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CONTEXT AND THE ORDERED SEARCH HYPOTHESIS

by

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Dedication

To John and Hilda Bergen

Abstract

This study investigated the effects of context on the processing of ambiguous words. In the literature, there exist a number of competing models to account for this processing. This study explored the claims of one of these, the Ordered Search Model. Proponents of this model suggest that dominant meanings of words are always easier to access than subordinate meanings. This research was undertaken to determine whether there was evidence for the Ordered Search Model, and secondly, whether the access of meaning was a context free process.

Forty subjects listened to sentences ending in ambiguous words, and were asked to decide whether the words had another meaning or not. The subjects were assigned to one of three training conditions, of which one was a control condition. Thus, two of the three groups looked for meanings under the influence of a particular context.

The resulting response times, error proportions, and d prime statistics were analyzed across subjects and items. It was found that no coherent model emerged to explain the results of the response time analyses. However, the analyses of the error proportions and d prime statistics indicated strong support for the ordered search model under conditions of no context. Given a particular context, those meanings related to that context were easier to find, and those meanings competing with that context were harder to find. Meanings unrelated to the context were processed in the same manner as those in the control condition.

This experiment indicated that context can influence the processing of meanings if those meanings are related to the context. Furthermore, support was provided for an ordered search in the absence of context. Generally, dominant meanings were easier to find than subordinate meanings. In other words, meanings that are used most often are the easiest to find. However, if a particular context is available, the meanings most relevant to that context are the most available.

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1. INTRODUCTION

1.1 Preliminaries

Spoken language consists of words uttered either alone or in conjunction with other words. Words seem to be the basic element of verbal communication. Though it can be argued that morphemes are the essential units of meaning, they have to exist as words to be considered meaningful by the listener. TELE and PHONE are both meaningful morphemes. Though PHONE can stand alone since it is both an accepted abbreviation for TELEPHONE and is a linguistic term, TELE is meaningless as a free standing unit of communication.

From the interactions of words in a string, a meaningful sentence can be formed and from sentences, a discourse. In English, different arrangements of the same words can produce different meanings. "The man killed the tiger" and "The tiger killed the man" mean different things, but the essential components are the same. Only the relationships between them are different. Most simply put, sentences cannot exist without words. Though different meanings can arise from different arrangements of the same words, none of these meanings can arise without those initial words.

Once polysemous words are considered, complications arise. If confronted with the newspaper headline "Man Flies Plane," the listener/reader can derive several readings but will probably get the intended meaning rather quickly and without even consciously considering any alternatives. The receiver will not interpret the above string as a non-sentence consisting of three nouns or as describing a situation in which an individual pilots a geometrical concept or drafting tool. The nouns hypothesis will be rejected due to preset assumptions about the canonical form of English structures. Nouns are usually followed by verbs which are often followed by nouns. Thus, a reader will likely interpret the second word in the above-mentioned string as a verb and not a noun. The last word is possibly derived through pragmatic knowledge – what is more likely to be flown by a man. However the derivation of PLANE is quite possibly arrived at without any resort to pragmatic knowledge. Even if PLANE has more than one meaning, its dominant or default use is as a term for a flyable object. As seen, there are many possible sources of disambiguation even in the absence of context, but the last source will be the focus of the present study.

Theoretically, the concept of a default meaning makes sense. If meanings are stored under phonic images, that is, if all the meanings for PLANE are stored under PLANE, then there is little reason for them to be equally accessible. If access to meanings is sequential, and the retrieval process is efficient, then infrequent meanings should be harder to access. If the dominant meaning is the first to be accessed, then most of the time the first access will be the right access. What this means is that a language user can, through a single algorithm, eliminate the need for higher level resources. If the first meaning isn't correct, the next most used entry is tried, and the process continues until an entry is accepted.

That lexical access occurs in such a fashion is purported by several researchers, most notably Hogaboam & Perfetti (1975). In a task designed to test the manner in which lexical access occurs, they asked subjects to listen to a number of sentences. An attempt was made to bias sentences toward either a dominant or a secondary meaning of the last word. For example, "A good sprinter uses his arms" is biased toward the dominant meaning of ARM and "The gun collector displayed the arms" toward the secondary. The subjects had to decide whether the last word of each sentence had another meaning or not. Hogaboam and Perfetti reasoned that in the case of the first sentence, the subject would have to re-access his or her lexicon in order to retrieve the second meaning, but in the case of the second sentence, the first meaning would already have been accessed so that its retrieval would be immediate. The pattern of their results was in general accord with this hypothesis. Secondary meanings took consistently and significantly longer to retrieve than dominant meanings, regardless of biasing contexts.

To account for these results, Hogaboam and Perfetti proposed an Ordered Access Model which stated that meanings were retrieved in a descending order of dominance until the appropriate meaning was found. They also stated that this was the case no matter what the context. That is, if PLANE was uttered in the context of a geometry conference, the "flyable object" meaning would still be accessed first. Only thereafter would the other meanings become available. This does not mean that no individuals have the geometric PLANE as the dominant meaning. The main argument is not which meaning is dominant, but rather that whatever the dominant sense is, that sense will be the first to be accessed.

A good and simple description of this model can be found in the instructions for using the Elementary Edition of Webster's New World Dictionary (1972). Referring to the entry for BRIGHT and the deciphering of the phrase "BRIGHT young girl who won a spelling contest," the instructions are as follows:

"Try to use meaning 1 of bright first, and if it does not fit, try meaning 2. If meaning 2 does not seem right, try meaning 3. Be sure to glance down through all the meanings. It could have been a lively, cheerful girl (meaning 3) who won the prize. But then you notice meaning 4, and realize it was probably a girl having a quick mind, a clever girl, who was being described. Always check all the meanings of a word before you decide that you have chosen the right one for use in the place where you need it."

It should be noted that the suggestions to glance down through all the meanings, and to check them all, does not describe any part of the Ordered Search model. Ordered Search stops once an adequate fit has been found.

Other views, however, are possible. It is possible that access may be selective so that context directs the access of which meaning is retrieved. The Selective Access Model is an example of a prior-decision model in which interpretive effects can take place during the actual access of the word. In this model, the determination of the "flyable object" PLANE in "Man Flies Plane" is not dominance-driven. The prior context would bias the actual access procedure for "things men fly"; in other words, the biasing would occur before the word was encountered. Yet another possibility is a mixed model in which Ordered Access is obtained only under conditions of weak or no context while when prior information is available, selective access takes place. In short, if there is context information, then it will be used to predict subsequent material. If there is none, as in the presentation of an isolated word, then various meanings will be accessed on the basis of relative dominance levels.

All the models assume that meanings are stored under common phonic images, but Miller (1986) argues that this assumption is a by-product of the experience of dictionaries. From observing children learning new words, Carey (1978) postulated a two-step learning process in which the new word is immediately assigned to a semantic category and only later are the distinctions between that word and others in the category established. For instance, "chartreuse" is a word that many people may lack a clear definition of, storing it as a sort-of-red color. With exposure to the color and the active labelling of it, the term would become more specific, more meaningful. Miller argues that since words are assigned to a category first and are only specified or defined later, words may be initially retrieved through their categories. Using Carey's results as a basis he presents his multiple-field hypothesis: The dictionary in your head is organized into many sub-dictionaries for different semantic fields, with minimal polysemy within any single field" (p. 177). Using Miller's model, access would occur within a given domain. This would not mean that context directs the choice in any predictive sense, but that the meaning accessed is simply a member of that domain and thus the only available choice.

Miller's insistence on context as a pre-condition for which meaning is accessed suggests selective access, yet whereas in the Selective Access model the context actually chooses one among several meanings, in Miller's model, no such choice is occurring. While playing cards, only card-SPADE is chosen because only card-SPADE is available. While working in the garden, only tool-SPADE is chosen because only tool-SPADE is available. As Miller implies, it would be unlikely that a polysemy would occur within a domain. If such were the case, it would strain the communicative function of language. If playing cards involved using two different cards both called SPADE, and working in the garden involved using two quite different tools both called SPADE, it would be difficult to talk to someone about those activities. If ambiguities existed within domains, Miller's theory would not specifically deny multiple access or a dominance-based search. However, as Miller states, the different meanings of a polysemous word belong to different domains. The evidence in support of an Ordered Search model shows a dominance effect across domains; the evidence in support of multiple access shows equal facilitation across domains. Therefore, though Miller's paper is theoretical, his suggestions oppose the major models of polysemous access and the findings associated with each model. It has been suggested that if Miller's theory is correct, puns would be less obvious than they are. If a meaning is context-addressable only, then puns should be noticeable only under conditions of a recently 'excited' context or an intermittently intrusive though inappropriate context. In other words, while playing cards, access to the non-card meaning of SPADE would be most likely if the card player had just been gardening or was considering his garden while playing cards.

1.2 A Note on Terminology

Most of the papers cited in this study refer to hypotheses of access. In the following experiment, these hypotheses are investigated through retrieval. For the purposes of this study, retrieval refers to the conscious apprehension of a meaning whereas access refers to the activation of a meaning. Thus, access necessarily precedes retrieval, but retrieval does not necessarily follow from access. In principle, the first meaning to be retrieved could have been the second meaning to be accessed. In other words, multiple access means that a number of meanings have been activated even though only one meaning may be retrieved. This is a retrieval study testing hypotheses of retrieval which may indicate supporting hypotheses of access.

Though frequency generally refers to printed frequency, in many of the papers cited in this study, frequency is synonymous with dominance. Usually the most frequent meaning is the dominant meaning. The search begins with the dominant (most frequent or strongest) to the next strongest (secondary) to the weakest (or least frequent). However, in order to avoid confusion with empirically defined 'frequency', I have used primacy wherever possible. So, where a paper has described a search as frequency-driven or as searching in order of descending frequency, I have substituted primacy. Primacy is preferred over dominance for two reasons. The first reason is simply to avoid possible confusion with 'domain', another prevalent term in this study. The second reason is that dominance can imply dominant whereas primacy can be used to mean a range of strength, encompassing dominant and subordinate.

1.3 Aim of Study

The purpose of this study is to extend the paradigm of Hogaboam & Perfetti (1975). In their experiment, as in most others, the explorations of context center on the effects of sentences on words. This study will examine the effect of domains of activity, such as a chess game, on the processing of words in sentences.

What will specifically be tested is: Is there empirical justification for the Ordered Access Model when stronger context information is presented within the framework of aurally presented sentences? Secondly, is ordered access independent of context (as Hogaboam & Perfetti state) or not? If the model is not supported, the gathered data should still indicate possible means by which the various meanings of a word might be retrieved under different conditions.

1.4 Overview

In Chapter 2, the various alternatives to the Ordered Access Model will be discussed, as well as some general methodological controversies. Furthermore, I will offer a detailed analysis of the major source study, Hogaboam & Perfetti (1975). In Chapter 3 the experiment will be described, in Chapter 4 the results, and in Chapter 5 conclusions will be offered.

2. LITERATURE REVIEW

2.1 Introduction

In this review, I will discuss the proposed models of how language users process ambiguous words. All of the models to be discussed, share the assumption that the processing of ambiguous words is different than that of unambiguous words. For example, it has been found that when subjects are asked to complete tasks such as detecting a particular phoneme immediately after having processed a word, the subjects take longer to detect the given phoneme after an ambiguous word than after a unambiguous one. Clearly, some kind of model had to be proposed to offer an explanation of why this increased processing difficulty was associated with ambiguous words. Since these words differ from others in that they have more than one meaning, the added processing time must be linked to that very quality. That time must be used in processing more than one meaning at a time, or in deciding among the meanings.

First of all, I will discuss the explanations for the processing of ambiguous words that have been proffered. The first model to be addressed is the Selective Access model. This model suggests that the language user utilizes all preceding knowledge to direct the access procedure. The second model is the Exhaustive Computation model. Proponents claim of this model, that the language user does not pre-select, but rather uses preceding information to decide among the meanings only after all the meanings have been made available. The third model is the Ordered Search model, which like the Exhaustive Computation model, holds that preceding information has no effect on the initial access procedure. It differs in that proponents claim that the meanings become available in order of descending dominance. The dominant meaning is the first meaning to become available, and only if it is inappropriate does the access procedure continue.

Each of these models, and their variants, will be discussed in detail along with evidence for and against each model. Within each of these sections, I will mention the possible influence of the experimental paradigms on the results.

Since the Ordered Search model is the focus of this work, Hogaboam and Perfetti's (1975) seminal study will be examined in detail. Following this, other contributions to the Ordered Search model will be described and examined.

Finally, a number of general issues will be discussed. First, the issue of context will be addressed. The term "context" has been used to mean different things in different experiments. Since this study examines the effects of context within the framework of the Ordered Search model, it is necessary to define what manner of context has been tested to date. Second, the modality problem will be discussed. In language processing, a langc proportion of the studies to date have been visual studies. I will argue for the use of aural studies. Lastly, I will explain why this study was undertaken.

2.2 The Selective Access Model

Supporters of the Selective Access model, who include Glucksberg, Kreuz & Rho (1986), Lehiste (1973), Schvaneveldt, Meyer & Becker (1976) and Swinney & Hakes (1976), suggest that longer processing times for ambiguous words appear only in the absence of context. It is thus assumed that context directs access. Only one meaning is activated and that is the one appropriate to the context. All preceding information (semantic and syntactic) is used to make predictions about upcoming input. If the input is irregular, the contextual guess will have to be overridden. Most adherents assume an information-pooling approach. They assume that people can recognize words in isolation, but if discourse or sentence-level information is available, this will speed the processing of the signal. A combination of the information from the actual signal plus the likelihood of the signal given the context determines the speed and method of deciphering that signal.

Swinney & Hakes (1976) used a phoneme monitoring task to assess the effects of prior context on the processing of ambiguous words. In their experiment, subjects listened to sentences which provided one of three context conditions. Either the sentence had a neutral context preceding the critical word, or a disambiguating context occurring immediately before the word, or a disambiguating context in a sentence preceding the sentence containing the critical word. Half of the critical words were ambiguous and half were not. Subjects were asked to listen for a particular phoneme which always occurred immediately after the critical word. They found that, in neutral context conditions, response times were significantly longer following ambiguous words than following controls. Yet under immediate and distant context conditions, the contrast between ambiguous and control words was not significant. Since the contrast disappeared under conditions of prior disambiguating context, Swinney & Hakes interpreted the results to mean that the prior context was restricting access to the appropriate meaning.

However, the same design had been used by Foss & Jenkins (1973) yielding results in favor of a post-access decision. They reasoned that if context biased the interpretive process before the ambiguity was encountered, then any ambiguity-control contrast would be eliminated. Using sentences with either preceding neutral or disambiguating contexts, they found that monitoring reaction times were significantly longer following ambiguous words than following their controls and that there was no significant interaction between this effect and the context condition. Since the context did not significantly reduce the ambiguity-control difference, the data appeared to support a post-decision hypothesis.

The difference in the results of these two studies using the same paradigm may arise from the fact that Swinney & Hakes used a stronger context. They felt that Foss & Jenkins' contexts were not restrictive enough, that "...context had not been highly predictive of a single meaning." Though the sentences had been biased toward one meaning, the alternative meanings were still possible. For example, Foss & Jenkins used sentences such as "The farmer put the STRAW beside the machine" in which FARMER biases STRAW toward its HAY-STRAW sense but does not exclude the SODA-STRAW meaning. In contrast, Swinney & Hakes used sentences such as "Rumor had it that, for years, the government building had been plagued with problems. The man was not surprised when he found several spiders, roaches and other BUGS in the corner of his room." If both sets of data are reliable, this could indicate that the strength (or the restrictiveness) of the context determines what sort of procedure takes place. However, both of these studies are suspect due to their use of phoneme monitoring. Mehler, Segui & Carey (1978) found that differences in monitoring times could be attributed to the differences in the length of the word preceding the target. The phonological similarity between the target-bearing words and the preceding words could also contribute to monitoring time differences (Newman & Dell, 1978). Since most studies preceding these critical papers did not control for prior word length, or for phonological similarity between critical and target-bearing words, the resulting evidence has been considered compromised by most investigators.

