

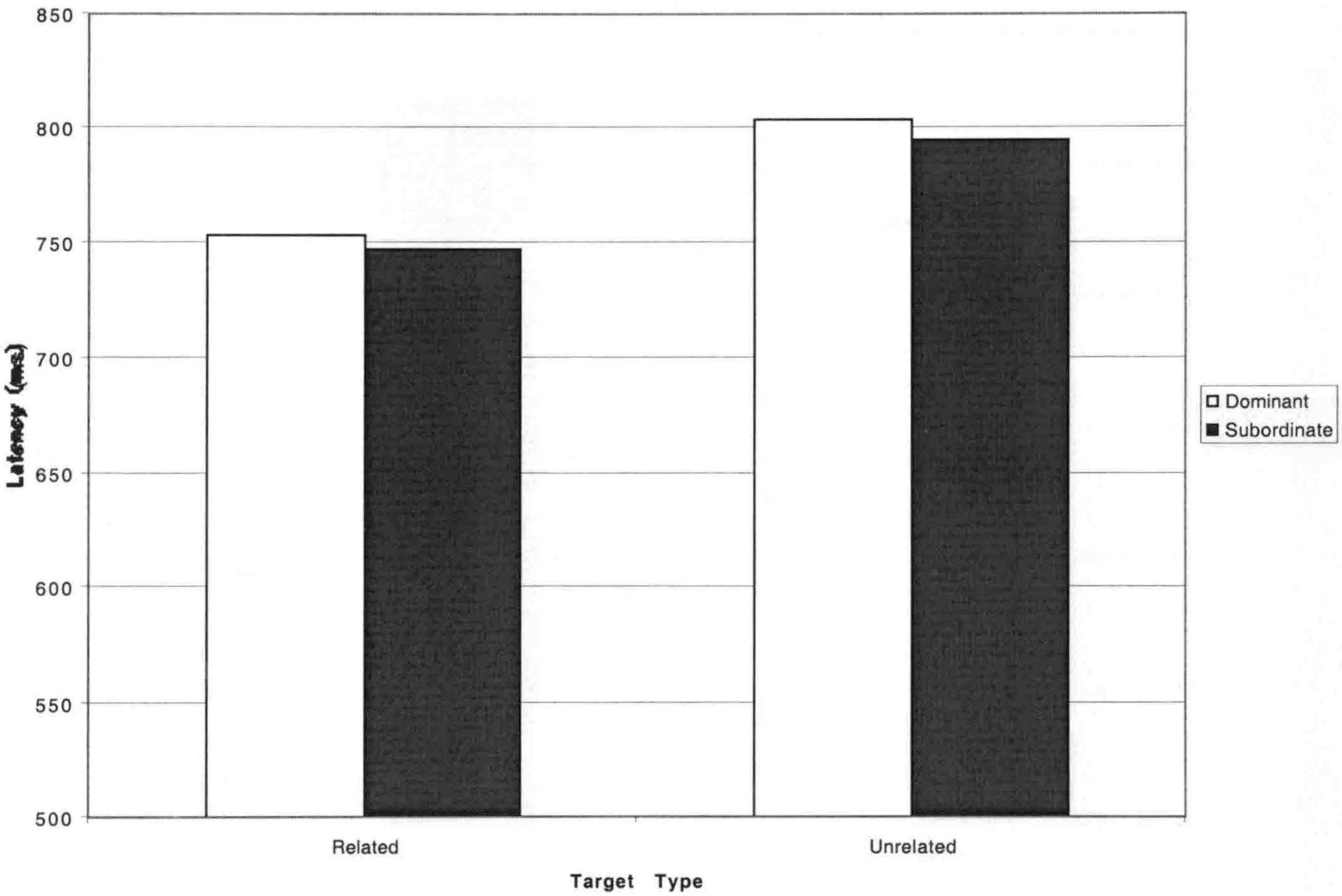

850
800
750
700
650
600
550
500
Latency (ms.)
Related
Unrelated
Target Type
Dominant
Subordinate

