CONTEXT EFFECTS IN HOMONYM PROCESSING

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CONTEXT EFFECTS IN HOMONYM PROCESSING

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Abstract

Sixty undergraduate students, paid volunteers, served as subjects in a study of the effect of context on the complexity of processing required for homonym comprehension. Homonyms were heard in sentences which cued their most common meaning (Dominant Context), their less common meaning (Secondary Context), or either/both meaning(s) (Ambiguous Context). Subjects were required to press a button on hearing a 'b' phoneme, which followed either a homonym or a frequency-matched unambiguous control word in the sentences presented. This provided a response latency measure of processing complexity. Subsequently, subjects responded 'old' or 'new' to words on a recognition list which included associates of both meanings of each homonym as well as old words and unrelated new words. The pattern of false recognitions (saying 'old' to new words) provided a second indication of processing complexity during comprehension. The Prior Decision Model, which holds that only the contextually appropriate meaning of a homonym is processed, was not supported by the results of either task. Two other

models, which postulate either processing of both homonym meanings independent of context (Choice Point Decision), or sequential processing that is terminated by a match between activated meaning and context cues (Ordered Search) each received partial support.

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Introduction

Information processing emerged as a new approach to the study of perceptual and cognitive processes following World War II. At that time, the work of individuals such as Shannon (1948), Cherry (1953), and Broadbent (1958) resulted in the development of models of attention and perception which traced the flow of information from input (the environment) to output (usually a response). During the 1960's these models were extended to include memory functions (e.g., Fiegenbaum, 1963; Waugh & Norman, 1965; Atkinson & Shiffrin, 1968). These developments reflected a desire to describe the events which occurred in the organism between stimulus and response. Behaviourist psychology largely ignored these internal events, restricting its focus to the contingencies relating stimuli and responses. With the introduction of information processing models, accompanied by techniques for testing them, these covert events could be identified and their characteristics explored. For example, classical psychophysics viewed a subject's response to a signal as simply a function of stimulus intensity. However, the "new" psychophysics, as Galanter (1962) described it, regards the determinants of behavior of a subject in a psychophysical experiment quite differently. The subject "detects signals" rather than "responds to stimuli," and the probability of signal detection is a function of both stimulus intensity and the subject's criterion for saying yes/no (the signal is present/absent). It is now generally accepted that a thorough description of performance in signal detection tasks can not be provided without recognizing the role of decision processes in determining the subject's response.

The information processing approach examines how individuals extract the information which is assumed to exist in the environment. When the human information processor encounters the environment, he encodes and transforms this information so that it can be stored and/or used. This coding or extraction of information is constrained by the information available from past experience (i.e., memory). This view has led to the consideration of the coding and recoding of information as the major component of learning (Kausler, 1974).

As suggested by Atkinson & Shiffrin (1968), memory is characterized by three structural components: sensory register, short-term store, and long-term store. These components are differentiated by the length of time they can hold information. Incoming information is initially stored in the sensory register. The content of this store is regarded as being isometric with the physical stimulus, and to have a very short duration (probably not more than one to two seconds; see Sperling, 1960; Neisser, 1967). Prior to its decay in the sensory register, the information may be coded into the short-term store (or working memory). This component of memory is a limited-capacity store (Miller, 1956) with a duration of a few seconds (Peterson & Peterson, 1959) unless control processes, such as rehearsal, are used to prolong the duration of information storage. Information from both the sensory register and long-term store may be coded into the short-term store. The third component, the long-term store, is a permanent, or near permanent, storage system. One type of information which is stored in the long-term store is information about the meaning of words -- sometimes referred to as semantic memory (Tulving, 1972) or the lexicon (Conrad, 1974).

Information processing models are constructed to trace the path of information through the various stages of processing which occur between activation of the sensory receptors and some final response (typically verbal or motor). Many such models have been proposed and tested in the area of cognitive psychology in recent years. One reason for the enthusiastic reception given to the information processing approach is the potential it appears to offer for a more powerful analytical and integrated examination of cognitive processes. However, this potential has yet to be fully realized.

In particular, any complete model of the human information processor must be able to explain how humans ascribe meaning to ambiguous stimuli such as homonyms (words which are used to convey more than one meaning). Within this group are the subsets of homophones, which share phonemic characteristics (e.g., rain, reign), and homographs, which share graphemic characteristics (e.g., 'bow,' meaning to incline one's body forward; and 'bow,' meaning a kind of knot). A subset of all homonyms is a group of words which both sound alike and look alike, e.g, spring (season), spring (leap). Ambiguity of this type is reasonably common in our experience, yet most individuals have no difficulty interpreting the correct meaning of messages which include homonyms, and often do not even notice that an ambiguity exists. The study of homonym processing is not only of intrinsic interest, but may also prove to be useful in developing a more general model of semantic processing. To the extent that all words have a variable rather than completely fixed or unique meaning, the study of homonym processing may prove to be a fertile source of information about word processing in general. The particular value of homonyms is that their different meanings are usually completely unrelated, making it easier to trace the course of linguistic (semantic) processing.