Schvaneveldt et al. (1976) used a task in which subjects were presented with three strings of letters, sequentially, on a screen, and asked to decide for each string whether the string formed a word. They found that in triplets such as SAVE--BANK--MONEY, where the first and third words were related to the same meaning of the central homograph, lexical decisions to the last word were faster relative to triplets with a central unrelated homograph. Facilitation was not found when the first and third words were related to the different senses of the central homograph as in RIVER--BANK--MONEY. Schvaneveldt et al argued that in the first case, SAVE biased BANK toward the monetary sense, which in turn primed MONEY. In the second case, RIVER biased BANK toward another sense, which if access was selective, would not prime MONEY. There was no reaction time difference between the latter case and the controls. Had multiple access been operating, MONEY should have been primed since all the senses of BANK would be active.

Evidence for a selective access procedure was obtained by Glucksberg et al.'s (1986) ingenious study. They used a visual pseudoword design in order to eliminate possible sources of backward priming effects that (they felt) had compromised evidence used in support of multiple activation. Backward priming is a concept developed by Koriat (1981) in which the target words bias the ambiguous primes. In cross modal priming procedures, where a word is visually presented immediately after auditory presentation of an ambiguous word, the subject's apprehension of the ambiguous word may follow or be simultaneous with that of the visual target word. In such a circumstance, the target may prime the "target"-sense of the prime. In other words, if the listener heard the sentence "The man played the ORGAN" with the subsequent visual presentation of PIANO on a screen, PIANO might be processed before ORGAN thus priming ORGAN for the PIANO-sense; KIDNEY would prime the KIDNEY-sense of ORGAN. Therefore, whatever the target is, evidence for facilitation is found. Thus, facilitative evidence in such cases reflects not the multiple activation of the prime, but its specific activation by the target. Glucksberg et al. believed that while ambiguous words could interfere with lexical decisions to possible words, these possible words (pseudowords) could not backwardly prime the ambiguous word. For example, ORGAN interferes with negative decisions to PIAMOE and KIDNEA since the pseudowords are so similar to PIANO and KIDN[illegible] [illegible]owever, it is less likely that KIDNEA or PIAMOE could prime ORGAN. Glucksberg et al. found that when subjects listened to sentences containing ambiguous words which triggered the visual presentation of a pseudoword that context interfered with the decision to declare an "appropriate" pseudoword a nonword; for instance, given the sentence "The telescope was fixed on a distant STAR," subjects took longer to decide that PLANUT was a nonword than CELEBTY was a nonword. The same influence was not found on "inappropriate" pseudowords. Thus, selective access operated to affect only the contextually appropriate targets.

2.3 The Exhaustive Computation Model

In the Exhaustive Computation model, also known as the Multiple Activation model, all meanings are accessed and checked, either in parallel or sequentially, for integration with the preceding information. Supporters of this model include Foss & Jenkins (1973), Holley-Willcox & Blank (1980), Lackner & Garrett (1972), MacKay (1970), Seidenberg, Tanenhaus, Leiman & Bienkowski (1982) and Swinney (1979).

In this model, higher level information, such as discourse topic or world knowledge, may play some role in post-access decisions, but has no influence on the actual access. If any higher level information is used, it is used at a later time to do matching and integration procedures. Low level information feeds upwards in a one-way process.

One particular strength of this model is that the data do not have to be matched against predictions at the initial stages of processing. Processing efforts are uniform regardless of the semantic or syntactic complexities. Salient aspects of the context do not direct the access procedure in any way. Whether the meanings are dominant or subordinate does not affect the procedure. All are accessed for participation in the matching procedure.

Using a lexical decision task, Swinney (1979) found that when a word was visually presented immediately after the aural presentation of a sentence-embedded ambiguous word, that in cases of either nonexistent or strong context both meanings of the ambiguous word facilitated recognition of the target. However, when the target was presented four syllables (approximately 800 ms) following the ambiguous word, only the contextually appropriate meaning facilitated recognition. This indicates that though an interpretive procedure takes place quite rapidly, it takes place after access of all the meanings.

Seidenberg et al. (1982) depart from this view in their suggestion of a possible influence of primacy on the access procedure. If the contextually appropriate reading strongly dominates the inappropriate reading, then selective access will occur. Through a series of experiments, they found strong evidence for multiple activation in all cases except for when they primed the noun-noun class of ambiguities. The noun-noun class of ambiguities is composed of words like PEN. PEN possesses the two distinct nominal meanings of "writing implement" and "place for the incarceration of men or animals." On the other hand, the word TIRE not only has two distinct meanings but the distinction varies by word class as well. TIRE can refer to a wheel or to the process of losing energy. Thus, TIRE is of the noun-verb class of ambiguities. They argued that in cases of noun-verb ambiguities, two different lexical nodes are accessed, whereas in cases of noun-noun ambiguities only one node is accessed. When a nonpriming bias, that is, a sentence without any words associatively related to the target, was used with the noun-noun class, multiple access was obtained. An example of a sentence with a nonpriming bias is "Go to the store and buy a SPADE." The sentence biases SPADE as a concrete "buyable" object but doesn't prime it to the same degree that "The bridge player trumped the SPADE" primes the card meaning.

They argued that their selective access results for the noun-noun ambiguities did not indicate the influence of context on the access procedure. They suggested that because selective access was obtained only when sentences containing words associated to the meanings of the critical words were used, that those associates were priming the targets within the lexicon itself. It was not the case that context was directing the access would be 0.0 if subjects responded "yes" to every presentation. If a subject judged all the ambiguous words to be unambiguous and all the unambiguous words to be ambiguous, the d' would be -4.615. In this study, the larger the d' statistic, the greater the agreement between the subject's and the experimenter's definition of ambiguous words.

After the experiment had been run, a reevaluation of the design suggested that parts of the experiment were too complicated to analyse. Data gathered from Session 2 for either of the two training groups and from Session 3 for all three groups is of limited value. For the two training groups, Session 1 consisted of the specified training procedure followed by the presentation of one half of the list. Session 2 consisted of the other training procedure followed by the presentation of the other half of the list. Thus, Session 2 involved the addition of one training condition onto another. The initial intent was to gather information that might illuminate differences between the training conditions. Session 3 involves the presentation of the second list which in the case of the training groups compounds the error of adding training conditions. Every critical word on the second list was being heard for the second time. In other words, though this design was followed, in Sessions 2 and 3, the factors are too confused for interpretation. However, since these sessions were not integral to the aim of the study, the loss of the data gathered in those sessions is of minimal concern. The principal hypotheses being tested do not require any data beyond that of Session 1. Therefore, except as noted below, though ANOVAs were run for the combined data of Sessions 1 and 2, specific ANOVAs were run for Session 1 alone. Session 1 is considered the only "clean" source of data.

Analyses of variance were run in order to assess the strength of the various factors in the design. In addition, where appropriate, t-tests were run in order to specify the origin of higher order interactions.

With one exception, no significant List effects or interactions appeared in the Session 1 ANOVAs for hits ($F(1,34) = 2.727$, $p = .1079$), misses ($F(1,34) = .487$, $p = .4901$), or d' (F (1,34) = 1.321, p = .2585). The single exception is a List by Primacy effect of F (1,34) = 5.239, p = .0284, from the misses ANOVA. Generally, no appreciable differences in the responses were attributable to which subjects had heard which list. Therefore, lists were collapsed and ANOVAs run on the combined data. For the means of the gathered data, see Tables 1 through 3. Latencies, proportions of misses, and d's were submitted to three way (training condition by word domain by primacy) analyses of variance, treating subjects and words as random factors. For the respective subject and item ANOVA summary tables, see Tables 4 through 9. Planned comparisons were carried out with t-tests. The required t-values were calculated by dividing the difference between the two observed means by the square root of the product of the mean square error term (taken from the ANOVA summary tables) and the inverted harmonic mean of the number of measures making up the observed means (see Kirk, 1968; p. 74).

As in the literature, F1 will be used to indicate F values from the subject analyses, and F2 will indicate F values from the item analyses. Only significant min F' will be reported. When only F1 and F2 are given, it can be assumed that min F' was found not to be significant. Following Clark (1973), for full generalization of results, that is, generalization to another pool of subjects with another pool of words, a significant min F' should be found. Analogously, in reporting t-values, t1 will indicate t-values derived from the subject analyses, and t2 the values derived from the item analyses. The ANOVAs were performed in order to provide some indication of the influence of general factors in the overall design. However, since specific contrasts were being examined, the greater part of the analysis takes the form of t-tests.

4.1.1 General Results

The response time ANOVAs found a main effect of Training; F1 (2,37) = 1.763, p = .1856; F2 (2,50) = 3.862, p = .0276. Following either chess or card training, shorter response times were recorded than in the control condition. Though only the item analysis was significant, the subject means reduced in the same direction as the item means. A Training by Primacy interaction was found; F1 (2,37) = 3.726, p = .0335; F2 (2,50) = 4.641, p = .0142. After either chess or card training, dominant meanings were located more quickly than in the control condition. The Training by Domain by Primacy interaction was not significant; F1 (2,37) = .010, p = .9900; F2 (2,50) = .358, p = .7008.

The miss proportion ANOVA found a substantial main effect of Domain; F1 (1,37) = 20.867, p = .0001; F2 (1,63) = 5.259, p = .0252; min F' (1,89) = 4.200, p < .05. Responses to card words were significantly different from responses to chess words. As in the response time ANOVA, a significant Training by Primacy interaction was recorded; F1 (2,37) = 4.001, p = .0267; F2 (2,63) = .819, p = .4457. Though lacking a strong F2, the Training by Domain by Primacy interaction (F1 (2,37) = 3.719, p = .0338; F2 (2,63) = 2.065, p = .1353) indicates that specific comparisons within conditions are warranted.

The d' ANOVAs also show a Training by Domain by Primacy interaction; F1 (2,37) = 3.074, p = .0582; F2 (2,63) = 1.537, p = .2229. The strong main effect of Domain (F1 (1,37) = 21.498, p = .0000; F2 (1,63) = 3.459; p = .0676; min F' (1,81) = 2.980, p < .05) buttresses the same effect found in the misses ANOVA. This is discussed in more detail in Section 4.4.

4.2 Evaluation of Hypothesis 1

Following Hogaboam & Perfetti (1975), it was assumed that when a subject gave a positive response, it meant that a second meaning had been retrieved. It was also assumed that some relationship existed between how long it took the subject to respond and how available the meaning was.

The basic tenet of the Ordered Search model is that subordinate meanings take longer to retrieve than dominant meanings. In order to evaluate this claim, and the first hypothesis, it was necessary to contrast the response times following words biased toward their dominant sense versus words biased toward their subordinate sense. As previously stated, the response time following dominantly biased words represents the search time for a subordinate meaning, and the time following subordinately biased words represents the search time for the dominant meaning. Thus, given Hypothesis 1, response times following dominantly biased words should be longer than those following subordinately biased words. In the interest of simplicity, response times will be referred to as search times for a dominant or subordinate sense, not as times following the presentation of subordinately or dominantly biased words. If it is necessary to address the possibility that a given phenomenon is most likely a reflection of processing the sentence rather than the subsequent search, the distinction between the two will be reasserted.

Hypothesis 1 makes predictions about Primacy differences. Given the evidence that Primacy interacts with Training (response time and miss proportion ANOVAs) and with Training and Domain (miss proportion and d' ANOVAs), simple effects of Primacy within levels of Training were explored. Since the investigation of Primacy differences involves specific directional predictions, *all t-tests involved in the exploration of Hypothesis 1 are one-tailed t-tests.*

4.2.1 Primacy Effects Within the Control Group

Hypothesis 1 predicts that search times for dominant meanings should be shorter than search times for subordinate meanings. However, Figure 1 shows that this group actually responded in the opposite direction. Given a sentence biasing a word toward its dominant meaning, as in "He spoke to the aged BISHOP," subjects found the subordinate meaning 336 ms faster than they found the dominant meaning when given a sentence biasing a word toward its subordinate meaning, as in "He moved up the back

BISHOp. " Since the direction of the effect was the reverse of the predicted, the null hypothesis cannot be rejected. This contrast was found to be significant; t1 (37) = -1.93, $p < .05$; t2 (50) = -2.45, $p < .025$. Subordinate senses were found in 1100 to 1300 ms and dominant senses in 1500 to 1700 ms. The response time data do not correspond to any of the discussed models of access. Under the Ordered Search model, subjects would be expected to find the dominant meaning faster than the subordinate meaning.

On the other hand, an analysis of the proportion of misses revealed findings interpretable under the Ordered Search model. Figure 2 indicates that the control group had a generally higher proportion of misses searching for a subordinate meaning than when searching for the dominant meaning; t1 (37) = 2.16, $p < .025$. That is, when given "He spoke to the aged BISHOP," subjects were less likely to find the other sense of BISHOP than when given "He moved up the back BISHOp. " However, the item analysis did not show a significant contrast; t2 (63) = 1.15, $p > .05$.

Since the ANOVA for proportion of misses (see Table 6) found a significant Training by Domain by Primacy interaction (F1 (2,37) = 3.719, p = .0338), the Primacy contrast will be examined within levels of Domain. For chess words, both analyses (t1 (37) = 1.95, $p < .05$; t2 (63) = 1.89, $p < .05$) show significance. For card words, the analysis by subjects is significant, t1 (37) = 1.95, $p < .05$, but the analysis by items is not (t2 (63) = .46, $p > .05$). In each case, the subordinate sense is missed more often than the dominant sense. Subjects failed to locate subordinate senses 31 to 52 percent of the time as contrasted with the failure to locate dominant senses 17 to 25 percent of the time.

If Table 3 is examined, it is seen that for the control group, the d' means for the dominant bias are smaller than the corresponding d' means for the subordinate bias. This is a significant contrast for both card words (t1 (37) = 1.95, $p < .05$; t2 (63) = .39, $p > .05$) and chess words (t (37) = 2.31, $p < .025$; t2 (63) = 1.51, $p > .05$). The parallel to the results from the proportion of misses analysis is to be expected given that d's are calculated with miss proportions.

4.2.2 Primacy Effects Within Chess Training

Since Hogaboam & Perfetti (1975) consider ordered search to be context independent, exploring Primacy within the two non-control training conditions serves not only to define the nature of the Primacy by Training interaction but also addresses the question of how global context effects may have influenced the pattern of miss data which, in the control condition, appears to be consistent with Hypothesis 1.

The simple main effects of Primacy within Domain indicate that there are no significant differences between search times for dominant and subordinate meanings. Subject means fell within a 211 ms range and item means within an 89 ms range. In the control group, subjects took significantly longer to find a dominant than a subordinate meaning. In this group, subjects took the same amount of time to search for a dominant (1000 to 1100 ms) as they did for a subordinate meaning (1000 to 1200 ms); $t1\ (37) = .06$, $p > .05$; $t2\ (50) = .1$, $p > .05$.

The misses are significant for chess words; $t1\ (37) = -2.15$, $p < .025$; $t2\ (63) = -1.11$, $p > .05$. Though t2 is not significant, the direction of the difference is the reverse of the general direction. It was found that for chess words, dominant meanings were missed 40 to 48 percent of the time compared with subordinate meanings which were missed 26 percent of the time. Dominant meanings were less retrievable than subordinate meanings. For card words, dominant meanings were missed 12 to 19 percent of the time, and subordinate meanings 29 to 32 percent of the time; $t1\ (37) = 1.67$, $p > .05$; $t2\ (63) = .96$, $p > .05$.

Few significant differences were seen in the d's. However, the chess words, though not significant, showed the reverse of the general direction; $t1\ (37) = -1.65$, $p > .05$; $t2\ (63) = .82$, $p > .05$. As previously mentioned, since d' is partially derived from the pattern of misses, this is what would be expected given that chess words were missed more often in the dominant sense than in the subordinate sense. The t-values for card words were t1 (37) = 1.95, $p < .05$ and t2 (63) = .16, $p > .05$.