Figure III

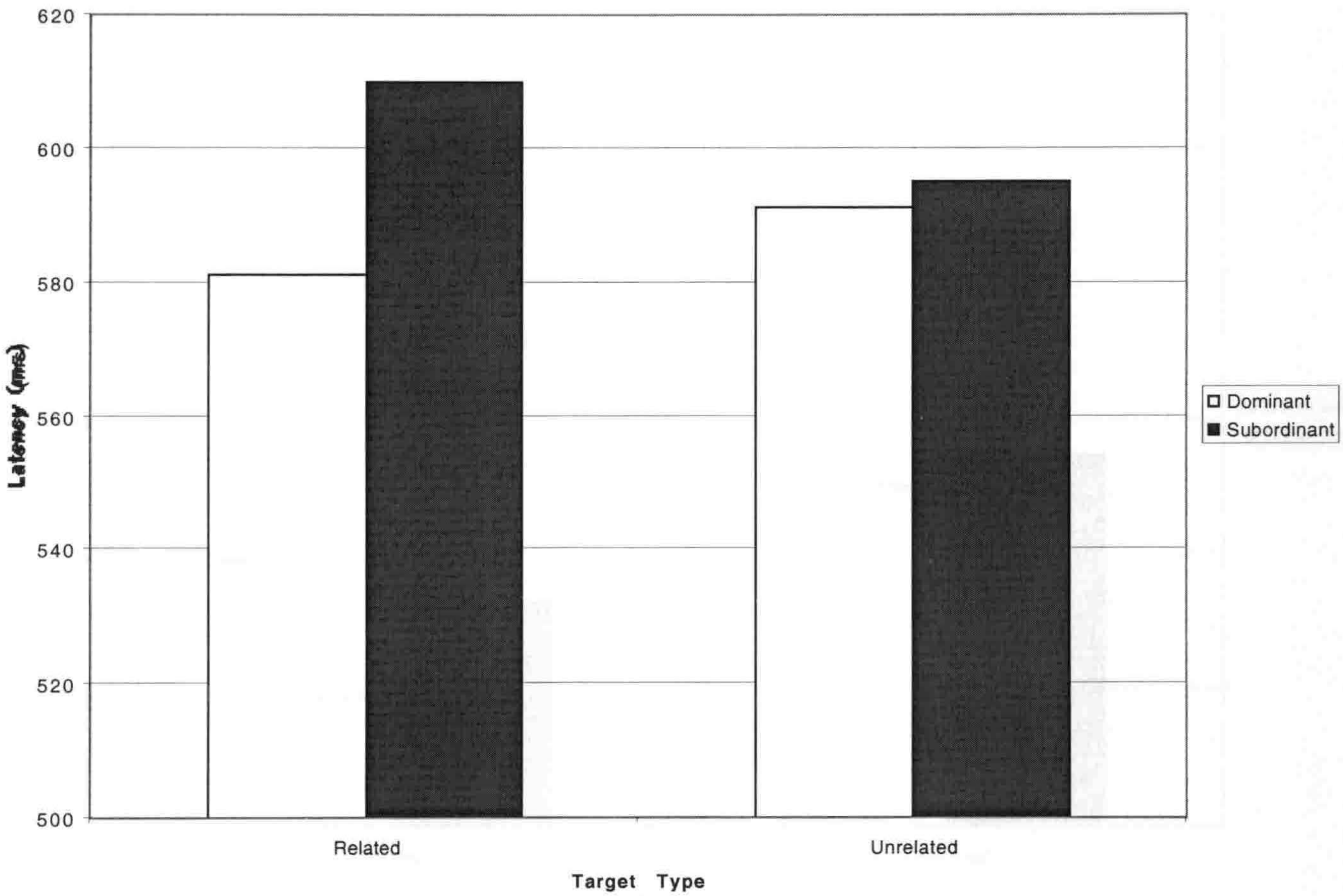
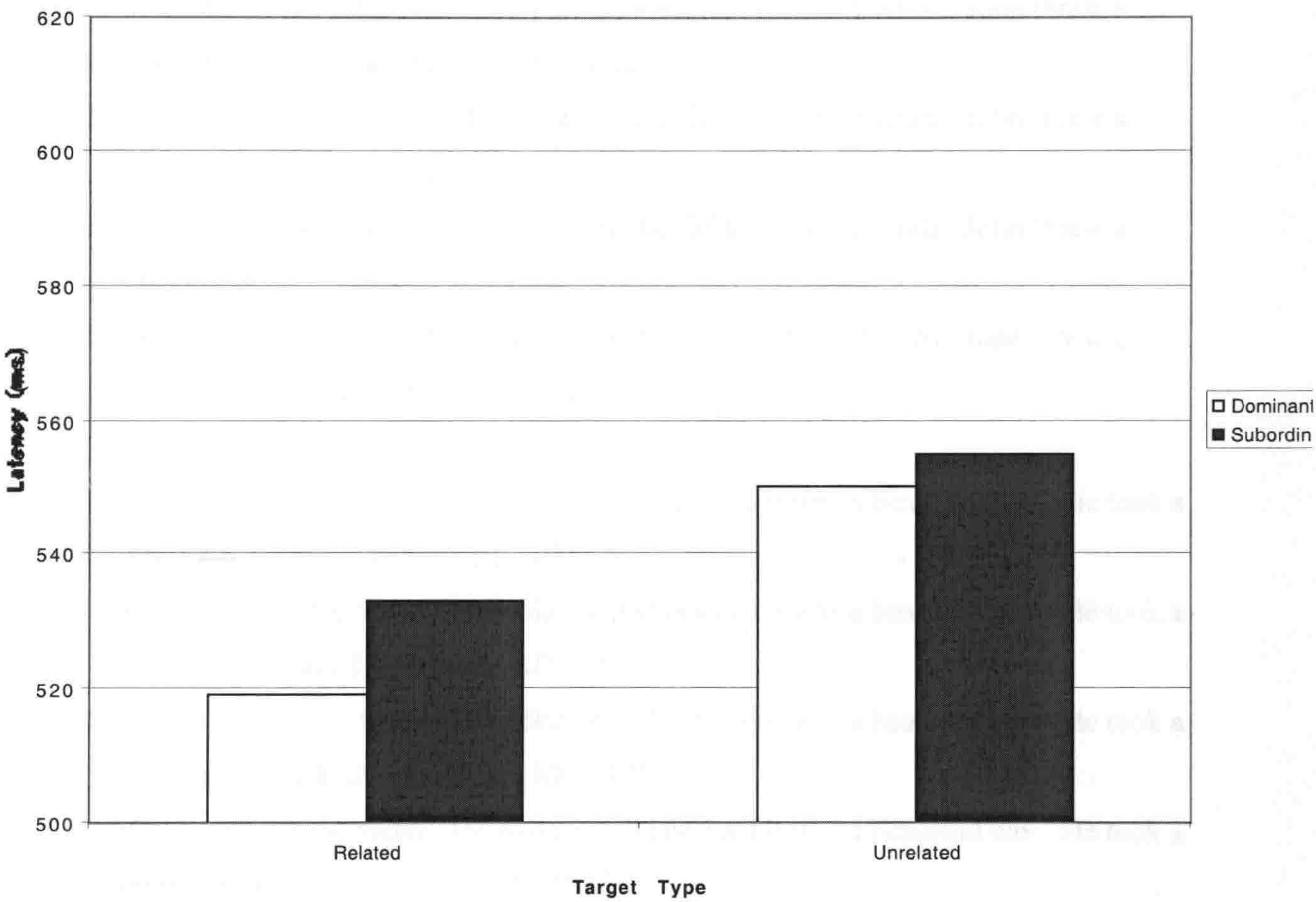