Sentence processing is assumed to require processing of the meanings of words in sentences. Incoming words are presumed to activate stored representations in LTM. Activated information is then transferred to working memory, where it is integrated to provide meaning, and consequently understanding of the information conveyed in the sentence. While it is generally agreed that when a homonym is encountered its comprehension requires the activation of information in semantic memory, the nature and amount of information activated is a matter of debate among information processing theorists. Three general models of homonym processing have been proposed. These models will be described, relevant literature in the area reviewed, and the present research study described in the following sections of this chapter.

Models of Homonym Processing

The Prior Decision Model. The simplest model of homonym processing assumes that disambiguation of the homonym occurs before lexical information is accessed. This model has been referred to as the Garden Path Theory (Lashley, 1951) or the Prior Decision Model (Foss & Jenkins, 1973). According to this model, only one meaning of the homonym is activated, the meaning which is contextually appropriate. In those cases where the context is ambiguous, is absent, or follows homonym presentation, the most frequently used meaning of the homonym will be activated. Should this meaning subsequently be found to be inappropriate, reprocessing will occur. The one-meaning model thus suggests that any ambiguity in input does not result in multiple activation of meanings. Rather, one and only one meaning will be processed -- the particular meaning being determined by context or frequency.

The remaining two models both suggest that disambiguation occurs after lexical activation, but they disagree on the type of processing involved.

The Choice Point Decision Model. The Exhaustive Computation Hypothesis (Conrad, 1974) or Choice Point Decision Model (Foss & Jenkins, 1973), assumes that both (all) meanings of homonyms are activated simultaneously and transferred to working memory. At that point a comparison with contextual information results in the selection of the appropriate meaning. Context does not in any way limit the amount of processing up to the working memory stage. The frequency of usage of the different meanings may influence the speed of activation, but it is presumed that the selection or matching process does not occur until after all necessary information has been transferred to working memory.

The Ordered Search Model. The third model, which has been suggested by Hogaboam & Perfetti (1975), is called the Ordered Search Model. According to this model, only one meaning of the homonym is initially activated and compared with context. If a match occurs, processing terminates. If, however, a match does not occur, then a second meaning is activated and compared. This processing continues until the appropriate meaning is selected. The order in which the different meanings are activated is determined by the frequency with which the lexical entries have been used in the past. That is, the most frequent usage is always activated first regardless of the context in which the homonym occurs. Context, according to this model, does limit processing since it is terminated when a match occurs; but context is not the criterion which determines the order of processing, frequency of usage serves that function. If the most frequently used meaning is appropriate to the context, only one meaning will be activated. If, however, the third most frequently used meaning is required, then three different meanings will be sequentially processed in order to find a match with context.

In summary, the Prior Decision Model proposes that only one meaning of a homonym is initially processed. The Choice Point Decision Model suggests that both (all) meanings are processed simultaneously. The Ordered Search Model suggests that the number of meanings processed will vary, depending on the frequency of usage of the different meanings and on the context in which the homonym occurs. An example may be useful in illustrating the differences among the models. The word 'yarn' may be used to mean a type of string or a story. Two sentences which convey these different meanings are:

(A) The knitting yarn became tangled.

(B) The old man's yarn became confused.

Assume that sentence A represents the most frequent usage of yarn. The one-meaning or Prior Decision Model would predict that if sentence A was presented, the listener would process only the 'string' meaning of yarn; if sentence B was presented, only the 'story' meaning would be processed. The Choice Point Decision model suggests that, for each sentence, both meanings of yarn would be processed and that these would be compared with the rest of the sentence (the context) to select the appropriate meaning. The Ordered Search Model would predict that if sentence A occurred, only the 'string' meaning would be processed; if, however, sentence B was heard, both meanings of 'yarn' would be processed since the most frequent meaning ('string') would be inappropriate in the context provided by sentence B. This mismatch would result in a continuation of processing to the next most frequent meaning ('story'). Since this second meaning produces a match, processing would terminate.

Two general methods have been used in an attempt to determine which of these models provides the most appropriate description of what occurs when a homonym is understood: (1) recognition memory techniques, and (2) on-going processing techniques.

Recognition Memory Studies

Recognition memory techniques involve the presentation of a number of nonsense syllables, words, phrases, or sentences for study by the subject. A subsequent test requires subjects to recognize the previously studied items in an expanded list containing both the studied items and new distractor items. The subject's responses in the test phase are used to make inferences about the processing which occurred during the study phase.