4.2.3 Primacy Effects Within Card Training

Significant differences in subject search times were found between dominant and subordinate meanings; t1 (37) = 1.72, $p < .05$; t2 (50) = .67, $p > .05$. Dominant meanings were found in 1000 to 1400 ms, and subordinate meanings were found in 1100 to 1600 ms.

For card words, the misses analysis found no significant contrasts for card or chess words. For card words, dominant meanings were missed 21 to 24 percent of the time and subordinate meanings were missed 11 to 14 percent of the time; t1 (37) = -.71, $p > .05$; t2 (50) = -.67, $p > .05$. However, though significance was not reached, in regards to card words, the direction of the effect was the reverse of the control group. This constitutes sufficient evidence to suspect a training effect. For chess words, dominant meanings were missed 30 to 31 percent of the time and subordinate meanings 38 to 46 percent of the time; t1 (37) = .72, $p > .05$; t2 (63) = 1.22, $p > .05$.

Few significant differences were found in the analysis of the d's. However, the primacy relationship of the card words was the reverse of the typical; t1 (37) = -.92, $p > .05$; t2 (63) = -.88, $p > .05$. For chess words, the values were t1 (37) = .2, $p > .05$ and t2 (63) = 1.95, $p < .05$. In most cases, the d' associated with the subordinate bias (search for the dominant) was higher than that associated with the dominant bias (search for the subordinate).

4.2.4 Discussion

The response times and miss proportions differed greatly from Hogaboam &

Perfetti's results. Whereas in the control group of this study subjects found dominant senses in about 1600 ms and subordinate senses in about 1250 ms, in their study, dominant senses were found in about 1000 ms and subordinate senses in about 2500 ms. This study found a 350 ms difference in the opposite direction to their 1500 ms difference (their times were estimated from a figure showing reciprocal latencies). As well, the miss proportion in this study's control group was about thirty percent compared with their ten percent. Some of the difference in the response times might be due to the fact that they measured response times from the offset of the last word as opposed to timing from the beginning of the signal as occurred in this study. More importantly, Hogaboam and Perfetti's subjects were not required to hit a key for negative responses. The longer choice time would likely produce lower error rates and higher mean response times for hits. Subjects could have an initial negative decision, but revise that decision before the fifteen seconds elapsed. In this forced choice design, subjects could not change their response and had to make a positive or negative decision within a five second time period.

The response time means of the control group do not support the Ordered Search model. Under that model, response times to locate dominant senses should have been shorter than response times to locate subordinate senses. The results were significant in the opposite direction. Subjects took longer to find alternate meanings when given a subordinate sense than when given a dominant sense. However, the proportion of misses showed support for the Ordered Search model. Given a dominant sense, a failure to find another sense was significantly more likely than when given the subordinate sense. This appeared to indicate that dominant senses were more accessible than subordinate senses.

Since the Ordered Search model, as formulated by Hogaboam & Perfetti (1975), is context independent, the chess and card training groups should have found dominant meanings more often and more quickly than subordinate meanings. Both groups found dominant or subordinate senses in about the same amount of time. As this pattern is different from the control group, it is unlikely that a context free model is appropriate. At this point, the most likely model is the Selective Access model. Proponents of this model suggest that context influences access. If the sentence is considered the context, rather than the training condition, it can be argued that context determines sense selection. Dominant and subordinate senses should take the same amount of time to retrieve. Yet, were Selective Access true, there should have been no difference between search times for dominant and subordinate senses in the control condition.

The miss patterns for the training groups diverge from the pattern for the control group. The control group missed subordinate senses more often than dominant senses (interpretable as ordered search). With chess training, dominant senses of chess words were missed more often than their subordinate senses, but with card words, no contrast between locating dominant and subordinate senses is evident. With card training, a similar though not significant contrast is evident; dominant senses of card words are missed more often than their subordinate senses, but with chess words, no contrast between locating dominant and subordinate senses occurs. In each case, training is associated with a higher success rate of locating related meanings as compared with the unrelated meanings. In addition, training does not affect the inappropriate domain. The chess training group has the same pattern of misses with card words as the control group, and the card training group has the same pattern of misses with chess words as the control group. The only difference is that the contrast is no longer significant.

Since the relationships between the search for dominant and subordinate senses vary among the training groups, the context free claim of Hypothesis 1 appears to be unsupported. The only possible evidence for Hypothesis 1 exists in the proportion of misses results from the control group.

It is certain that Training interacts with Domain, but a closer examination of how the training groups differ is needed. Therefore, the effects of Training through levels of Domain and Primacy will be explored. Since Hypothesis 2 predicts a direction of effect of Training on Domain-relevant meanings, t-tests concerning the effect of Chess training on chess terms and Card training on card terms are one-tailed. In other words, *all t-test comparisons of Training groups and Training-relevant items with the Control groups and the same items will be one-tailed and specified as such; all other t-tests can be assumed to be two-tailed.*

4.3 Evaluation of Hypothesis 2

If Hypothesis 1 is correct, no significant effects of Training should emerge. Regardless of training or domain, subordinate senses should take longer to retrieve than dominant senses. If Hypothesis 2 is correct, domain-specific training effects should emerge. Chess words should show a chess training effect; chess senses should be easier and dominant senses harder to retrieve in the chess training condition than in the control condition. Card words should show a card training effect; card senses should be easier and dominant senses harder to retrieve in the card training than in the control condition.

Since there is evidence that Training interacts with Primacy, and with Domain and Primacy, it is unlikely that Hypothesis 1 will be supported. However, finer analysis is necessary to determine if there is evidence supporting Hypothesis 2. Just as the investigation of Hypothesis 1 explored the effects of Primacy within levels of Training and Domain, investigating Hypothesis 2, which is a Training hypothesis, requires exploring the effects of Training within levels of Domain and Primacy.

4.3.1 Training Effects Within Chess Words

The card training group retrieved the dominant senses 400 ms faster than the control group, t1 (37) = 2.51, p < .02; t2 (50) = 1.79, p > .05. Card training facilitated the search for dominant meanings of chess words. Chess training provided the greater facilitation of 700 ms; t1 (37) = 3.65, p < .001; t2 (50) = 3.63, p < .001. No significant difference was found between card and chess training means; t1 (37) = 1.19, p > .05; t2 (50) = 1.91, p > .05.

Little effect of training of either kind was found on the search for chess senses. Compared with the control group, card training was associated with a rise of 0 (subjects) to 500 (items) ms; t1 (37) = .20, p > .05; t2 (50) = -2.73, p < .01. The chess training group found the chess sense 100 to 300 ms faster than the control group, one-tailed t1 (37) = 1.86, p < 05; one-tailed t2 (63) = .55, p > .05. The difference between chess and card training was significant; t1 (37) = 1.73, p > .05; t2 (50) = 3.41, p < .01. After chess training, subjects found chess senses in about 1000 ms. After card training, they found chess senses in 1300 to 1600 ms. Though chess trained subjects found chess senses 300 to 600 ms more quickly than card trained subjects, their locating of the chess senses did not significantly differ from the control group.

For the chess training group, following the presentation of the dominant sense of a chess word, the chess meaning was found 22 to 26 percent more often than in the control condition, one-tailed t1 (37) = 1.83, p < .05; one-tailed t2 (63) = 1.88, p < .05. Subjects trained in cards did not differ significantly from the control group; t1 (37) = .63, p > .05; t2 (63) = .42, p > .05. As well, responses for the chess training group did not significantly differ from the card training group; t1 (37) = 2.01, p > .05; t2 (63) = .92, p > .05. Generally, chess trained subjects failed to locate chess senses 26 percent of the time whereas card trained subjects failed to locate chess senses 38 to 46 percent of the time.

For the chess training group, following the presentation of a chess (subordinate) sense, another meaning was found 15 to 23 percent less often, (t1 (37) = -2.27, p < .05; t2 (63) = -1.06, p > .05). After chess training, subjects were less likely to locate an alternative meaning, when given the chess meaning, and more likely to find the chess meaning when given the non-chess meaning. Subjects trained in cards showed a 5 percent increase in the failure to locate the dominant senses of chess words; t1 (37) = -.6, p > .05; t2 (63) = -.33, p > .05. Generally, chess trained subjects failed to locate dominant senses 40 to 48 percent of the time with card trained subjects failing 30 percent of the time. This was not a significant contrast; t1 (37) = 1.67, p > .05; t2 (63) = .77, p > .05.

Chess trained subjects searching for dominant senses produced a lower d' than the control group; t1 (37) = 2.42, p < .05; t2 (63) = .72, p > .05, and a higher d' when searching for chess senses (one-tailed t1 (37) = -.74, p > .05; one-tailed t2 (63) = -1.65, p > .05). Comparing control and card training conditions for chess senses (t1 (37) = -.08, p > .05; t2 (63) = -.07, p > .05) and for dominant senses (t1 (37) = 1.29, p > .05; t2 (63) = -.24, p > .05) and comparing card and chess training groups, for chess senses (t1 (37) = .68, p > .05; t2 (63) = 1.78, p > .05) and for dominant senses (t1 (37) = -1.17, p > .05; t2 (63) = -1.00, p > .05) revealed no significant differences.

4.3.2 Training Effects Within Card Words

The card training group found dominant senses 500 to 600 ms faster than the control group, t1 (37) = 3.06, p < .01; t2 (50) = 2.69, p < .01. The chess training group found the dominant sense 400 to 600 ms faster than the control group, t1 (37) = 2.22, p < .05; t2 (50) = 2.80, p < .01. Generally, either card or chess training had the effect of significantly reducing response times following subordinate senses while leaving measures following dominant senses unchanged. No significant differences were found between card and chess training were found; t1 (37) = .87, p > .05; t2 (50) = -.12, p > .05.

All search times for card senses fell within a 100 ms range. There were no significant differences among the three groups; between card training and control (one-tailed t1 (37) = .56, p > .05; one-tailed t2 (63) = .09, p > .05); between chess training and control (t1 (37) = .06, p > .05; t2 (63) = .6, p > .05); between card and chess training (t1 (37) =

.42, $p > .05$; t2 (63) = -.45, $p > .05$).

Planned comparisons revealed that when the card training group was given the dominant sense of card words, they found the card sense 20 to 22 percent more often than the control group; one-tailed t1 (37) = 2.18, $p < .025$; one-tailed t2 (63) = 1.39, $p > .05$. Whereas the control group found the card sense 64 to 69 percent of the time, the card training group found the card sense 86 to 89 percent of the time. No significant difference was found between the control and the chess training group in the search for card senses (t1 (37) = .76, $p > .05$; t2 (63) = -.08, $p > .05$). As well, no difference was found between chess and card training groups (t1 (37) = 1.43, $p > .05$; t2 (63) = 1.56, $p > .05$).

No significant differences among the three groups were found in the search for dominant meanings; between card training and control (t1 (37) = -.48, $p > .05$; t2 (63) = .13, $p > .05$); between chess training and control (t1 (37) = .48, $p > .05$; t2 (63) = .36, $p > .05$); between card and chess training (t1 (37) = .95, $p > .05$; t2 (63) = .37, $p > .05$).

In the search for card senses, no d' differences among the groups was found; between card training and control (one-tailed t1 (37) = -.89, $p > .05$; one-tailed t2 (63) = -1.32, $p > .05$); between chess training and control (t1 (37) = -.84, $p > .05$; t2 (63) = .12, $p > .05$); between card and chess training (t1 (37) = .92, $p > .05$; t2 (63) = 1.37, $p > .05$).

In the search for dominant senses, no significant differences were found; between card training and control (t1 (37) = 1.37, $p > .05$; t2 (63) = -.07, $p > .05$); between chess training and control (t1 (37) = .27, $p > .05$; t2 (63) = .36, $p > .05$); between card and chess training (t1 (37) = 1.13, $p > .05$; t2 (63) = -.45, $p > .05$).

4.3.3 Discussion

In reference to the response times, the only substantial effect is that the training conditions significantly reduced the response times following the sentences biased toward the secondary meaning by about 500 ms (the Training by Primacy interaction).

When examined by domain, it was found that for both card and chess words, card or chess training significantly shortened the search times for dominant senses. Either kind of training facilitated the search for dominant senses. Card training appeared to inhibit the search for chess senses. Chess training did not inhibit the search for chess senses, nor did either kind of training influence the processing of card senses. These results do not provide evidence interpretable in terms of Hypotheses 1 or 2.

In the examination of the proportion of misses in the control condition, it was found that subjects were less likely to locate another meaning when given the dominant meaning for a word. This was true for both chess and card words (refer to Figures 3 and 4).

In general, for each training condition, correct responses to the appropriate words were affected, but responses to inappropriate words were not. In other words, chess training affected the responses to chess words but did not change the response pattern to card words. This appears to be evidence in support of Hypothesis 2.

Chess trained subjects found chess senses more often, and card trained subjects found card senses more often. As well, chess trained subjects found the dominant senses of chess words less often but card training did not affect the locating of the dominant senses of card words. Chess training did not affect any responses to card words nor did card training affect responses to chess words. Neither training condition provided evidence for any significant effect on inappropriate items. All measures for both subjects and items remained within eight percent of the control condition measures.

The proportion of misses data indicate that training selectively affected the processing of associated meanings. In comparison with the control group, card training reduced the failure to locate card senses with a slight (insignificant) rise in the failure to locate dominant meanings of card words. Chess training not only increased the ability to locate chess senses, but actually decreased the likelihood of locating alternative senses for word biased toward their chess meanings. Chess training had no effect on card words and card training had no effect on chess words.

4.4 Domain Differences

Indicative of a difference between chess and card words, a substantial Domain effect was recorded in both the miss proportion ANOVA, F1 (1,37) = 20.867, p = .0001; F2 (1,63) = 5.259, p = .0252; min F' (1,89) = 4.200, p < .05, and in the d' ANOVA, F1 (1,37) = 21.498, p = .0000; F2 (1,63) = 3.459, p = .0676; min F' (1,81) = 2.980, p < .1. In other words, responses to card words were significantly different from responses to chess words. In comparison with chess words, card words are associated with higher discriminability and a lower miss rate. This domain difference did not extend to response times. As no specific predictions are involved, *all t-tests reported in this section are two-tailed.*

4.4.1 Domain Effect Within the Control Group

Contrasting Domain in the search time for dominant meanings found t1 (37) = 1.22, p > .05, and t2 (50) = .53, p > .05. While the dominant senses of chess words took 1700 ms to find, the dominant senses of card words took 1500 to 1600 ms. Subordinate senses did not show a Domain contrast; both chess and card senses took about 1200 ms to find (t1 (37) = .59, p > .05; t2 (63) = -.75, p > .05).

Though no significance was found in the contrast, the failure to find dominant meanings was 17 to 24 percent for card words and 25 percent for chess words (t1 (37) = .83, p > .05; t2 (63) = .76, p > .05). The failure to find subordinate meanings was 31 to 36 percent for card senses and 44 to 52 percent for chess senses (t1 (37) = .83, p > .05, t2 (63) = 1.51, p > .05). Chess senses were harder to find than card senses.

No significant differences were found in the d' data. However, a pattern consistent with the misses report was present. Chess word d's were lower than their corresponding card word d's; for dominant meanings, t1 (37) = 1.5, p > .05; t2 (63) = .20, p > .05; for subordinate meanings, t1 (37) = 1.86, p > .05; t2 (63) = 1.03, p > .05.

4.4.2 Domain Effect Within Chess Training

Chess trained subjects showed few differences. All measures, whether dominant or subordinate, whether chess or card words, fell between 1000 and 1200 ms; for dominant senses, t1 (37) = -.06, p > .05; t2 (63) = -.38, p > .05; for subordinate senses, t1 (37) = -1.13, p > .05; t2 (63) = -.73, p > .05.

A significant difference was found in comparing the failure rate for dominant senses of card words (12 to 19 percent) and the dominant senses of chess words (40 to 48 percent); t1 (37) = 3.58, p < .001; t2 (63) = 1.59, p > .05. Comparing the subordinate sense means found a 29 to 32 percent failure rate for card words compared with a 26 percent failure rate for chess senses (t1 (37) = -.24, p > .05; t2 (63) = -.46, p > .05).