620
600
580
560
540
520
500
Latency (ms)
Related
Unrelated
Target Type
Dominant
Subordinant

Figure IV


620
600
580
560
540
520
500
Latency (ms)
Dominant
Subordin
Related
Unrelated
Target Type

Appendix A

1. bat

(1) After dinner Joe went outside to play on the field with his friends. John threw a baseball to him. Then he saw a bat. HIT

(2) After dinner Joe went outside to play on the field with his friends. John threw a baseball to him. Then he saw a robe. HIT

(3) After dinner Joe went outside to play on the field with his friends. John threw a baseball to him. Then he saw a bat. MAN

(4) After dinner Joe went outside to play on the field with his friends. John threw a baseball to him. Then he saw a robe. MAN

2. bank

(4) Matt lives near the water. He woke up and noticed it was a beautiful day. He took a shower and walked to the bank. RIVER

(1) Matt lives near the water. He woke up and noticed it was a beautiful day. He took a shower and walked to the top. RIVER

(2) Matt lives near the water. He woke up and noticed it was a beautiful day. He took a shower and walked to the bank. MONEY

(3) Matt lives near the water. He woke up and noticed it was a beautiful day. He took a shower and walked to the top. MONEY

3. seal

(3) Jack went on a trip to Alaska last year. He had always wanted to see the wildlife. During his travels someone gave him a seal. ANIMAL

(4) Jack went on a trip to Alaska last year. He had always wanted to see the wildlife. During his travels someone gave him a jam. ANIMAL

(1) Jack went on a trip to Alaska last year. He had always wanted to see the wildlife. During his travels someone gave him a seal. CLOSE

(2) Jack went on a trip to Alaska last year. He had always wanted to see the wildlife. During his travels someone gave him an jam. CLOSE

4. buck

(2) Sarah walks five miles every day for exercise. Sometimes she finds money on the sidewalk. The other day she saw a buck. BILL

(3) Sarah walks five miles every day for exercise. Sometimes she finds money on the sidewalk. The other day she saw a cube. BILL

(4) Sarah walks five miles every day for exercise. Sometimes she finds money on the sidewalk. The other day she saw a buck. MAMMAL

(1) Sarah walks five miles every day for exercise. Sometimes she finds money on the sidewalk. The other day she saw a cube. MAMMAL

5. nut

(1) Bill's major is forestry. He is excellent at identifying trees. He specializes in classifying nuts. CRACKER

(2) Bill's major is forestry. He is excellent at identifying trees. He specializes in classifying mates. CRACKER

(3) Bill's major is forestry. He is excellent at identifying trees. He specializes in classifying nuts. CRAZY

(4) Bill's major is forestry. He is excellent at identifying trees. He specializes in classifying mates. CRAZY

6. bar

(4) Marc made a lot of trouble downtown the other night. He was loud and obnoxious all night. Everyone knew it was trouble when he hit the bar. DRINK

(1) Marc made a lot of trouble downtown the other night. He was loud and obnoxious all night. Everyone knew it was trouble when he hit the hole. DRINK

(2) Marc made a lot of trouble downtown the other night. He was loud and obnoxious all night. Everyone knew it was trouble when he hit the bar. METAL

(3) Marc made a lot of trouble downtown the other night. He was loud and obnoxious all night. Everyone knew it was trouble when he hit the hole. METAL

7. ball

(3) There are many occasions when you must get dressed up. Last night I had to put on my suit. At my friend's house there was a ball. DANCE

(4) There are many occasions when you must get dressed up. Last night I had to put on my suit. At my friend's house there was a scene. DANCE

(1) There are many occasions when you must get dressed up. Last night I had to put on my suit. At my friend's house there was a ball. BASE

(2) There are many occasions when you must get dressed up. Last night I had to put on my suit. At my friend's house there was a scene. BASE

8. cast

(2) Most people like a good theatre performance. It is fun to watch the show and transfer to another time and place. The key factor is the cast. PLAY

(3) Most people like a good theatre performance. It is fun to watch the show and transfer to another time and place. The key factor is the trap. PLAY

(4) Most people like a good theatre performance. It is fun to watch the show and transfer to another time and place. The key factor is the cast. BROKEN

(1) Most people like a good theatre performance. It is fun to watch the show and transfer to another time and place. The key factor is the trap. BROKEN

9. note

(1) Jennifer likes to play the guitar. She is dedicated, but not very good. She has trouble changing notes. MUSIC

(2) Jennifer likes to play the guitar. She is dedicated, but not very good. She has trouble changing news. MUSIC

(3) Jennifer likes to play the guitar. She is dedicated, but not very good. She has trouble changing notes. BOOK

(4) Jennifer likes to play the guitar. She is dedicated, but not very good. She has trouble changing news. BOOK