Corresponding to the dominant miss rate contrast, a dominant d' of significance was found, by subjects; t1 (37) = -3.27, p < .01; t2 (63) = -.59, p > .05. For subordinate senses, the values were t1 (37) = .33, p > .05; t2 (63) = .16, p > .05.

4.4.3 Domain Effect Within Card Training

Differences were found in the search time for subordinate senses by the card trained group; t1 (37) = 1.01, p > .05; t2 (50) = 2.23, p < .05. Whereas subjects found chess senses in 1300 to 1600 ms, they found card senses in 1100 to 1200 ms. Dominant meaning search times of 900 to 1100 ms for card words contrast with 1300 to 1400 ms for chess words (t1 (37) = 1.89, p > .05; t2 (50) = 1.50, p > .05). In each contrast for this group, the chess response time is higher than the card response time.

A significant difference was found in contrasting the failure to find chess senses (38 to 46 percent) with the failure to find card senses (11 to 14 percent); t1 (37) = 3.58, p < .001; t2 (63) = 1.59, p > .05. Failures to find the dominant meaning of chess words, 30 to

31 percent, contrasted with a 21 to 24 percent failure rate associated with card words ($t1$ (37) = .95, $p > .05$; $t2$ (63) = .45, $p > .05$). In each case, chess measures were higher than card measures.

Correspondingly, a significant d' comparison of subordinate senses was found; $t1$ (37) = 2.13, $p < .05$; $t2$ (63) = 2.88, $p < .01$; for dominant senses, $t1$ (37) = .97, $p > .05$; $t2$ (63) = .04, $p > .05$. All d's for chess words were smaller than those for card words.

4.4.4 Discussion

Though few significant contrasts were found, response times to chess words generally took longer than response times to card words. Failures to locate chess words were higher than failures to locate card words.

4.5 General Discussion

Hypothesis 1 predicted that subjects would find the dominant meaning easier to retrieve than the subordinate meaning. The combined data for the control group suggest that subordinate meanings are more difficult to retrieve but, if retrieved at all, are retrieved more quickly than dominant meanings. Conversely, dominant meanings are retrieved more often, yet take take longer to retrieve than their subordinate counterparts. The most likely answer to this pattern appears to be a speed-accuracy tradeoff (compare Figures 1 and 2). Subjects were correct more often when they took longer to respond. This happened after being primed for a subordinate sense. When presented with a dominant sense, subjects tended to respond rapidly and with much less precision. In the control condition, subordinate senses took 1259 ms to find but the failure rate was over forty percent. Dominant senses took 1594 ms to find and the failure rate was about twenty percent. The results indicate that, on the average, the slower subjects responded, the more likely they were to find the other meaning. No similar pattern was evident in the training conditions.

A speed-accuracy tradeoff is one explanation for the results in the control condition. In order to address the possibility of such a tradeoff, the Session 2 results for the control condition are required. Though all data beyond the first session are of little use for the exploration of the effects of the training (because training conditions are added), the control condition results may be used. Since no addition of training effects occurred in this condition, the only difference between Session 2 and Session 1 is that Session 2 represents the second 24 sentences the subjects are exposed to. When Figures 1 and 2 are examined, the speed-accuracy tradeoff explanation loses credibility. Were there simply a tradeoff, the 300 ms reduction in mean response times following the presentation of a subordinate sense would be accompanied by an increase in errors. As well, the 15 percent reduction in errors following the presentation of a dominant sense would be accompanied by an increase in mean response times. Neither of these occurred. Therefore, a speed-accuracy tradeoff is an unlikely explanation for the pattern of results.

What then can explain the longer response times following the presentation of subordinate senses? The Ordered Search model predicts the opposite: Response times following subordinate senses should be shorter than those following dominant senses. The dominant sense should take less time to locate than the subordinate sense. The Selective Access model predicts that if the sentence contexts are comparable, then there should be little difference between response times following dominant and subordinate senses. Whether or not the Exhaustive Computation Model is valid, evidence for that model would have vanished by this point in processing. As previously mentioned, multiple activation evidence is located within the first 200 ms of response time (Tanenhaus, Leiman & Seidenberg, 1979). None of the discussed processing models predict that dominant senses should take longer to find than subordinate senses.

One possibility is that there might be some inherent difference between "game" and "non-game" sentences. Since game sentences are designed to bias targets toward their subordinate senses, it might be expected that game contexts might be stronger than non-game contexts. Thus it could be that for game sentences, the highly restricted context could make the alternative sense more difficult to retrieve even if that sense were the dominant meaning. However, if the sentences are examined (Appendix 1), it is seen that though game sentences are more likely to have direct lexical associates of the targets in the preceding contexts, in most cases, both game and non-game sentence contexts are restrictive enough to ensure only one possible meaning. In fact, if any sentences allow more than one possible meaning, they tend to be game sentences such as "He lead with a high HEART" or "The face cards were all in one SUIT."

If, as Seidenberg et al. (1982) suggest, that selective access effects appear when a word related to the target occurs in the sentence, this might explain the longer response times following game sentences. If game sentences elicit selective access, the longer search times for dominant senses may be the result of inhibition generated by the selection. Since the non-game sentences are less likely to have preceding associates to the targets, and thus be less likely to produce selective access, inhibition is less likely to occur, and therefore it would be easier to locate the subordinate sense. However, as will be discussed, this explanation does not hold for the pattern of errors.

An examination of the training conditions shows that, the response times following subordinately biased words are shorter than in the control condition. This change has the effect of eliminating the differences between dominant and subordinate sense response times. In the terms of this paradigm, search times for a dominant sense are shorter following training than otherwise.

This pattern of results is difficult to explain. If training or context have any effect, that effect should be to make those senses that are appropriate to the training more accessible. If training or context have no effect, subordinate senses should be followed by longer response times than the dominant senses. The results appear to indicate that training did not affect related items but somehow made dominant (unrelated) senses more readily accessible. There was no change in the search times for subordinate or related senses.

There is another possibility. The search for dominant senses took longer but had a lower failure rate. The search for subordinate senses did not take as long but was less likely to be successful. Given the Ordered Search model, when given a subordinate bias, retrieving the subordinate meaning entails having accessed and rejected the dominant meaning. The system might "know" of the existence of another meaning and therefore allocate a longer search time. On the other hand, a dominant bias would cause the access and retrieval of the dominant meaning alone. The system would not "know" of another meaning so less time would be allocated to this possibly futile quest.

Can this explanation be applied to the training conditions? Training could have the effect of seeming to shorten the search time for the dominant by facilitating the search for the subordinate meaning. In the control condition, the search for the subordinate sense required the access of the dominant and then the access and retrieval of the subordinate. If there is not only a specific but also a general game effect of training, training could make the subordinate sense more accessible, and thereby shorten the time for retrieving that meaning thus shortening the overall task time. However, even though under this model, retrieving the dominant does not require accessing the subordinate, the actual search for the subordinate sense should be facilitated and therefore lower the search time as well, which it doesn't appear to. Therefore, this explanation is inadequate.

Recall that Hogaboam & Perfetti (1975) considered the Ordered Search model to be context free. Not only do the search times differ from the control to the training conditions, neither of the patterns are agreeable to the Ordered Search model. If Ordered

Search is as postulated, dominant meanings should take less time.

As with the control condition, the training condition results do not correspond to any of the predictions of the discussed models, nor do they correspond to explanations associated with a context effect. There is a training effect. Training reduced the responses times following subordinate items. A major aspect of the problem is that both chess and card training affected chess and card words. If such undifferentiated effects occurred in the proportion of misses results as well one could postulate a general game effect. If the control group is not considered, the results from the training groups appear to be supportive of Selective Access. However, no such pattern arises from the misses data.

Only the miss data provide any evidence in support of a primacy component in the search procedure. In the control condition, failures to find the subordinate senses outnumbered failures to find the dominant senses. The miss proportion results are much easier to interpret in terms of the given models. The Ordered Search model provides the simplest explanation. Subordinate senses were less accessible than dominant senses. In comparison to the control condition, in the card training condition, the card senses were easier to find but, no difference was found in the retrieval of the dominant alternative senses. In contrast to the control condition, chess training increased the ability to find the chess senses and decreased the ability to find other meanings of chess terms. The stronger results for chess might be traceable to the fact that the cards domain covers a variety of games (for example; poker, bridge, cribbage) whereas the chess domain is composed of chess alone. Though chess is a less popular domain, it is a more restricted one.

The most likely explanation of these results is that the existence of a strong context has increased the capability of finding related meanings and to a lesser degree decreased the capability of finding alternative (and dominant) meanings of related items. Clearly, this training effect contradicts the context-free claim of Hogaboam &

Perfetti (1975). The results appear to support Simpson (1981) in that primacy is the strongest factor in conditions of weak or neutral bias, whereas in conditions of strong bias, selective access is found.

It should be noted that Simpson's results derive from response times and not error rates. As well, Simpson's definition of bias is sentence context and not a more elaborated context such as in these training conditions. As previously discussed, the sentence sets do not appear to differ greatly in terms of bias strength so the contrast must derive from the training conditions. The training conditions combine with the training related sentences to create strong bias conditions which then interfere with the ability to locate alternative meanings.

For example, chess training combines with a chess sentence to strengthen the bias toward the last word as a chess term. This increased bias produced a net selective retrieval effect. Other meanings became easier to miss. Also, chess training bias competes with a non-chess sentence bias to make other (chess) meanings easier to find. This training bias has no effect on card sentences or non-card sentences. Those sentences behave as they did in the control condition, that is, as if dominance relations determined the order of access.

Perhaps in light of results from Simpson & Burgess (1985), a more appropriate explanation can be derived. In studies varying the stimulus onset asynchrony, multiple activation was found with the rapid selection of one meaning taking place at under 200 ms. The latencies recorded in this study are much higher. Simpson & Burgess found that for dominant senses, activation remained high beyond 750 ms whereas with subordinate senses, activation waned after 300 ms. They concluded that though all senses were initially activated, the activation of dominant senses was faster, and the focus of attention on the more frequent sense caused activation to remain longer than with subordinate senses. If this is the case, in the present study, when at 1000 ms or so, subjects are making their responses, the dominant sense is still active. The subordinate sense is not. So given a subordinate sense, the subject can find the other sense easily. Given a dominant sense, the subordinate sense is difficult to locate. Following training, related items are highly activated. These items become the dominant senses. Their activation is not only more rapid but longer lasting than the previously dominant senses. This activation not only makes them easier to locate but draws attention from the other sense making it more difficult to locate. It is difficult to determine from this design whether context has its effect by 'overriding' primacy effects or by changing primacy relations.

In conclusion, the presence of a strong context made related items more retrievable and unrelated items less retrievable. Evidence in support of Hypothesis 1 emerged in the control condition. Dominant senses appeared to be more retrievable than subordinate senses. The training conditions produced evidence in support of Hypothesis 2. A global context made related senses more retrievable. All this evidence was gathered from the pattern of misses analyses. Analyses of the search times did not correspond to any of the known model nor was a satisfactory explanation discovered.

5. CONCLUSIONS

5.1. Summary of the Results of the Experiment

The purpose of this study was to explore the effects of context within the framework of the Ordered Search model, and the experimental paradigm of Hogaboam & Perfetti (1975). The results indicated that training increased the ability to find relevant meanings and decreased the ability to find other meanings. The fact that context or training affected the pattern of responses provided evidence that dominance relations are not immune to the effects of global context. Findings from the control group showed that dominant meanings were more retrievable than subordinate meanings. However, when subjects performed the same task within an elaborate context, previously subordinate meanings were more readily retrieved. Thus, these results argue against Hogaboam & Perfetti's claim that ordered search operates independently of context.

These results and conclusions are derived primarily from an analysis of the proportion of errors. The response time results corresponded to none of the discussed models. Assuming that response times reflected search times, the measures indicated that subordinate senses were more accessible than dominant senses. When subjects performed the same task within a context, the search for dominant senses seemed to be facilitated. It is not clear what these results represent. A number of possible explanations were considered but none proved satisfactory. Sentence sets were examined for possible item confoundings, but no evidence for this was found. Other possibilities were considered but none proved to be satisfactory.

There are a number of reasons that the error analysis can be emphasized over the response time analysis. The proportion of misses results are coherent with access models and response time results are not. No rational explanation for the response time results is apparent. The time constraints combined with the forced choice design, and the explicit suggestion to decide quickly, may have increased the incidence of errors.

In a sense, rather than asking the question "can you find another meaning?," this design asked the question "can you find another meaning quickly?." Error rates were high. Given that empty cells required the loss of some subjects for the response time ANOVA, the error analysis represented a greater number of responses. In summary, the error data represent a greater number of responses, are coherent with previous analyses, and reflect specific aspects of the design. Given the lack of fit between the latency and error analyses, it appears that the response times are not measuring the same aspects of the sense retrieval procedure as the error analysis.

Though these results appear to be in disagreement with previous studies, it is not the data that disagree, but the various interpretations of what is meant by context. This study found a context effect which may have been absent from previous studies simply because a global context was absent as well. It is suggested that the present design, and, by extension, the findings, are more indicative of typical discourse situations than those of many other studies precisely because of this difference in contexts.

5.2 Implications for Further Research

This study indicated that subordinate meanings are more difficult to retrieve than dominant meanings, and that training can facilitate the retrieval of related subordinate senses, and to a lesser degree, inhibit the retrieval of unrelated dominant senses.

The pattern of results also indicated that, with this particular design, the effect of dominance and its interaction with training was more effectively demonstrated through an analysis of the failure rate rather than by gathering response times.

The design of this study intended to achieve greater power of generality by using two domains. Though generality was achieved, a more productive design might be one with a single domain being tested and varying training and subject groups. If chess was the domain being tested, weak and strong training conditions could be contrasted with no training, and non-player and strong-player subject groups could be contrasted. At this point, it might be preferable to concentrate on the effects of a context in detail rather than the differences among contexts. As well, occasions of difficult data, as in the response time data in this work, might be more effectively tracked with a single context design.

Alternatively, the discovered Domain effect might indicate another direction to pursue. Differences between chess and card domains were found. This suggests that rather than there being a 'domain' effect, there might be many different kinds of domain effects. In this case, chess as a more restricted domain had a strong and focused effect whereas cards as a more diffuse domain had a weaker effect and lacked the inhibitive power that chess exhibited. It might be profitable to contrast domains. The nature of the domain effect might indicate something about the structure of the domain itself.

One particular weakness of this design is that it is difficult for the experimenter to know if the subject is locating the desired meaning. Hogaboam & Perfetti surmounted this by having subjects use the sense in a sentence. In this study, it was feared that such a task would not only further complicate a complicated procedure, but would strengthen awareness of the game items independently of the training conditions. However, it might be advantageous to eliminate this source of uncertainty in future studies.

Another source of uncertainty is simply the number and complexity of studies that must be theoretically accommodated. As Simpson (1984) summarizes, "...the results [to date] seem better served by a model that proposes some activation of all meaning,' but allows the relative degree of activation to vary. The research suggests that the factors to which the activation levels are sensitive include the frequency of the meanings and the strength of the context...type of context...time available to process the context...A model of such flexibility in fact seems to render virtually meaningless the rigid distinctions previously drawn between the three models. Access may indeed be exhaustive in that more than one meaning is activated but to the extent that the level of activation may vary, access appears to be context and frequency sensitive as well" (p. 326).

5.3 Conclusion

This study has shown limited support for a primacy component in the access of meaning. Dominant meanings were easier to find in conditions of sentential context alone, but global or training context influenced the finding of related meanings.

Table 1 — Mean Search Response Times in Milliseconds

	CARD WORD		CHESS WORD	
	Subordinate	Dominant	Subordinate	Dominant
CARDS TRAINING				
subjects	1106	940	1278	1262
items	1194	1070	1626	1361
CHESS TRAINING				
subjects	1177	1088	984	1060
items	1104	1047	966	992
NO TRAINING				
subjects	1205	1482	1313	1707
items	1232	1611	1076	1722

procedure. This priming within the lexicon or "intralexical priming" has been used in other studies as well to explain facilitative effects without having to postulate contextual influences on the access procedure. This concept is dealt with more fully under Section 2.5.1.

With a similar syntactic contextual design, using time delays of 0, 200, and 600 ms, Tanenhaus, Leiman & Siedenberg (1979) found that multiple readings were available at the time of access. By 200 ms, only facilitation to the biased reading occurred. As in the previous studies, these results were interpreted to mean that multiple readings are initially available, but inappropriate readings are rapidly suppressed.

Studies in support of multiple access have been criticized on the basis that the designs may not have allowed integration of the preceding contexts prior to the processing of the critical word. In response to this, Tanenhaus and Donnenwerth-Nolan (1984) inserted a pause of about 400 ms by having the critical (ambiguous) word mouthed before its presentation. This, presumably, would allow for integration. As well, they made sure that the syntactic contexts were truly restrictive. Yet, multiple access effects were still obtained. Since all the cited experiments employ cross modal tasks, the evidence may be confounded due to Koriat's (1981) backward priming. If backward priming occurred, then it is possible that all readings at 0 ms reflect the effects of backward priming rather than the effects of multiple activation. That is, the targets selectively prime the ambiguous words.

2.4 The Ordered Search Model

2.4.1 Introduction

According to the Ordered Search model, a language user accesses meanings in descending order of dominance until the proper meaning is reached at which time the procedure terminates. The supporters of this model include Forster & Bednall (1976), Hogaboam & Perfetti (1975), Simpson (1981) and Simpson & Burgess (1985). This model suggests that meanings are ordered in terms of frequency of usage (relative dominance), and will always be accessed in that order regardless of context. Consequently, lexical ambiguity increases processing difficulty only when the subordinate meanings are being retrieved.

2.4.2 Hogaboam & Perfetti

In 1975, Hogaboam and Perfetti asked 24 subjects to listen to a number of sentences and after each sentence to decide whether the last word of the sentence was ambiguous or not. Hogaboam and Perfetti constructed 48 sentences which ended in ambiguous words. These words possessed either high or low printed frequency. As well, the words differed on whether their primary meaning was highly dominant, or whether the difference between the primary and secondary meanings was marginal.

Using Kucera & Francis (1967), high frequency words were defined as those having a printed frequency count between 121 and 376 per million; low frequency words were defined as those having a count between 1 and 34 per million. Dominance was determined by the percentage of subjects in a normative task who produced an association related to that sense when given the word in isolation. All words chosen had only two distinct meanings. A high dominance word was one that had an association of .71 or higher whereas a low dominance word had an associative value of .65 or lower.

Finally, these words were biased toward their primary or a secondary meaning by the sentences they occurred in. From these sentences two lists were formed. All qualities were fully crossed. For instance, list one contained "The tired hiker rested his

FEET" and "The investor's money earned INTEREST" and list two contained "The building's dimensions were measured in FEET" and "The anti-pollution campaign created INTEREST." The two lists together would form one replication. Each list contained the same composition of high frequency, low frequency, high dominance, and low dominance words. Each list was then compiled with 24 control sentences and then randomized. Since each subject would have only one list, no subject would hear both instances of any word. The sentences were recorded on one channel of a tape recorder. The second channel was used for a signal which coincided with the end of the sentence which started a timer.

In the task itself, the presentation of the sentences was auditory. Subjects were to listen to the sentence and then to press a key if the word had another meaning, and, if the word was ambiguous, to illustrate the other meaning either by using it in a sentence or by giving a definition of the word. If the word was not perceived as ambiguous, the subjects were to wait for the next sentence. The depression of the key stopped the timer. There was a fifteen second latency between sentences. Response times were recorded from the offset of the last word in the sentence.

After rejecting four subjects, the data were drawn from the remaining pool of twenty. For six of the subjects, measurements to some of the sentences were missing. These measures were estimated. All response times were transformed to speed scores; they were inverted. Misses composed about ten percent of the data. In these cases a fifteen second latency was recorded.

In the initial analysis, misses were included. This was considered reasonable since the fifteen second latency was believed to be an underestimate of the actual decision times. A second analysis was run with only hits to make certain that the pattern of results was not due to the influence of the misses. Hogaboam & Perfetti used a six factor analysis of variance; the six factors were sense (primary or secondary), dominance (high or low), tape, replications, and words (six words nested in each dominance by printed frequency combination). The F' (quasi F) statistic was used for the fixed factors and their interactions.

The analysis found that when a word was presented in its secondary sense, that it tok less time to find another meaning than when presented in its dominant sense (p = .002; for hits alone, p = .014). Hogaboam & Perfetti did not report the actual response times, but they included a figure representing the reciprocal latencies. This particular finding was buttressed by the result that there were more misses when a word was presented in its dominant sense than in the alternative case (p = .002). A significant sense by dominance interaction (p = .007; for hits alone, p = .012) showed that though for low dominance words reactions times following the two senses showed no difference, for high dominance words, responses following presentations of the secondary sense were significantly shorter than responses following presentations of the primary sense. That is, for words where the primary sense was greatly dominant over the secondary sense, the primary sense was much easier to retrieve than the secondary sense.

Though the first analysis found a significant main effect for words and a words by sense interaction, the hits only analysis did not. While in the first analysis, printed frequency was not significant (p = .13), in the hits only analysis, marginal significance was obtained (p = .049). All other effects failed to reach significance.

All in all, these results indicated that the primary sense was easier to access than the secondary sense. Printed frequency appears to have been a lesser factor than whether the sense was dominant or not. Thus, as Hogaboam and Perfetti argued, since subjects were able to retrieve the primary sense quite easily when given the secondary sense, and since subjects found the secondary sense more difficult to retrieve when given the primary sense, the secondary sense must be less accessible. Such a situation could be modeled most succinctly through an ordered search strat

In summary, Hogaboam & Perfetti argue that when presented with a polysemous word, the dominant meaning is the first meaning available to the language user. If that is not the appropriate meaning, then the next most prominent meaning of that word is accessed. This procedure is quite efficient since in most cases the dominant meaning is the right meaning.

2.4.3 Other Ordered Search Studies

Two studies directly concerned with the Hogaboam & Perfetti design suggested that the constant end-of-sentence position of the target might encourage special strategies. In a visual study, Holmes (1979) replicated Hogaboam & Perfetti, procured the same results and buttressed them with a word sentence classification task. Holmes varied the sentence context so that both prior and subsequent context effects were tested. Holmes did however diverge from pure replication in that the presentation was visual and that the subjects were asked to decide whether the sentence contained an ambiguous word.

Holmes found that when the dominant sense was employed, detection of the ambiguous word took longer and subjects were more likely to fail to detect the ambiguity at all. He also found shorter comprehension times for sentences using the more frequent sense of the word. An example of a sentence using the dominant sense is "The botanist inspected the PLANT thoughtfully" as contrasted with "The foreman inspected the PLANT thoughtfully" for an example of a sentence using the secondary sense.

Holmes also determined that the frequency effect was confined to sentences containing ambiguous words. The same effect was minimal in sentences containing unambiguous words of the same frequency levels as in the test sentences. This implied that longer detection times for sentences biased for the subordinate sense of the ambiguous word reflected more than just longer search times for infrequent meanings.

Thus, the processing of the subordinate senses might entail accessing the dominant meanings first. Since the longer times did not occur with sentences biased toward the dominant senses, this would support the Ordered Search Hypothesis. The fact that dominant-sense sentences were comprehended more quickly than subordinate-sense sentences would indicate the same. If the dominant sense was appropriate no further access was required.

Onifer & Swinney (1981) used an aural presentation with the simultaneous visual presentation of a word on a screen. At 0 ms, they found facilitation to both meanings of the critical word. However, at 1500 ms following the ambiguity, only facilitation to the relevant sense was in evidence. Yet, it could be argued that not only does the use of the cross modal task call the multiple access results into question, but the 1500 ms delay could have been long enough to eradicate any trace of an ordering factor. They concluded that "...postaccess process operates to evaluate accessed entries in terms of frequency of meaning and contextual information...but that the effects of context rapidly overwhelm any bias provided by relative frequency of meaning."

To quote Onifer & Swinney's criticisms of Hogaboam & Perfetti, "...the verbal report or analysis of the listener to the nature of the material he heard is typically not a direct reflection of the series of unconscious (and, in most cases, automatic, non-interruptible) stages involved in the access process.." (p. 225-6). And "...it seems possible that it is only at a point long following lexical access that the operations reflected in Hogaboam & Perfetti's (1975) data take place...In addition, because place of occurrence of the target ambiguity was always predictable in these experiments, specialized task performance strategies may have been at least partially responsible for the results." (p. 227).

Though Onifer & Swinney offer several strong arguments, the consistent results of Hogaboam & Perfetti (subordinate senses always took longer to retrieve than the dominant senses) indicate that the ambiguity detection task adequately reflects a primacy influenced mechanism at some point in the retrieval procedure. It is quite possible that initial multiple activation takes place followed by a dominance ordering. The differing methodologies may be tapping different stages of a sequential two or three step procedure.

Simpson (1981) agrees with the Ordered Search model, but not in the context-free claim. He had subjects make lexical decisions to visually presented words (or nonwords) after being presented with recorded sentences. Given the dominant target of NUMBER and subordinate target of DUKE, an example of a strong bias sentence for the dominant sense is "My dog wasn't included in the final COUNT" and for the subordinate sense "The vampire was disguised as a handsome COUNT." For weak or intermediate bias, the example for the dominant sense is "The musician kept losing the COUNT" and for the subordinate sense "The king kept losing track of the COUNT." For the neutral bias, the example sentence is "We had trouble keeping track of the COUNT." Under strong preceding bias, he found facilitation to only the relevant senses. In intermediate bias conditions, he found that words biased toward their secondary sense would facilitate responses to both meanings, but words biased toward their primary sense would facilitate responses to a primary sense alone. Given a neutral context or no context at all, Simpson found that dominant meanings were facilitated more strongly than subordinate meanings. He argued for the independent contributions of context and primacy.

Simpson & Burgess (1985) used an isolated word study in which subjects made lexical decisions about words that were related to the dominant or subordinate meaning of an ambiguous word. Critical words and targets were visually presented. Through varying the stimulus onset asynchrony, they gathered results indicating initial multiple access, but with activation building faster for the dominant meanings. They found that for the subordinate meanings, facilitation was negligible at 16 ms building to an apex at 300 ms and then falling to nothing by 750 ms. This seems to indicate a slow rise (the dominant meaning facilitation was immediately high) and subsequent inhibition. For dominant meanings, facilitation was immediately high at 16 ms rising to an apex at 100 ms and then falling slightly but still quite high at 750 ms. Unlike the subordinate meanings, dominant meanings did not appear to be subject to inhibition. This appears to indicate a system geared toward rapid processing of dominant meanings. They also found that they could not get subjects to adopt a strategy favoring subordinate meanings. When given a set of items in which eighty percent of the senses were subordinate, a condition in which the appropriate strategy would be to allocate attention to the subordinate sense, the same pattern of results was obtained.

Simpson & Burgess suggested that primacy was doubly implicated in their results. Though all meanings were initially accessed, the rate of access was faster for the dominant meaning. In a later stage, attention was focused on the dominant meaning and subordinate meanings were inhibited.

These results are in conflict with Tanenhaus, Lieman and Seidenberg (1979) who after a 200 ms delay found facilitation only to the appropriate sense. The disagreement may arise from the fact that Tanenhaus et al. used sentences as compared with Simpson & Burgess who used isolated words. It could be that a sentence context is strong enough to emphasize post decision inhibitory processes.

2.5 General Issues

2.5.1 The Problem of Context

The cited experiments limit context to sentence context. However, it is questionable whether an isolated string is strong enough to elicit anything other than the weakest of associations. Seidenberg et al. (1982) found that the sentence context produces selective effects only when a word related to the target actually appeared in the sentence. Kinoshita (1985) also found a lack of sentence context on access stating that "...lexical access is unaffected by sentence context, and that the only effect of sentence context is to temporarily suspend further processing of an entry that is semantically incongruous with it." (p. 590). The instantiation of a domain of activity or a discourse theme is much more likely to elicit true context effects as well as more closely simulate real language use.

Frauenfelder and Tyler (1987) make the distinction between "semantic" and "interpretive" contexts. Semantic context refers to information derived from word meanings (associative priming) and syntactic structure. Interpretive context refers to information derived from discourse context and world knowledge. Seidenberg et al. (1982) draw a similar distinction between lexical-priming and nonpriming contexts. As well, they point out that much previous work is difficult to evaluate due to the mixing of the two types of context. In a differential effects task study, Seidenberg, Waters, Sanders & Langer (1984) found that associative priming affected the lexical level and contextual (interpretive) priming the post-lexical level.

In a series of experiments examining the scope of various priming effects, Seidenberg et al. found that facilitative effects due to syntactic relations between words, backward associations, or changes in the proportion of related items, occurred with a lexical decision task, but not with a naming task. However, semantic and associative priming occurred with both tasks. Whereas associative priming refers to the activation arising from the association between words like DOCTOR and NURSE which will cause either one to be primed by the other, semantic priming refers to activation arising from semantic relations as with BOY and PRINCE. BOY does not evoke PRINCE yet it is semantically related to it. The two tasks were chosen for the purpose of showing differential effects. While the lexical decision task was considered by them to be sensitive to both pre- and post-lexical influence, the naming task was considered to be only sensitive to pre-lexical effects. Naming takes place too rapidly for context to be used. Thus, naming should not be affected by post-lexical processes. Only semantic and associative priming was found, suggesting that these types of priming derived from automatic spreading activation (for a discussion of spreading activation, see Collins & Loftus, 1975).

Facilitative effects within the sentence have usually been explained away with the "intralexical priming" concept. This phenomenon occurs entirely within the lexicon. In a recent article, Tanenhaus and Lucas (1987) write: "...the structure of the lexicon simply mirrors the structure of experience. Whatever is frequently connected in the real world is reflected in connections between corresponding nodes in the mental lexicon" (p. 225). They continue on, paraphrasing Fodor's (1984; p. 78-82) argument that "...intra-lexical associations have the virtue of increasing the efficiency of processing lexical items in context as if expectations had been generated without bringing into play the expensive (in terms of time and capacity) central processes that usually generate expectations" (p. 225).

However, Tyler & Wessels (1983) argue that simple interlexical semantic associations cannot explain it all. In their experiment, they deliberately used context sentences which did not contain semantic associates of the target. Still, they found facilitory effects with the semantic context. No facilitation was found due to syntactic context.

In their experiment, they examined the effects of syntactic and interpretive priming on word identification. Subjects heard a sentence either semantically related to the target word or not. If related, the sentence had no semantic associates of the target, so any context effects were sentential and not interlexical. After the sentence, another began, and then after weak or strong syntactic priming, the target was given.

The target was a word presented in segments of 50 ms. Subjects had to identify the word. Identification times averaged from 250 to 400 ms. Tyler & Wessels found that syntactic priming had a small effect, but interpretive priming had a substantial effect. As no associates of the target were used, they argue that their results suggest prelexical contextual effects. However, they used a gating procedure, which like the use of degraded stimuli, might encourage specialized contextually-based processing strategies. As well, though translations of the Dutch stimuli are given, it is noted that Dutch syntactic constraints do not operate in the same way they do in English, and thus, it is difficult for non-Dutch speakers to evaluate the nature of the materials and by extension the validity of the results. More importantly, since the identification times were longer than 200 ms, contextual effects might have been involved in the process.

In another area of research, Perfetti (1982) found that poor readers were more affected by context than good readers. He argued that active contextual influence occurred only when the lower level procedures were faulty or the input was degraded. Forster (1976) also contended that access was context directed only when the language user was faced with sketchy input. It could be argued then, that context directed access is a special strategy. If so, then any use of degraded stimuli provide evidence for these special situations and not for normal operating procedures.