10. charge

(4) Tim has a lot of problems with his car. It never starts when he wants. It is very hard for him to make a charge. BATTERY

(1) Tim has a lot of problems with his car. It never starts when he wants. It is very hard for him to make a test. BATTERY

(2) Tim has a lot of problems with his car. It never starts when he wants. It is very hard for him to make a charge. CREDIT

(3) Tim has a lot of problems with his car. It never starts when he wants. It is very hard for him to make a test. CREDIT

11. crane

(3) Greg is an animal rights activist. He spends most of his time trying to save the wetlands. The other day he saw a crane. BIRD

(4) Greg is an animal rights activist. He spends most of his time trying to save the wetlands. The other day he saw an hose. BIRD

(1) Greg is an animal rights activist. He spends most of his time trying to save the wetlands. The other day he saw a crane. LIFT

(2) Greg is an animal rights activist. He spends most of his time trying to save the wetlands. The other day he saw a hose. LIFT

12. deck

(2) John loves his sail boat. Each part of the boat takes a lot of work to clean and maintain. What requires most time is the deck. BOAT

(3) John loves his sail boat. Each part of the boat takes a lot of work to clean and maintain. What requires most time is the stove. BOAT

(4) John loves his sail boat. Each part of the boat takes a lot of work to clean and maintain. What requires most time is the deck. CARDS

(1) John loves his sail boat. Each part of the boat takes a lot of work to clean and maintain. What requires most time is the stove. CARDS

13. draft

(1) Mary composes sonnets for magazines. Her favorite place to work is in the den of her house. Last night she did not like the draft. DRAW

(2) Mary composes sonnets for magazines. Her favorite place to work is in the den of her house. Last night she did not like the bride. DRAW

(3) Mary composes sonnets for magazines. Her favorite place to work is in the den of her house. Last night she did not like the draft. WIND

(4) Mary composes sonnets for magazines. Her favorite place to work is in the den of her house. Last night she did not like the bride. WIND

14. fan

(4) Ricky is not a very good baseball player. He does not practice hard enough to be a superb athlete. In spite of that he does have a fan. CLUB

(1) Ricky is not a very good baseball player. He does not practice hard enough to be a superb athlete. In spite of that he does have an nest. CLUB

(2) Ricky is not a very good baseball player. He does not practice hard enough to be a superb athlete. In spite of that he does have a fan. COOL

(3) Ricky is not a very good baseball player. He does not practice hard enough to be a superb athlete. In spite of that he does have a nest. COOL

15. hatch

(3) Last weekend John went sailing. Every time he went into the cabin he got sick. So he had to run out of the hatch. DOOR

(4) Last weekend John went sailing. Every time he went into the cabin he got sick. So he had to run out of the ranch. DOOR

(1) Last weekend John went sailing. Every time he went into the cabin he got sick. So he had to run out of the hatch. EGG

(2) Last weekend John went sailing. Every time he went into the cabin he got sick. So he had to run out of the ranch. EGG

16. interest

(2) Mathew is a very good student. He likes every subject in school. But science maintains his interest. HOBBY

(3) Mathew is a very good student. He likes every subject in school. But science maintains his minute. HOBBY

(4) Mathew is a very good student. He likes every subject in school. But science maintains his interest. RATE

(1) Mathew is a very good student. He likes every subject in school. But science maintains his minute. RATE

17. pipe

(1) There are many ways to move water from one place to another. The Romans used aqueducts many centuries ago. Today we use pipes. LINE

(2) There are many ways to move water from one place to another. The Romans used aqueducts many centuries ago. Today we use bait. LINE

(3) There are many ways to move water from one place to another. The Romans used aqueducts many centuries ago. Today we use pipes. SMOKE

(4) There are many ways to move water from one place to another. The Romans used aqueducts many centuries ago. Today we use bait. SMOKE

18. ring

(4) John has been in love with Sarah for a long time. Marriage is the next step in their relationship. Tonight he will give her a ring. FINGER

(1) John has been in love with Sarah for a long time. Marriage is the next step in their relationship. Tonight he will give her a joke. FINGER

(2) John has been in love with Sarah for a long time. Marriage is the next step in their relationship. Tonight he will give her a ring. BELL

(3) John has been in love with Sarah for a long time. Marriage is the next step in their relationship. Tonight he will give her a joke. BELL

19. horn

(3) Scott has played music since he was a child. His dream is to play in the orchestra. He plays the horn. BLOW

(4) Scott has played music since he was a child. His dream is to play in the orchestra. He plays the roll. BLOW

(1) Scott has played music since he was a child. His dream is to play in the orchestra. He plays the horn. ANTLER

(2) Scott has played music since he was a child. His dream is to play in the orchestra. He plays the roll. ANTLER

20. cell

(2) Jessie is a biologist. She studied medicine in graduate school. She discovered a type of cell. BLOOD

(3) Jessie is a biologist. She studied medicine in graduate school. She discovered a type of fruit. BLOOD

(4) Jessie is a biologist. She studied medicine in graduate school. She discovered a type of cell. JAIL

(1) Jessie is a biologist. She studied medicine in graduate school. She discovered a type of fruit. JAIL

21. court

(1) Eric went to law school. He is now a well known lawyer. He spends all his time in court. JUDGE

(2) Eric went to law school. He is now a well known lawyer. He spends all his time in mouth. JUDGE

(3) Eric went to law school. He is now a well known lawyer. He spends all his time in court. TENNIS

(4) Eric went to law school. He is now a well known lawyer. He spends all his time in mouth. TENNIS