2.5.2 Modality

Though most researchers seem to agree that the underlying mechanisms remain the same regardless of the modalities employed, the initial apprehension of the signal may differ importantly. Since written language is stable in place and time, it is easier to use multiple processing of some kind. The stimulus can be reread if desired. It can be differentially manipulated by the language user. An aural signal on the other hand is not under the control of the language user. It exists in a specific time frame, and as such is necessarily processed over time. In response to this, some researchers have been quite specific in stating that their results are concerned only with the processing of spoken language (Marslen-Wilson & Tyler, 1980).

It is argued (Seidenberg & Tanenhaus, 1986) that since an auditory signal becomes available over time, aural studies seem to demonstrate the clearest evidence for contextual effects on the processing of words. According to Perfetti (1982), contextual effects are slow and the serial processing of aural stimuli may give these effects enough time to become influential in the access procedure, though this would contradict the results of Tanenhaus and Donnenwerth-Nolan (1984), who found that a four syllable delay between context and target did not eliminate evidence of multiple access. As previously described, a lack of contextual effect on the access procedure provides evidence of multiple access.

Bradley & Forster (1987) while believing that there are no fundamental differences between operations involving spoken and written stimuli, do suggest that the frequency effect might be obscured in words longer than one syllable. This is not due to the modality being used per se, but simply to the durational qualities of the stimulus in the auditory mode. The authors refer to findings that higher frequency effects are found for monosyllables than disyllables, that there is a larger frequency effect for visual than auditory materials, and that lexical decisions for spoken words show no correlation at all with frequency ratings.

Grosjean and Gee (1987) emphasize the need for more aural studies. They contend that written language research and theory has overly influenced aural research. They argue that since written language research has been the focus, spoken language research has been in the unfortunate position of borrowing written language assumptions such as the word being the basic unit of processing even though the actual acoustic-phonetic stream does not reflect this. As well, much of language recognition research has used the single word in its investigations and not operations involving continuous lexical access. Experimental tasks have been skewed toward the single word further encouraging the perception of speech as discrete verbal units being the basic processing unit. Whether this is the case or not, it would be preferable to do aural experimentation whenever possible even if it is more difficult.

2.6 Motivation for this Study

I have chosen to work with the Ordered Search model simply because it seems the most reasonable. There is a fair amount of evidence suggesting a mechanism based on primacy. Though the Hogaboam & Perfetti procedure may not be fine enough to determine where primacy exerts its influence, it seems to be adequate to the task of determining whether primacy exerts an influence. Though there is evidence for the Selective Access model, the existence of equally strong evidence for other models precludes its full acceptance. The evidence for multiple computation tends to be compromised by possible backward priming. Cross modal tasks are often used in which the sentence is heard and then a target seen. Given the durational quality of the auditory signal, the visual target may be processed before the preceding auditory material. However, if multiple access operates, it is not certain that it contradicts the evidence for a primacy-based search. Both Seidenberg et al. (1982) and Holmes (1979) find evidence supporting multiple activation for subordinate senses, but selective access for dominant senses. This means that the dominant meaning is always available no matter which meaning is sought. If the dominant meaning is sought, only the dominant meaning is available. This means that retrieval is influenced by the relative strengths of the senses of a word. Simpson (1981) offers support for the same pattern, but only when the preceding bias is neutral or weak. Under strong bias conditions, he found selective access for either primed sense. Yet, as the weak bias condition shows, there is a primacy component in the procedure even if it may be obscured by a strong bias effect. Evidence for multiple activation, but with a strong contribution from primacy, was found by Simpson and Burgess (1985). Though not endorsing primacy as the sole factor in access, they do present evidence in favor of a primacy component in the meaning access procedure.

This proposal is designed to assess the effects of context within the framework of the Ordered Search model. Though Hogaboam and Perfetti (1975) have stated that context has no effect on the ordered search strategy, I contend that the effects of context have not been adequately tested by their design. Though Simpson (1981) and Simpson & Burgess (1985) present the most likely interaction of bias and primacy, I would contend that they, too, have not tested the effects of an encompassing context.

In order to pursue this goal, I have used my control conditions to attempt to replicate their findings in support of the model and then, I have added training conditions which provide a highly elaborated context. It is hoped that these conditions adequately reflect the type of context that the language user encounters in the real world. If contextual effects are uncovered, it will be difficult to establish exactly where they exert their influence. The ambiguity detection task is not precise enough to determine if a contextual effect operates before or after access. What it appears to be capable of measuring is whether there is a primacy component to the procedure and if that component is susceptible to the influence of context.

The following chapter outlines the experiment in detail.

3. THE EXPERIMENT

3.1 Introduction

In this chapter, the study to establish word norms, and the main experiment are described.

The experiments are arranged around two main hypotheses which are as follows:

Hypothesis 1: Subordinate meanings take longer to retrieve than dominant meanings. That is, when asked whether an ambiguous word has another meaning, subjects will take longer to provide a positive response if the word is presented at the end of a sentence biasing the word toward its *dominant* sense than if the word is presented at the end of a sentence biasing the word toward its *subordinate* sense. As well, failures to locate subordinate senses will outnumber failures to locate dominant senses. In other words, dominant meanings are more accessible than subordinate meanings. Testing this hypothesis serves the two-fold purpose of replicating Hogaboam and Perfetti (1975) and of creating a baseline for the second hypothesis.

Hypothesis 2: Given a strong context, the retrieval of appropriate meanings will be facilitated. That is, the presentation of a strong context will increase the success rate, and the speed, of finding associated meanings. Whereas the retrievability of related meanings will be increased, the retrievability of unrelated meanings will not be affected. For instance, given a chess game, the processing of chess words would be facilitated but the processing of card words would not. Testing this hypothesis serves the purpose of investigating the effects of context on the retrieval of the various senses of ambiguous words.

3.2 Normative Study

Hypothesis 1 claims that subordinate meanings take longer to retrieve than dominant meanings. Hence, in order to test Hypothesis 1, the dominant and subordinate senses of each word to be used in the experiment had to be established. As outlined in the previous chapter, it was assumed that when a particular word had a chess or card sense and another sense, the chess or card sense would be subordinate to the other sense, and would therefore take longer to access. For example, for HEART to be included as a word in the experiment, the card-HEART meaning would have to be subordinate to the organ-HEART meaning. Hence, in order to arrive at the words to be used in the experiment, it was decided that some native speaker judgements would be essential. The way that these judgements were collected is described below.

3.2.1 Subjects

Twenty-one subjects were used. All were members of an undergraduate linguistics class.

3.2.2 Materials

Two lists were created. Each list was composed of 25 words. The first list contained two words relevant to chess (CHECK, ROOK), seven words relevant to cards (CLUB, RUN, HAND, HEART, JACK, POT, SPADE), seven words relevant to either chess or cards, or games in general (POINT, MATCH, MAN, TIE, BOARD, QUEEN, MOVE) and nine fillers. The second list contained five words relevant to chess (KNIGHT, CASTLE, BISHOP, MATE, PAWN), seven words relevant to cards (CARD, DECK, FLUSH, SUIT, ACE, POKER, TRICK), two words relevant to either chess or cards, or games in general (KING, PIECE) and eleven fillers (see Lists A and B below).

Altogether, there were seven specific chess terms, fourteen specific card terms and nine game terms. However, more of the game terms (POINT, MATCH, MAN, BOARD, MOVE, PIECE) are closer to the chess than to the card domain.

List A (in order of presentation):

CLUB, GEM, LOT, POINT, RUN, MOAT, HAND, MATCH, DANCE, TURN, CHECK, HEART, MAN, TIE, DOG, JACK, BOARD, REED, POT, QUEEN, MOVE, WORD, SPADE, WATCH, and ROOK.

List B (in order of presentation):

DAY, CARD, SCALE, STAR, NIGHT, DECK, CASTLE, NAIL, FLUSH, DRINK, KING, NOTE, STAND, SUIT, STONE, PEN, PIECE, BISHOP, ACE, PICK, MATE, FLAT, POKER, TRICK, and PAWN.

Sheets with numbers and corresponding spaces to write in were made up.

3.2.3 Procedure

Both Lists A and B were read to an undergraduate senior level linguistics class comprised of 21 people — List A at the beginning of the class and List B at the end. First of all, sheets of paper were distributed to the students and they were instructed to listen to each word, and after having done so, to write down all the associations that they formed with each word. Students were further instructed not to assume that a particular aurally presented word had a particular spelling; they were simply to write down what came to mind after hearing the word. At this point, the experimenter began to read the list. Each word was read in isolation and repeated once. The experimenter waited until all students had finished writing their particular list of associations before reading the next item. The experiment proceeded in this fashion until all the items on the list were read. This process was repeated for List B. Finally, the sheets were gathered and the responses tallied. After both lists had been read, subjects were asked to provide details of their linguistic experience and the extent of their involvement in either card or chess activities.

3.2.4 Results

Subjects responded as expected. Most chess/card terms appeared lower in the lists than other meanings and thus appeared to be subordinate in meaning. Since four of the students were non-native speakers and had problems with even primary meanings, the pool of usable subjects dropped to seventeen. The seventeen were native speakers and, though a few played chess and most played cards, none was particularly active in these pursuits. It was arbitrarily decided that if more than 25 percent of the subjects responded to a critical word in a card, chess or game manner as their first choice, then that word would be excluded from further consideration. This was true of the terms PAWN, ROOK, SPADE and ACE; so these words were rejected. Responses to the other words in a chess, cards, or game manner was less than expected, averaging out at less than ten percent of the subjects mentioning the game meanings, and those only as a second or third meaning. POKER was close to rejection with four respondents listing the card association as the main association and most others listing the card association as the second choice. Subjects who responded to the game meaning of QUEEN and KING responded in a cards manner but again only as second or third meanings. After the task, a few students professed to have been aware of the chess-cards emphasis, but this was not reflected by their actual written responses.

The normative task resulted in the choice of HEART, TRICK, JACK, SUIT, DECK, POT, HAND, CLUB, FLUSH, POKER, QUEEN and KING for the card terms. The chess terms selected were BOARD, CASTLE, CHECK, KNIGHT, MAN, MATE, MATCH, PIECES, POINT, BISHOP, QUEEN and KING.

3.3 Main Experiment

3.3.1 Subjects

Sixty University of Alberta undergraduates enrolled in either linguistics or psychology courses were paid for their participation. The subjects ranged in age from eighteen to thirty.

3.3.2 Materials

The normative task resulted in the choice of HEART, TRICK, JACK, SUIT, DECK, POT, HAND, CLUB, FLUSH, POKER, QUEEN and KING for the card terms. The chess terms selected were BOARD, CASTLE, CHECK, KNIGHT, MAN, MATE, MATCH, PIECES, POINT, BISHOP, QUEEN and KING. In the initial design, QUEEN and KING were discarded since they could belong to either of the domains. Since the revised design required a symmetrical distribution over two lists, two additional terms for each domain were required. Since the vocabulary specific to these domains is limited, the lack of alternatives determined the inclusion of QUEEN and KING.

Two types of sentences were constructed – those for ambiguous terms, and those for unambiguous or filler terms. For the ambiguous terms, two sentences were constructed for each term, one biasing the word toward its dominant sense, as in "He spoke to the aged BISHOP," and another biasing the word toward its subordinate sense as in "He moved up the back BISHOp. " For the filler terms, one sentence was constructed for each term. The filler term itself was a unambiguous word. In every case, the critical word was located at the end of the sentence. Though this might have encouraged specialized strategies, since this was a replication of the Hogaboam and Perfetti paradigm, and since it was easiest in a purely aural study to direct subjects' attention to the end of a sentence, it was decided that the sentence-final position should be retained. As well, the measurement capabilities of the available hardware and software were restricted to the sentence-final position. The sentence-final words were one or two syllables in length, while the sentences ranged from six to nine syllables in length. (See Appendix 1.)

In summary, the stimuli consisted of twelve chess sentences and controls, twelve card sentences and controls, 24 fillers form-matched with the preceding sentences and 24 unmatched fillers. For example, the chess sentence "The pawns fell off the BOARD" had as a control "The nails fell off the BOARD." The matched filler for this pair was "The bottles fell off the TABLE" For a card example, the critical sentence "He lead with a high HEART" had as a control "He ran with a bad HEART." The matched filler for this pair was "He played with a bent SPOON."

Since each domain acts as a filler for the other, each critical set was embedded within a filler set of 72 sentences. The 48 ambiguous words were matched with 48 unambiguous words to ensure proportionality.

Two lists of 48 sentences each were constructed. Each list contained six sentences biasing chess domain terms toward their chess sense, six sentences biasing chess domain terms toward their alternate or default sense, six sentences biasing card domain terms toward their card sense, six sentences biasing card domain terms to their default sense, and 24 sentences ending in unambiguous words. Apart from KING and QUEEN, no two senses of any word appeared on the same list.

These sets of sentences, and an additional set of training sentences, were recorded by an adult male native English speaker using a TEAC cassette tape recorder. The two recording sessions were done in a sound neutral chamber. At the time of the recording, the speaker was not aware of the purpose of the experiment or of the role of the recording in the experiment.

The sentences were then sampled, digitized, and stored on a PDP12 minicomputer using the Alligator operating system. The sentences were stored individually in Alligator disk files. This was necessary so that the set could be easily randomized for every presentation.

The signals were stored on two disks. Then, eight Alligator programs were written: MIX (a program which randomized the given list), SPLONE and SPLTWO (a program which split the randomized list into two sessions in such a fashion that each session had the same proportion of critical elements), COPY (a program which reunited the list), DECONE and DECTWO (programs which generated two playback lists out of the randomized list), PRESEN (a presentation program for the first two stages), and AGAIN (a presentation program for the third stage).

The recording of reaction times was done through a IBM-PC connected to the PDP12 minicomputer. The IBM-PC was equipped with a Metrobyte clock timer (model France 8541 DB255) and a constructed yes-no switchbox hooked up to the PDP12. Using specially designed software, response times and key identities were captured by the IBM-PC.

A relay was tripped immediately before the sentence was played, tripping the clock on the Metrobyte, and when the subject responded, the closed circuit was detected by the Metrobyte. The signals were measured for temporal length and then, at a later stage, these times were subtracted from the reaction time data. There was a five second latency between sentences.

3.3.3 Procedure

Before any subject participated in the experiment, each was randomly assigned to one of three groups which corresponded to the type of training that the particular subject received. Those in Group 1 received card training, those in Group 2 chess training, and those in Group 3 no training.

Subjects were tested individually. At the beginning of the experiment, subjects were told that the experiment involved detecting ambiguous words. It was explained that an ambiguous word was one that had more than one meaning. An example was supplied by the experimenter at this point to illustrate this notion. It was explained that they would be hearing a number of sentences which ended in words that possibly had more than one meaning, and that their task would be to decide if the word indeed had more than one meaning. They were told that once they decided whether the word had another meaning or not, that they were to hit either "yes" or "no" on the switch box in front of them. They were further instructed not to assume that the aurally presented word at the end of each sentence had a particular spelling. In addition, subjects were asked to look for "real" differences in meaning. For example, some words exhibit only different nuances of the same meaning. The difference between the figurative and literal meanings of words can be viewed in this way. For instance, the ATEs in "He ATE the soup" and "He ATE his words" differ in that the former has a literal meaning while the latter has a figurative one. Conversely, the BOXes in the sentences "He likes to BOX" and "He built a BOX" exhibit "real" differences in meaning.

Then, before the actual experiment started, subjects were given a simple ambiguity test. First of all, they were shown how to use the switch box. They were told that is was important to keep their thumbs above the switches so their reactions to either switch would be the same. Then, sentences representative of the test sentences were presented, and subjects were asked to decide whether the last word had another meaning or not. As well, they were asked to use the switch box and after each decision to repeat the sentence that they had just heard. The responses were discussed with the subjects to ensure that they knew what to do. (See Appendix 2).

If the subjects belonged to Group 1, they received some card training. At first, subjects participated in an informal dialogue about card games and the associated terminology. In particular, they were instructed on or reminded of the relative value of various poker hands. (See Appendix 3). Once it was established that the subject was comfortable with these definitions, one round of five card stud poker was played by the experimenter. Three hands were dealt face-up. The subject was then instructed to memorize all the cards present in the above-mentioned round of poker. The subject was given as much time to memorize the cards as s/he wished. Then the cards were mixed with the remaining cards in the deck and placed face-up in front of the subject.

[illegible] point, the subject was ready to begin the ambiguity detection task. When the [illegible] indicated that s/he was ready, the sequence of sentences was started. The e[illegible] to leave the room to start the sequence, but returned in time to m[illegible]dure. The subject heard the sentences through a pair of speakers that were se[illegible] the room. After listening to each sentence, the subject decided whether the word was ambiguous or not, and indicated his or her choice by hitting either the "yes" or "no" button on the switch box.

After the 24 sentences were presented the subjects were asked to reconstruct the three poker hands. The experimenter recorded how well the subject did to give the appearance that the reconstruction task was indeed one of the major components of the experiment.

If the subjects belonged to Group 2, they were trained in a chess problem. This involved talking about the game of chess to make sure that they knew the names of all the pieces on the board, and the movements associated with each of these pieces. Next, the experimenter arranged the chess pieces on the board and moved the pieces through a pre-established set of four movements. This was done until the subject fully understood what the movements meant. After this was accomplished, the pieces were left in a final arrangement which was to be memorized by the subject. The subject was then given as much time as was necessary to memorize this arrangement. Then, once the arrangement was memorized, the pieces were mixed up on the chess board so that the subject could not continue to view the memorized arrangement.

In both the card and the chess training sessions, the training materials were left in view in order to encourage the subject to think about the coming reconstruction, and therefore, the domain.

S/he then proceeded with the disambiguation task as outlined in the discussion of Group 1. After the set of 24 sentences was presented, the subject was asked to reconstruct the chess board.

If the subjects belonged to Group 3, no domain training was given. Subjects received the same instructions regarding the ambiguity task and made judgements about the same number of sentences.

Though the preceding describes the part of the experiment integral to the hypotheses and the subsequent analysis, subjects were involved in additional procedures. If subjects belonged to Group 1, after completing their task (Session 1), subjects were given the training and tasks given to Group 2. If subjects belonged to Group 2, after completing their task, they were given the training and tasks given to Group 1. Subjects belonging to Group 3 received no training for the second session.

For Session 3, all groups were asked to follow the same switch box procedure with the second list of 48 sentences, with no additional training being given. In summary then, subjects in Group 1 received two kinds of training — training in cards, training in chess, and a final session without training. Subjects in Group 2 received training in chess, training in cards, and a final session without training. Subjects in Group 3 received no training throughout. Hence, the subjects responded to the first 24 sentences of the first list, the second 24 sentences of the same list, and finally the 48 sentences of the second list. Subjects were given a five minute break between each session.

Session 3 was not considered an integral part of the experiment. It was added as an afterthought to the original design. It was thought that since the subjects were already there, little effort would be required to gain the extra data.

3.3.4 Scoring

Before running the experiment, the duration of each sentence was measured and recorded by the PDP12 minicomputer. As each sentence was transmitted from the PDP12, its identity and position were stored along with the name of the subject. When the subject responded, both the length of the response and the identity of the chosen switch were captured on the IBM-PC. All files from the PDP12 and the IBM-PC were moved over to the university mainframe (Michigan Terminal System). On the mainframe, the responses were derandomized and organized into categories for later analysis. The response times were subtracted from the corresponding signal lengths to give the subject's true response time. Timing was begun at the start of the signal rather than at the end to allow for the possibility of negative response times. If timing started at the end of the signal, and the subject had predicted the word and responded rapidly, no time would have been captured. It was found through oscilliscopic measurement that software implementation delays and mechanical relay effects introduced a constant delay of 135 ms ± 5 ms. A program was written to remove this time from each response. After correcting these response times, these files were moved onto a Macintosh PC for statistical analysis.

4. RESULTS AND DISCUSSION

4.1 Introduction

Statistical tests were conducted to evaluate the experimental data. In this chapter, the results of the statistical tests are reported, and the hypotheses evaluated.

From the initial sixty subjects, nine were rejected either due to their failure to follow instructions or mechanical failure of the equipment once the experiment was already in progress. A further eleven subjects were rejected due to their having one or more empty cells in the response time tallies. In general, each cell represented the mean of a subject's responses for a given condition. Thus, response time tallies represented a mean calculated from one to three positive readings for that cell. If no positive readings occurred, that is, if the subject falsely rejected each critical item constituting that cell, then, no reading was incurred for that cell. An item is defined as a response to either the dominant or subordinate sense of a word. Since empty cells are problematic for many statistical designs, and certainly for any generalization of the results, any subject with an empty cell was rejected. The reported results were drawn from the remaining 40 subjects. This subject pool consisted of twelve subjects in the control group and fourteen subjects in each of the training groups.

The data from the 40 subjects were entered into a Macintosh PC and analyzed using a repeated measures ANOVA design. Following Forster and Bednall (1976), if a subject responded with a time more than two standard deviations from the mean of his/her total responses, then that response time was set at the two SD cutoff point. Out of the nine hundred and sixty data points associated with the critical items, (presented in the first two sessions), five were altered in this manner. Separate ANOVAs were run for hit response times (responding "yes" when an ambiguous word was presented), proportion of misses (responding "no" when an ambiguous word was presented) to total responses and the response bias indicator of d'. An ANOVA for miss response times was run, but was rejected as unsuitable since too many empty cells were present.

Item analyses corresponding to the subject analyses were run. For the response time analysis, responses from the same 40 subjects were collapsed and measures were gathered by item. Means were gathered for each word in each condition; Words (six) by Training (three) by Domain (two) by Primacy (two) rendered 72 possible measures. Words refers to the words composing each critical set (see Appendix 1). Training refers to which type of training (chess, card, or none) subjects were given. Domain refers to whether the subordinate meaning of the critical words are chess or card meanings. For example, chess words are words that have chess senses as their subordinate senses. Primacy refers to whether the word was biased toward its dominant or subordinate sense.

For two words, the randomization program did not provide a presentation. Though one of the two lists was randomized, only half the list was presented to any subject. Even with a sizable subject pool receiving the same list, there is no assurance that all the words, or words in both their senses would be presented. For an additional fourteen cases, no positive responses were gathered. Therefore, in the response time analysis, the final pool consists of 56 items, and in the error analysis, the final pool consists of 70 items. As well, in the analysis by subject, Training is the only between groups factor, with Domain and Primacy as within group factors, whereas in the analysis by items, Training and Domain are between group factors, with Primacy as a within group factor.

Due to the different averaging procedures, the subject and item grand means differ. In the subject response time ANOVA, each cell mean is determined by averaging over the one to three responses for that cell. In the item response time ANOVA, each cell mean is determined by averaging over all the responses gathered for that item. Since different measures contribute to different averages, and with the greatest divergences arising from those "averages" that consist of one number, the final means are not equal. The same explanation applies to the differences between the subject and item means for the error proportions and d'.

The d' statistic represents subject's response tendencies, independent of the test parameters. This measure is derived from the relationship between the proportion of hits (correct positive responses) and the proportion of false alarms (incorrect positive responses). For discussions of d', see Engen (1971) and Lachman, Lachman & Butterfield (1979, p. 163-171).

Using McNicol (1972) as a guide, a program was written to produce the d' values. D' was calculated by taking the log of a figure consisting of a numerator of (1.0-proportion of false alarms) multiplied by (1.0-proportion of misses) and a denominator of the proportion of false alarms multiplied by the proportion of misses. To both the denominator and the numerator, .01 was added in order to avoid the problem of a zero denomination in the calculation.

The proportion of misses used in the calculations were individually drawn from each cell of three responses within each subject. Since the unambiguous words were not directly matched with the ambiguous words, the proportions of false alarms used in the equation were drawn from the subject's average over the session.

As either the proportion of false alarms or the proportion of misses rise, the d' statistic decreases in size. The more often the subject responds "correctly," the higher the d' will be. For example, if a subject discriminated perfectly between ambiguous and unambiguous words, the d' for that subject would be 4.615. If a subject judged ambiguous words to be ambiguous half the time and considered unambiguous words to be ambiguous half the time, the associated d' would be 0.0. This value will be associated with any cases where the proportion of hits equals the proportion of false alarms. D'

Table 2 — Proportions of Misses

	CARD WORD		CHESS WORD	
	Subordinate	Dominant	Subordinate	Dominant
CARDS TRAINING				
subjects	.1428	.2141	.3810	.3095
items	.1139	.2403	.4575	.2994
CHESS TRAINING				
subjects	.2856	.1189	.2618	.4764
items	.3167	.1924	.2567	.3992
NO TRAINING				
subjects	.3612	.1666	.4444	.2498
items	.3060	.2421	.5167	.2527

Table 3 — D Prime Figures

	CARD WORD		CHESS WORD	
	Subordinate	Dominant	Subordinate	Dominant
CARDS TRAINING				
subjects	3.33	2.75	2.05	2.17
items	3.56	2.76	.94	2.72
CHESS TRAINING				
subjects	2.26	3.43	2.46	1.47
items	2.20	2.35	2.56	1.81
NO TRAINING				
subjects	2.78	3.60	2.00	2.97
items	2.31	2.69	1.01	2.49

Table 4 — ANOVA Summary Table — Response Times — Subjects

FACTOR	DF	SS	MS	F	P
TRAINING	2	3630142.982	1815071.491	1.763	.1856
Error	37	38087800.738	1029400.020		
DOMAIN	1	407169.213	407169.213	2.377	.1317
TD	2	934098.009	467049.004	2.726	.0786
Error	37	6339152.488	171328.446		
PRIMACY	1	250325.905	250325.905	1.377	.2481
TP	2	1354412.415	677206.207	3.726	.0335
Error	37	6724545.774	181744.480		
DP	1	207521.053	207521.053	1.024	.3182
TDP	2	4093.298	2046.649	.010	.9900
Error	37	7499124.310	202679.035		

Table 5 — ANOVA Summary Table — Response Times — Items

FACTOR	DF	SS	MS	F	P
TRAINING	2	2845692.299	1422846.150	3.862	.0276
DOMAIN	1	174860.132	174860.132	.475	.4940
TD	2	1083234.184	541617.092	1.470	.2396
Error	50	18419879.164	368397.583		
PRIMACY	1	274175.170	274175.170	1.049	.3107
TP	2	2426817.191	1213408.595	4.641	.0142
DP	1	32363.623	32363.623	.124	.7264
TDP	2	187259.826	93629.913	.358	.7008
Error	50	13072279.179	261445.584		

Table 6— ANOVA Summary Table — Miss Proportions — Subjects

FACTOR	DF	SS	MS	F	P
TRAINING	2	.051	.025	.313	.7333
Error	37	2.997	.081		
DOMAIN	1	.768	.768	20.867	.0001
TD	2	.062	.031	.838	.4405
Error	37	1.362	.037		
PRIMACY	1	.129	.129	2.705	.1085
TP	2	.381	.190	4.001	.0267
Error	37	1.762	.048		
DP	1	.063	.063	.960	.3337
TDP	2	.487	.243	3.719	.0338
Error	37	2.421	.065		

Table 7 — ANOVA Summary Table — Miss Proportions — Items

FACTOR	DF	SS	MS	F	P
TRAINING	2	.066	.033	.304	.7391
DOMAIN	1	.569	.569	5.259	.0252
TD	2	.099	.050	.459	.6342
Error	63	6.813	.108		
PRIMACY	1	.112	.112	.911	.3434
TP	2	.201	.100	.819	.4457
Error	63	7.718	.123		

Table 8 — ANOVA Summary Table — d Primes — Subjects

FACTOR	DF	SS	MS	F	P
TRAINING	2	4.949	2.474	.547	.5834
Error	37	167.405	4.524		
DOMAIN	1	27.832	27.832	21.498	.0000
TD	2	.357	.179	.138	.8715
Error	37	47.901	1.295		
PRIMACY	1	2.628	2.628	1.423	.2406
TP	2	9.046	4.523	2.449	.1003
Error	37	68.338	1.847		
DP	1	1.805	1.805	.725	.4000
TDP	2	15.303	7.651	3.074	.0582
Error	37	92.110	2.489		

Table 9 — ANOVA Summary Table — d Primes — Items

FACTOR	DF	SS	MS	F	P
TRAINING	2	3.352	1.676	.322	.7258
DOMAIN	1	18.000	18.000	3.459	.0676
TD	2	8.768	4.384	.843	.4354
Error	63	327.817	5.203		
PRIMACY	1	4.776	4.776	.831	.3656
TP	2	8.850	4.425	.770	.4675
DP	1	7.424	7.424	1.291	.2601
TDP	2	17.679	8.839	1.537	.2229
Error	63	362.221	5.750		

Figure 1 — Mean Search Response Times in Milliseconds

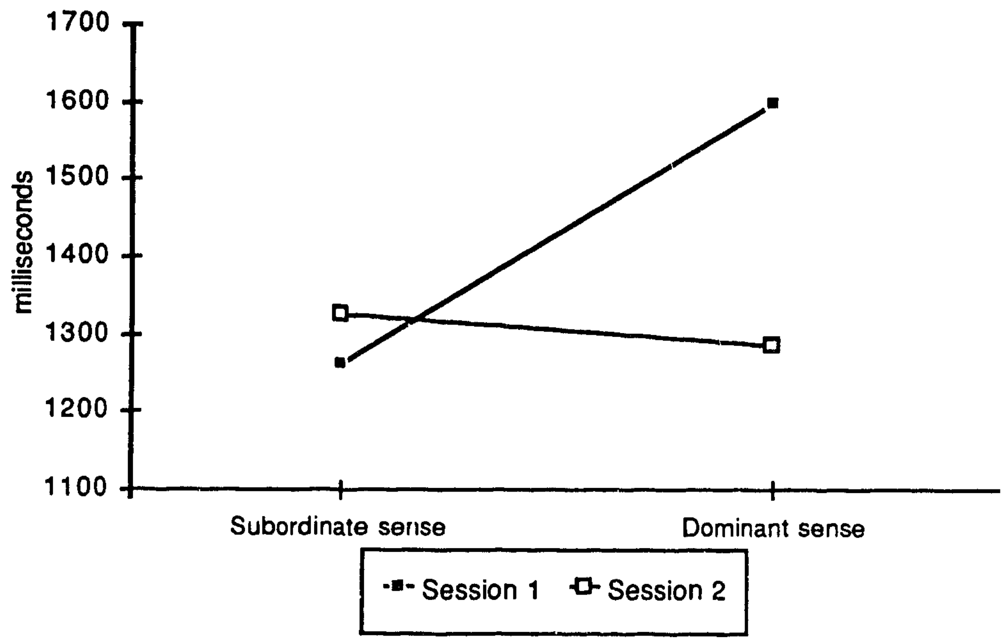


Figure 2 — Mean Proportion of Errors

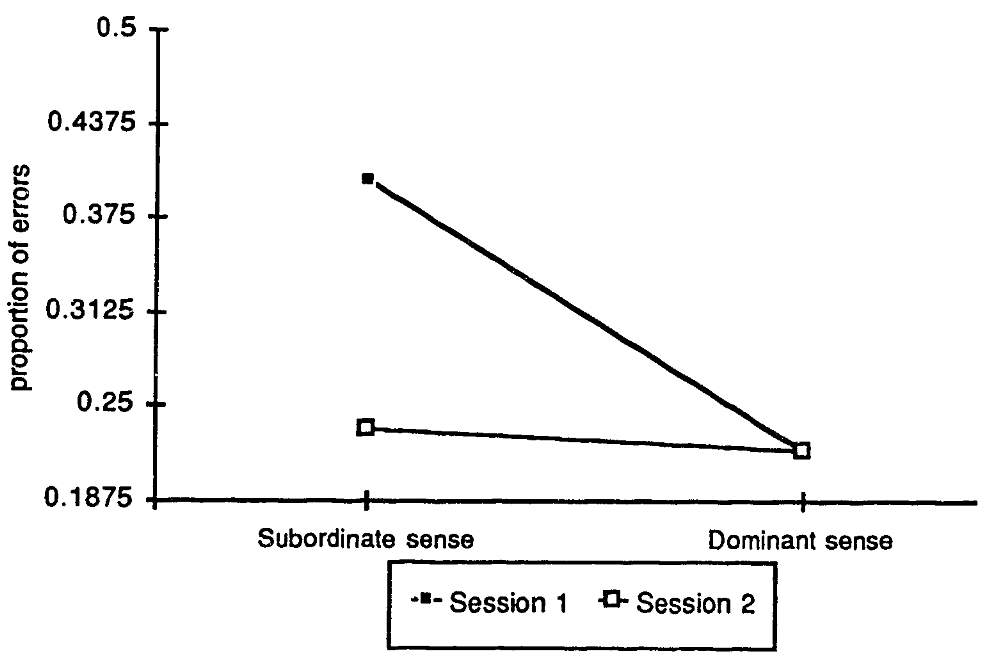


Figure 3 — Mean Proportion of Errors — Chess Words (Subjects)