22. bridge

(4) My mother loves to socialize. She spends every Thursday with her friends. They talk and play bridge. GAME

(1) My mother loves to socialize. She spends every Thursday with her friends. They talk and play trial. GAME

(2) My mother loves to socialize. She spends every Thursday with her friends. They talk and play bridge. WATER

(3) My mother loves to socialize. She spends every Thursday with her friends. They talk and play in the trial. WATER

23. bat

(2) On Monday there was not a cloud in the sky. John stood outside and stared at the stars most of the night. He saw a bat. MAN

(1) On Monday there was not a cloud in the sky. John stood outside and stared at the stars most of the night. He saw a robe. MAN

(4) On Monday there was not a cloud in the sky. John stood outside and stared at the stars most of the night. He saw a bat. HIT

(3)On Monday there was not a cloud in the sky. John stood outside and stared at the stars most of the night. He saw a robe. HIT

24. bank

(1) Cindy is a financial advisor. She tells people what they should do with their savings. Most of her time is spent at the bank. MONEY

(4) Cindy is a financial advisor. She tells people what they should do with their savings. Most of her time is spent at the top. MONEY

(3) Cindy is a financial advisor. She tells people what they should do with their savings. Most of her time is spent at the bank. RIVER

(2) Cindy is a financial advisor. She tells people what they should do with their savings. Most of her time is spent at the top. RIVER

25. seal

(4) Ivan writes a lot of letters. He enjoys writing to his friends. Last year his mother gave him a seal. CLOSE

(3) Ivan writes a lot of letters. He enjoys writing to his friends. Last year his mother gave him an jam. CLOSE

(2) Ivan writes a lot of letters. He enjoys writing to his friends. Last year his mother gave him a seal. ANIMAL

(1) Ivan writes a lot of letters. He enjoys writing to his friends. Last year his mother gave him a jam. ANIMAL

26. buck

(3) Barry is a hunter. He spends most of his time in pursuit of animals. While walking through the woods he saw a buck. MAMMAL

(2) Barry is a hunter. He spends most of his time in pursuit of animals. While walking through the woods he saw a cube. MAMMAL

(1) Barry is a hunter. He spends most of his time in pursuit of animals. While walking through the woods he saw a buck. BILL

(4) Barry is a hunter. He spends most of his time in pursuit of animals. While walking through the woods he saw a cube. BILL

27. nut

(2) Freud spent his life working with people. He was interested in how the brain functioned. He was good at talking to nuts. CRAZY

(1) Freud spent his life working with people. He was interested in how the brain functioned. He was good at talking to mates. CRAZY

(4) Freud spent his life working with people. He was interested in how the brain functioned. He was good at talking to nuts. CRACKER

(3) Freud spent his life working with people. He was interested in how the brain functioned. He was good at talking to mates. CRACKER

28. bar

(1) Mary is on the track and field team. She is best at the high jump. Unfortunately, in a competition she hit the bar. METAL

(4) Mary is on the track and field team. She is best at the high jump. Unfortunately, in a competition she hit the hole. METAL

(3) Mary is on the track and field team. She is best at the high jump. Unfortunately, in a competition she hit the bar. DRINK

(2) Mary is on the track and field team. She is best at the high jump. Unfortunately, in a competition she hit the hole. DRINK

29. ball

(4) Tyler is a sports fanatic. He has a very large collection of autographed baseball cards and collectibles. At his house yesterday he let me see the ball. BASE

(3) Tyler is a sports fanatic. He has a very large collection of autographed baseball cards and collectibles. At his house yesterday he let me see the scene. BASE

(2) Tyler is a sports fanatic. He has a very large collection of autographed baseball cards and collectibles. At his house yesterday he let me see the ball. DANCE

(1) Tyler is a sports fanatic. He has a very large collection of autographed baseball cards and collectibles. At his house yesterday he let me see the scene. DANCE

30. cast

(3) Playing sports can be quite dangerous. Sometimes you may get seriously hurt. You might even need a cast. BROKEN

(2) Playing sports can be quite dangerous. Sometimes you may get seriously hurt. You might even need a trap. BROKEN

(1) Playing sports can be quite dangerous. Sometimes you may get seriously hurt. You might even need a cast. PLAY

(4) Playing sports can be quite dangerous. Sometimes you may get seriously hurt. You might even need a trap. PLAY

31. note

(2) Amy likes to do charity work. She has a kind heart but is forgetful. To avoid this she writes notes. BOOK

(1) Amy likes to do charity work. She has a kind heart but is forgetful. To avoid this she writes news. BOOK

(4) Amy likes to do charity work. She has a kind heart but is forgetful. To avoid this she writes notes. MUSIC

(3) Amy likes to do charity work. She has a kind heart but is forgetful. To avoid this she writes news. MUSIC

32. charge

(1) Tim was glad to receive a letter from his bank. The bank issued him a new account. He plans to use it to make a charge. CREDIT

(4) Tim was glad to receive a letter from his bank. The bank issued him a new account. He plans to use it to make a test. CREDIT

(3) Tim was glad to receive a letter from his bank. The bank issued him a new account. He plans to use it to make a charge. BATTERY

(2) Tim was glad to receive a letter from his bank. The bank issued him a new account. He plans to use it to make a test. BATTERY

33. crane

(4) Bob has been a construction worker for over 20 years. Every day of the week he works with large machines. His favorite is the crane. LIFT

(3) Bob has been a construction worker for over 20 years. Every day of the week he works with large machines. His favorite is the hose. LIFT

(2) Bob has been a construction worker for over 20 years. Every day of the week he works with large machines. His favorite is the crane. BIRD

(1) Bob has been a construction worker for over 20 years. Every day of the week he works with large machines. His favorite is the hose. BIRD

34. deck

(3) Blackjack dealers are amazing to watch. They move so quickly that it is hard to follow what they are doing. They take special care of their deck. CARDS

(2) Blackjack dealers are amazing to watch. They move so quickly that it is hard to follow what they are doing. They take special care of their stove. CARDS

(1) Blackjack dealers are amazing to watch. They move so quickly that it is hard to follow what they are doing. They take special care of their deck. BOAT

(4) Blackjack dealers are amazing to watch. They move so quickly that it is hard to follow what they are doing. They take special care of their stove. BOAT

35. draft

(2) William has a wonderful cabin on the river. It has a great view from every window. But there is a problem with the bad draft. WIND

(1) William has a wonderful cabin on the river. It has a great view from every window. But there is a problem with the bad bride. WIND

(4) William has a wonderful cabin on the river. It has a great view from every window. But there is a problem with the bad draft. DRAW

(3) William has a wonderful cabin on the river. It has a great view from every window. But there is a problem with the bad bride. DRAW

36. fan

(1) Some of the days during summer the weather is unbearable. You have to keep your body cool somehow. It is necessary to have a fan. COOL

(4) Some of the days during summer the weather is unbearable. You have to keep your body cool somehow. It is necessary to have an nest. COOL

(3) Some of the days during summer the weather is unbearable. You have to keep your body cool somehow. It is necessary to have a fan. CLUB

(2) Some of the days during summer the weather is unbearable. You have to keep your body cool somehow. It is necessary to have a nest. CLUB

37. hatch

(4) In some species of birds the male takes care of the young. He keeps an eye out for predators. And he never goes far from the hatch. EGG

(3) In some species of birds the male takes care of the young. He keeps an eye out for predators. And he never goes far from the ranch. EGG

(2) In some species of birds the male takes care of the young. He keeps an eye out for predators. And he never goes far from the hatch. DOOR

(1) In some species of birds the male takes care of the young. He keeps an eye out for predators. And he never goes far from the ranch. DOOR

38. interest

(3) Jack is a stock broker. He has made a lot of smart investments over the years. He will soon be able to live off the interest. RATE

(2) Jack is a stock broker. He has made a lot of smart investments over the years. He will soon be able to live off the minute. RATE

(1) Jack is a stock broker. He has made a lot of smart investments over the years. He will soon be able to live off the interest. HOBBY

(4) Jack is a stock broker. He has made a lot of smart investments over the years. He will soon be able to live off the minute. HOBBY

39. pipe

(2) Even though people worry about their health they still smoke. Nowadays many people smoke cigarettes. Some people still like to use a pipe. SMOKE

(1) Even though people worry about their health they still smoke. Nowadays many people smoke cigarettes. Some people still like to use a bait. SMOKE

(4) Even though people worry about their health they still smoke. Nowadays many people smoke cigarettes. Some people still like to use a pipe. LINE

(3) Even though people worry about their health they still smoke. Nowadays many people smoke cigarettes. Some people still like to use a bait. LINE

40. ring

(1) Joey met a girl at school the other day. She gave Joey her number. He thought that he might give her a ring. BELL

(4) Joey met a girl at school the other day. She gave Joey her number. He thought that he might give her a joke. BELL

(3) Joey met a girl at school the other day. She gave Joey her number. He thought that he might give her a ring. FINGER

(2) Joey met a girl at school the other day. She gave Joey her number. He thought that he might give her a joke. FINGER

41. horn

(4) Dan decided to drive across the country. In one forest, he saw many deer. Some even had horns. ANTLER

(3) Dan decided to drive across the country. In one forest, he saw many deer. Some even had rolls. ANTLER

(2) Dan decided to drive across the country. In one forest, he saw many deer. Some even had horns. BLOW

(1) Dan decided to drive across the country. In one forest, he saw many deer. Some even had rolls. BLOW

42. cell

(3) Jack took a trip to California. He went on a day trip to Alcatraz. He was shocked by the size of the cells. JAIL

(2) Jack took a trip to California. He went on a day trip to Alcatraz. He was shocked by the size of the fruit. JAIL

(1) Jack took a trip to California. He went on a day trip to Alcatraz. He was shocked by the size of the cells. BLOOD

(4) Jack took a trip to California. He went on a day trip to Alcatraz. He was shocked by the size of the fruit. BLOOD

43. court

(2) Ben bought a new racquet. He is the professional at the club. He is most comfortable when playing on the court. TENNIS

(1) Ben bought a new racquet. He is the professional at the club. He is most comfortable when playing mouth. TENNIS

(4) Ben bought a new racquet. He is the professional at the club. He is most comfortable when playing on the court. JUDGE

(3) Ben bought a new racquet. He is the professional at the club. He is most comfortable when playing on the mouth. JUDGE

44. bridge

(1) Everyday Joan walks to back home. It is a nice five minute walk through the park. She goes through the garden and across the bridge. WATER

(4) Everyday Joan walks to back home. It is a nice five minute walk through the park. She goes through the garden and across the trial. WATER

(3) Everyday Joan walks to back home. It is a nice five minute walk through the park. She goes through the garden and across the bridge. GAME

(2) Everyday Joan walks to back home. It is a nice five minute walk through the park. She goes through the garden and across the trial. GAME

* number in parenthesis denotes the group number the sentence was assigned.