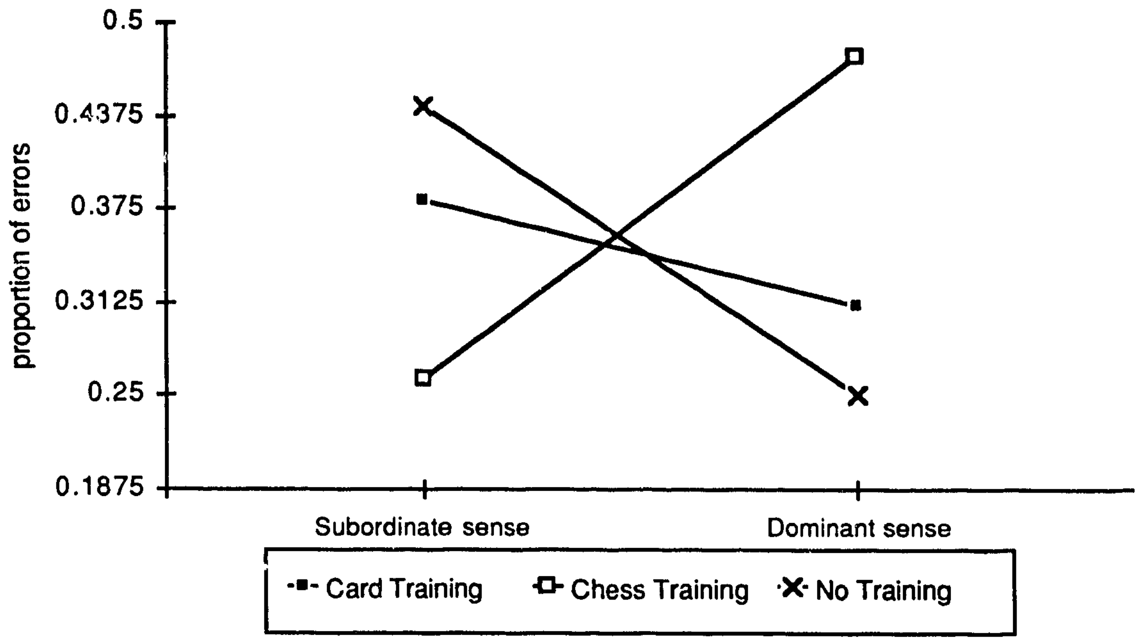
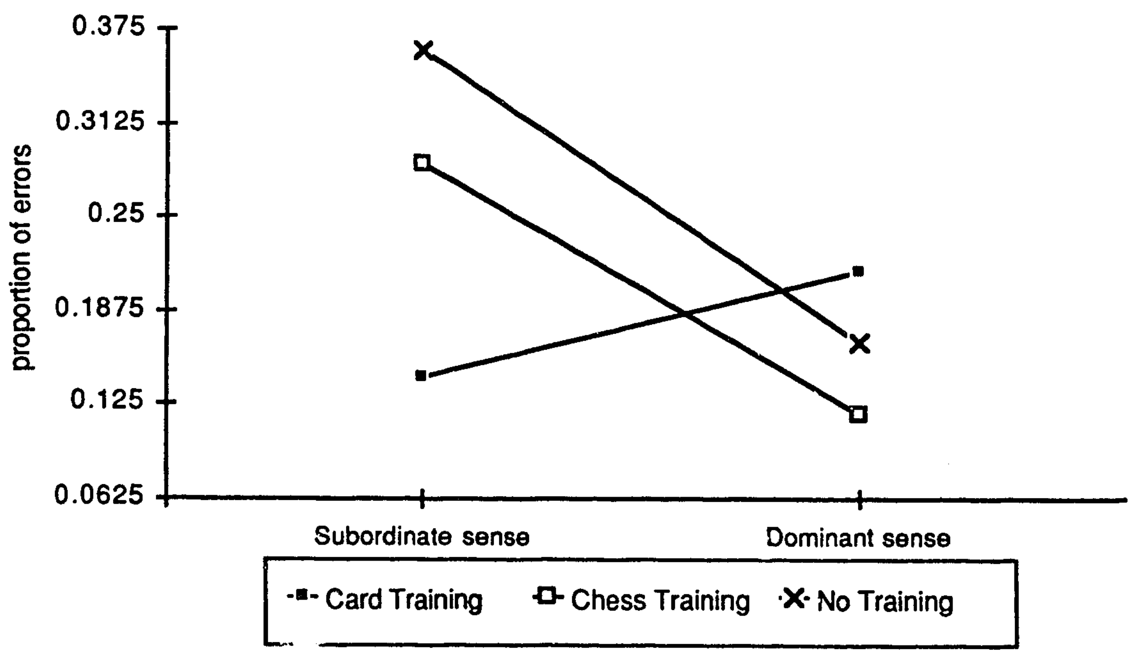


Figure 4 — Mean Proportion of Errors — Card Words (Subjects)



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APPENDIX A — Experimental Materials: Lists 1 and 2

LIST 1

1. He lead with a high HEART.
2. I won the game on the last TRICK.
3. The card turned over was a JACK.
4. The face cards were all in one SUIT.
5. He shuffled the second DECK.
6. My only spade was the KING.
7. Before I knew it I was in CHECK.
8. His white rook took my black KNIGHT.
9. He traded his pawn for another MAN.
10. A chess game ends with a MATE.
11. The pawns threatened the CASTLE.
12. On the third move I lost my QUEEN.
13. With care, I held my injured HAND.
14. The weapon was a small CLUB.
15. He broke out in a FLUSH.
16. I killed him with the POKER.
17. I threw the chicken into the POT.
18. I was impressed by the QUEEN.
19. The pencil has a dull POINT.
20. He spoke to the aged BISHOp.
21. The nails fell off the BOARD.
22. The German carefully lit the MATCH.
23. It was broken into three PIECES.

24. I forgot to tell the KING.

25. He passed them in the SLUSH.

26. The bottles fell off the TABLE.

27. He sold the man a CHAIR.

28. He left his truck at the other HOUSE.

29. The chemist almost ruined the BATCH.

30. The cake is worth one DOLLAR.

31. I checked the time on the CLOCK.

32. The man fell asleep at his DESK.

33. It often gets warm in SUMMER.

34. He spilt the glass of MILK.

35. The car slid off the ROAD.

36. The books were on the SHELF.

37. We watched the falling LEAVES.

38. He sharpened the dull KNIFE.

39. The shovel fell down the HOLE.

40. He ate the last piece of CAKE.

41. He played with a bent SPOON.

42. The truck was carried on a TRAILER.

43. He stirred the muddy WATER.

44. With care, I tested my damaged BIKE.

45. We found the hidden FORT.

46. They dropped the loose STRING.

47. The ashtray was made of GLASS.

48. The mechanic changed the OIL.

LIST 2

1. With the ace, I held a good HAND.
2. The card was just a low CLUB.
3. He beat the pair with a FLUSH.
4. He wiped them out in POKER.
5. I anted my dollar into the POT.
6. I was finessed with the QUEEN.
7. The pawn is worth one POINT.
8. He moved up the back BISHOp.
9. The pawns fell off the BOARD.
10. The Russian quietly won the MATCH.
11. White was behind by three PIECES.
12. I forgot to move my KING.
13. He ran with a bad HEART.
14. I beat him with a dirty TRICK.
15. The car was raised up on a JACK.
16. The credit cards were in the blue SUIT.
17. He walked the lower DECK.
18. My only friend was the KING.
19. Before I cashed it, I signed the CHEQUE.
20. He drove through the rainy NIGHT.
21. He gave his car to another MAN.
22. The dog ran with its MATE.
23. The moat surrounded the CASTLE.
24. On the third day, I met the QUEEN.
25. He hit them with the HAMMER.

26. The garden surrounded the MANSION.
27. He left before the end of the MONTH.
28. The play ended with a BANG.
29. It was divided into three UNITS.
30. He ignored the anxious NURSE.
31. The servant forgot the GLOVES.
32. It often gets cold in WINTER.
33. The present was quite a SURPRISE.
34. The boxer fell against the ROPES.
35. He put the money in his WALLET.
36. He put the ring on his FINGER.
37. He waded through the SNOW.
38. The tools were dropped in the BAG.
39. He melted the lump of METAL.
40. He opened the dirty CASKET.
41. The gold coins were in the heavy SAFE.
42. I threw my book into the FIRE.
43. The building was near a small CHURCH.
44. I rubbed it witn a damp CLOTH.
45. We found the lost CITY.
46. They caught the largest FISH.
47. The table was made of PLASTIC.
48. The mechanic changed the TIRE.

APPENDIX B — Ambiguity Training Procedure

You are going to hear a number of sentences. What I would like you to do is listen to them very carefully and try to decide whether the last word in the sentence has more than one meaning. Not whether it has more than one meaning in terms of the sentence but rather whether it as a word has more than one meaning. I'll give you plenty of examples. First of all, I'll just read these out to you and you tell me whether you think the last word in these sentences has more than one meaning or not. OK, now which of these sentences, do you think, end in a word that has more than one meaning?

1. I put the paper into a FILE.
2. The pillow was filled with DOWN.
3. The goose was very LARGE.
4. He picked out another SITE.

In sentence #1 FILE, can mean either a repository for information (paper or electronic) or a tool to dull an edge with (ie. a nail file). In sentence #2, DOWN can mean either a direction or feathers. As well, a computer system can be DOWN or not functioning. In sentence #3, LARGE, though possibly vague, has only one meaning. In sentence #4, SITE can mean location. When spelled SIGHT, it can mean vision.

Since you will be hearing these sentences, and not reading them, try not to worry about how the words are being spelled. Just think about how they sound. Just think: Does this word have another meaning?

This switchbox will record your responses. If you think the last word has another meaning, press this button -YES. If you think the last word has no other meaning press this one -NO. And try to do this as quickly as you can. Alright, now we're going to make it just a little more difficult. After you press the button of your choice, repeat the sentence. So, in summary: listen to the sentence, decide if the last word in the sentence has another meaning or not, press the relevant button and then repeat the sentence. Now we'll try a few to get used to the procedure. (Play pre-recorded training sentences.)

TRAINING SENTENCES

1. I gave her a DRINK.
2. He ordered a rare STEAK.
3. I erased the TAPE.
4. We attended the late SHOW.
5. The lawyer lost his CASE.
6. The car left the GARAGE.
7. The ducks flew off the LAKE.
8. She dropped the heavy BOOK.
9. She found the white TIE.
10. He mixed up the BATTER.
11. The horse jumped the SHRUB.
12. The judge banged his GAVEL.
13. The dog smelled the FLOWER.
14. The teacher bought a STOVE.
15. The pig escaped its PEN.

Ok. Now we're going to make it a little more complicated. At this point, for Group 1, the chess training procedure is initiated, for Group 2, the card training procedure is initiated, and for Group 3, a pause occurs. Now we're going to do the initial task again. No memory problems this time. Just listen to the sentences and make the judgements you were making before and then repeat the sentences. Thank you.

APPENDIX C — Card Problem

Before engaging the problem the relative values of the various poker hands (what beats what etc.) were reviewed. As well, a general discussion about cards, and various kinds of card games, occurred in order to draw out the nature of the subject's card terminology.

The highest hand is a ROYAL FLUSH (Ace through 10 in the same suit). Next is a STRAIGHT FLUSH (five cards in a row in the same suit). Then FOUR OF A KIND. Then a FULL HOUSE (THREE OF A KIND and a PAIR). Then a FLUSH (five cards in the same suit). A STRAIGHT (five in a row, not the same suit). Then THREE OF A KIND. Then two PAIRS. Then a PAIR. Then a high card.

Given the same configurations, the winner is the one with the highest suit (SPADES, HEARTS, DIAMONDS then CLUBS), or the highest cards comprising the configuration. A simple poker sequence was devised to use most of the terms in the list and generally to talk about cards. The following hands were set up: 1. 3 of Diamonds, 3 of Clubs, 5 of Diamonds, 5 of Spades, and King of Hearts. 2. Queen of Diamonds, Queen of Spades, King of Spades, 4 of Hearts, and 10 of Hearts. 3. 2 of Clubs, Ace of Clubs, 8 of Clubs, Jack of Clubs, and 10 of Clubs.

These three hands will be set out face down. Cards will be faced up one at a time along with approximately the following dialogue. 1. Though in games like bridge or 9-5-2 you can win individual tricks; that is, each card in the hand can be played for effect; here, in poker, we bet on the possible accumulated value of the whole hand. The individual card doesn't mean much; it's what the hand is worth. 2. 3 of Diamonds. Pretty low. 3. Queen of Diamonds. Certainly beats the three. Wouldn't like to bet on just one card if I didn't have to. 4. 2 of Clubs. Not much there. Lowest card in the deck. 5. 3 of Clubs. With the other trey we have a pair. 6. Queen of Spades. A higher pair than the 3s.

7. Ace of Clubs. Not much in this hand so far but the Ace high just might pay off if another Ace shows up. 8. 5 of Diamonds. Could be worse. Might get a run out of this. 9. King of Spades. Looking good. 10. 8 of Clubs. Don't know what's happening here. 11. 5 of Spades. Makes this two pairs and the leading hand. There's a good chance that this will be the best hand. 12. 4 of Hearts. 13. Jack of Clubs. A possible flush here which would beat the two pairs, as long as they don't get a 3 or 5 and score a full house. 14. King of Hearts. Damn. Ah well, still the top of the heap. 15. 10 of Hearts. No good. 16. 10 of Clubs. Great. All the cards in the same suit. A flush and the winning hand.

The hands were splayed out and the subjects given as much time as they wanted to study them. Then the cards were mixed together with other cards face up. The memory task was to reconstitute the three hands.

APPENDIX D — Chess Problem

Before engaging the problem, the moves and names of all the chessmen were reviewed. It was necessary at this point to evaluate the subject's knowledge of the game and to determine what level of chess vocabulary s/he were familiar with.

A fairly simple beginners' problem was chosen from Barden (1980), p. 19. The initial setup was (insert diagram?), using standard chess notation, for White: King on h1, Queen on e3, Rook on e1, and three Pawns on b2, g2 and h3. Black was: King on g8, Queen on b8, Bishop on c6 and the four Pawns on a4, f7, g7, and h7. The following sequence of moves is the most likely. Again using chess notation:

1................................Q*b2 2.Qe8+........................B*e8 3.R*e8 mate. The Black queen takes White's pawn on b2. White's queen moves to e8 putting the king into check. Black's bishop then takes the queen. White's rook then takes the bishop thus checkmate. (This horrible state of affairs can be averted by Black's first move being to move Pawn to h6 thus providing an escape route.) This problem was played through until s/he understood it.