Appendix B

Consent Form

Principal Investigator
The principal investigator is Frazer Orgain. He is supervised by Dr. Ping Li. Should you have any concerns please contact Frazer Orgain (287-1916) or Ping Li (289-8125).

Voluntary Participation
Your participation is voluntary and you are free to withdraw participation in the project at any time and without penalty.

Confidentiality of Records
Results of this study will only be reported in group form. Participants' identities will be kept confidential and they will be identified by numbers.

Subjects Rights Information
If you have any questions concerning your rights as a research subject, you may contact the Chair of the University of Richmond's Institutional Review Board for the Protection of Human Subjects at 289-8417.

Participant's Consent
The study has been described to me and I understand that my participation is voluntary and that I am free to withdraw my consent and discontinue my participation in the project at any time without penalty. I understand that the results of the study will be treated in strict confidence and reported only in group form in a APA-style manuscript . I understand that it I have any questions or concerns about this experiment I may pose them to Frazer Orgain or Ping Li (289-8125).

I have read and understand the above information and I agree to participate in this study by signing below.

____________________________ ______________________
Signature Date

____
Signature of Investigator

Appendix C

Oral Directions

Make sure that they are situated and room is removed of distractions.
No food, drink, etc.
Keyboard is in front of them
The chair is all the way down.
Response box to the side of them.

This is not an intelligence test.

It is a simple reading paradigm where your task is to read as quickly as possible while comprehending the sentences.

You will use the spacebar to move through the sentences.

Following the sentences there will be a word shown in blue. Your second and equally important task will be to determine whether the word in blue is a WORD or a NON-WORD as quickly as possible. You will do this by pressing YES for a WORD and NO for a NON-WORD on the response box.
This *(point)* is the response box.

For example if the word COLD appears on the screen you will press YES as quickly as possible.

The instructions will be on the screen.

Wait for me to leave the room and then you may begin.

Start whenever you are ready but make sure that once you start, you continue until told to stop by the computer.

Once you have completed reading all of the sentences come tell me and I will give you questions to answer about the sentences.

Do you have any questions?

Appendix D

Welcome to our lab.
In this experiment, you will be reading groups of sentences on the computer screen. You will first see a row of dashes like this:

_____ _____ _____ _____

The dashes precede a new sentence.

When you press spacebar, the first word of the first sentence will appear. Each subsequent time that you press the spacebar, the next word of the sentence will appear, and the prior word will disappear. In this way, you will make progress through each sentence.
At the end of the experiment you will be given a sheet to answer questions about the sentences you just read. This is to make sure that you actually read each sentence and didn't just press the spacebar blindly.

You also have a second and equally important task. At the end of the sentences you will see a blue word, your task is to decide whether it is a WORD or a NON-WORD as quickly as possible. If it is a word press YES if it is a non-word press NO.

For example:
If you see WATER
press YES.

If you see SOAZ
press NO.

Although this way of reading is somewhat strange, please try to read as naturally as possible, much as you would read a magazine or a newspaper. Your task is to understand each sentence in the shortest amount of time.

Let's begin first with 8 sets of practice sentences so that you are familiar with the task.

Do you have any questions? If not, press spacebar to continue.

*--- denotes page breaks

Appendix E1

Group I Questions **Name ___________________**
Please take a minute and answer these questions **Number _________________**

2. Was the task of reading the sentences while pushing the button difficult to get used to?

3. Did you notice any patterns in the sentence content while you were reading?

4. Did you experience any problems while completing the experiment? Explain.

5. Where did Matt decide to spend the day, because it was a beautiful day?

6. What did Mary and I take to the picnic?

7. What does Courtney fight with her mother about?

Other comments:

Appendix E2

Group II Questions **Name ________________**
Please take a minute and answer these questions **Number ________________**

8. Was the task of reading the sentences while pushing the button difficult to get used to?

9. Did you notice any patterns in the sentence content while you were reading?

10. Did you experience any problems while completing the experiment? Explain.

11. Bob was the construction worker, what was his favorite machine?

12. What was Freud interested in?

13. What does my mother play on Thursdays with her friends?

Other comments:

Appendix E3

Group III Questions **Name** ________________
Please take a minute and answer these questions **Number** ________________

14. Was the task of reading the sentences while pushing the button difficult to get used to?

15. Did you notice any patterns in the sentence content while you were reading?

16. Did you experience any problems while completing the experiment? Explain.

17. Bill is the forestry major, what does he specialize in?

18. According to the sentence, what did he see while walking through the woods?

19. Birds keep an eye out for predators and never go far from what?

Other comments:

Appendix E4

Group IV Questions **Name** ________________
Please take a minute and answer these questions **Number** ________________

20. Was the task of reading the sentences while pushing the button difficult to get used to?

21. Did you notice any patterns in the sentence content while you were reading?

22. Did you experience any problems while completing the experiment? Explain.

23. Where does Cindy, the financial advisor, spend all her time?

24. What did William have on the river?

25. During the hot summer months it is necessary to have a what?

Other comments:

Appendix F

Make sure that they are situated and room is removed of distractions.
No food, drink, etc.
Keyboard is on top of the monitor.
The chair is all the way down.
Response box to the side of them.
Microphone is positioned in front of them
Ask whether they are RH or LH

This is not an intelligence test.

It is a simple reading paradigm where your task is to read as quickly as possible while comprehending the sentences.

Following the sentences there will be a word shown in blue. Your second and equally important task will be to name this word as quickly as possible.

For example is the word COLD appears on the screen you will say "cold" as quickly as possible.

The instructions will be on the screen.

This *(point)* is the response box. You will use it to make your responses.

This is the microphone where you will make your vocal responses.

Wait for me to leave the room and then you may begin.

Start whenever you are ready but make sure that once you start, you continue until told to stop by the computer.

Once you have completed reading all of the sentences come tell me and I will give you questions to answer about the sentences.

Do you have any questions?

Appendix G1

	Incorrect	No response		Incorrect	No response
RAIN			GAME		
BUMP			MOUSE		
STICK			CAVE		
TUB			NAIL		
CRAB			MONEY		
RIVER			SEED		
CLOCK			ANIMAL		
STAMP			BILL		
GEM			STOVE		
MAMMAL			BUS		
SHELL			CRAZY		
LOCK			CHIP		
PUCK			METAL		
DRINK			FENCE		
TAG			PARTY		
ROUND			FOG		
GOAT			ACTORS		
BONE			GUN		
BIRD			MESSAGE		
SONG			CREDIT		
MUSIC			JAM		
BATTERY			LAW		
DOCK			BIRD		
MACHINE			MAP		
LAMP			SHIP		
SPY			PEA		
CARDS			WIND		
WRITE			PIN		
FOLLOWER			THORN		
EGG			COOL		
ARM			DASH		
FOG			OPENING		
WORTH			FOCUS		
NUT			BOX		
TUBE			WIG		
TICK			TOBACCO		
JEWELRY			PHONE		
DUCK			INSTRUMENT		
ANTLER			SAIL		
HAWK			BLOOD		
JAIL			TENNIS		
LEGAL			SPAN		

Appendix G2

	Incorrect	No response		Incorrect	No response
RAIN			SPAN		
BUMP			MOUSE		
STICK			CAVE		
TUB			NAIL		
CRAB			RIVER		
MONEY			SEED		
CLOCK			ANIMAL		
STAMP			MAMMAL		
GEM			STOVE		
BILL			BUS		
SHELL			CRAZY		
LOCK			CHIP		
PUCK			DRINK		
METAL			FENCE		
TAG			PARTY		
ROUND			FOG		
GOAT			BONE		
ACTORS			GUN		
BIRD			MESSAGE		
SONG			BATTERY		
MUSIC			JAM		
CREDIT			LAW		
DOCK			BIRD		
MACHINE			MAP		
LAMP			CARDS		
SPY			PEA		
SHIP			WIND		
WRITE			PIN		
COOL			THORN		
EGG			FOLLOWER		
ARM			DASH		
FOG			OPENING		
FOCUS			WORTH		
NUT			BOX		
TUBE			WIG		
TICK			TOBACCO		
PHONE			JEWELRY		
DUCK			INSTRUMENT		
ANTLER			SAIL		
HAWK			JAIL		
BLOOD			TENNIS		
LEGAL			CARDS		

Appendix G3

	Incorrect	No response		Incorrect	No response
RAIN			SPAN		
BUMP			MOUSE		
CAVE			STICK		
TUB			NAIL		
CRAB			RIVER		
MONEY			SEED		
CLOCK			STAMP		
ANIMAL			MAMMAL		
GEM			STOVE		
BILL			BUS		
CRAZY			SHELL		
LOCK			CHIP		
PUCK			DRINK		
METAL			FENCE		
TAG			ROUND		
PARTY			FOG		
GOAT			BONE		
ACTORS			GUN		
BIRD			MUSIC		
SONG			BATTERY		
MEMO			JAM		
CREDIT			LAW		
DOCK			MACHINE		
BIRD			MAP		
LAMP			CARDS		
SPY			PEA		
SHIP			WRITING		
WIND			PIN		
COOL			THORN		
OPENING			FOLLOWER		
ARM			DASH		
FOG			EGG		
FOCUS			WORTH		
NUT			BOX		
TOBACCO			WIG		
TICK			TUBE		
PHONE			JEWELRY		
DUCK			ANTLER		
INSTRUMENT			SAIL		
HAWK			JAIL		
BLOOD			LEGAL		
TENNIS			CARDS		

Appendix G4

	Incorrect	No response
RAIN		
BUMP		
CAVE		
TUB		
CRAB		
RIVER		
CLOCK		
ANIMAL		
GEM		
MAMMAL		
CRAZY		
LOCK		
PUCK		
DRINK		
TAG		
PARTY		
GOAT		
BONE		
BIRD		
SONG		
MEMO		
BATTERY		
DOCK		
BIRD		
LAMP		
SPY		
CARDS		
WIND		
FOLLOWER		
OPENING		
ARM		
FOG		
WORTH		
NUT		
TOBACCO		
TICK		
JEWELRY		
DUCK		
INSTRUMENT		
HAWK		
JAIL.		
TENNIS		

	Incorrect	No response
GAME		
MOUSE		
STICK		
NAIL		
MONEY		
SEED		
STAMP		
BILL		
STOVE		
BUS		
SHELL		
CHIP		
METAL		
FENCE		
ROUND		
FOG		
ACTORS		
GUN		
MUSIC		
CREDIT		
JAM		
LAW		
MACHINE		
MAP		
SHIP		
PEA		
WRITING		
PIN		
THORN		
COOL		
DASH		
EGG		
FOCUS		
BOX		
WIG		
TUBE		
PHONE		
ANTLER		
SAIL		
BLOOD		
LEGAL		
SPAN		