It is generally assumed that the study of an item involves the tagging or activation of that item's representation in LTM (Kausler, 1974). A subject's decision during the test phase of whether an item is old or new is variously viewed as a function of the proportion of that item's features which have been tagged for recency (Kausler, 1974), or the strength of the memory trace (Norman & Wickelgren, 1965; Kintsch, 1967). As the number of features tagged increases, or as the trace strength increases, it becomes more probable that some criterion number or strength will be exceeded and the subject will respond "old."

This activation of information appears to occur not only for the specific items studied, however, but also for semantically related items. Items which are semantically related to study items are more likely to be recognized as "old" when they are in fact "new" items (Kimble, 1968; Underwood, 1965). This, along with the suggestion that homonyms are multiply and independently represented in semantic memory (Rubenstein, Garfield & Millikan, 1970; Kausler, 1974), makes recognition memory techniques useful in evaluating the different models of homonym processing.

If all meanings of a homonym are processed, this should result in a greater probability of false recognition since the chance of a new item being related semantically to study items increases as the amount of information activated at study increases. If, on the other hand, only one, or a limited number of the meanings are processed, the probability of false recognitions should be less. That is, false recognition rate should vary depending upon the amount of information activated at study.

In general, recognition memory studies based on these assumptions have provided support for the Prior Decision Model rather than the Choice Point Decision and Ordered Search Models of homonym processing. Light and Carter-Sobell (1970) provided subjects with study and test cues during successive phases of their recognition task. These cues changed from study to test for experimental subjects. For example, the study item "strawberry jam" was changed to either a synonym (raspberry jam) or homonym (traffic jam) for the test phase. Their findings indicated that both changes produced a decrease in hit rate (recognition of jam as an old word) compared with a control group which received the same item for study and test. This decrease was significantly greater when the item was changed to a homonym than when it was changed to a synonym. While any change in context would be expected to decrease recognition performance according to the Encoding Specificity Hypothesis of Tulving & Thomson (1971), the significant difference in performance based on the type of change (synonym versus homonym) would not be expected.

In another study, Perfetti & Goodman (1970) presented subjects with a list of sentences, each cuing one meaning of a homonym. They predicted that subjects would later falsely recognize only that associate (i.e., semantically related word) which was related to the particular meaning of the homonym which was cued by the context in the sentence presented for study. It was also predicted that the associate related to the meaning of the homonym which was NOT cued at presentation would be correctly identified as a new item. These predictions were based on the Prior Decision Model of homonym processing. For example, subjects hearing the homonym 'country' embedded in the sentence, 'Many families rent a house in the country for the summer months.' were predicted to falsely recognize the the associate 'city' but not the associate 'nation' as old words. Their results were consistent with these predictions. That is, false recognitions occurred significantly more often with the associate related to the meaning cued by the study sentence than with the noncued associate. There was, however, a nonsignificant trend for noncued associates to be falsely recognized more often than neutral control words. The authors concluded on the basis of their study that sentences constrain the meaning of the homonyms which occur in them, but that this constraint may not be complete when there is some overlap of meaning.

According to Perfetti & Goodman, "ideal" homonyms (i.e., those with completely independent meanings) would be fully constrained in meaning by the context of the sentence in which they occurred.

Both the Light & Carter-Sobell and Perfetti & Goodman studies provide support for a model, such as the Prior Decision Model, which predicts limited processing of ambiguous words. This model, however, has processing restricted to only one meaning in instances where a determining context is absent. That is, limited processing is not restricted to those instances in which a biasing context cues one meaning of the homonym. Rather, in all instances one and only one meaning is processed. Neither of the former studies provides a satisfactory test of this prediction of the Prior Decision Model.

Winograd & Conn (1971) presented a list of homonyms to subjects and later asked them to recognize these words in sentences. The test sentences cued either a high or low frequency meaning. Results indicated that recognition performance was better for those subjects receiving the high frequency context at test. The performance of subjects in the no context condition did not differ from that of the high frequency context group. The authors regarded this as evidence for limited processing of unmodified homonyms, concluding that even when presented without a biasing context, homonyms are processed in terms of a single meaning (the most frequently used meaning).

A study by Kollasch & Kausler (1972), however, suggests that the processing of homonyms may not always be consistent with the Prior Decision Model. They hint that the particular model which is appropriate may depend upon some characteristic of the homonyms being studied. In their study, a recognition technique was used to examine the processing of homophones (e.g., pane, pain). The study list was presented aurally, followed by a visual test list in which the test item cued either the high or low frequency meaning of the homophone. The degree of homophone dominance was determined by the disparity of frequencies of the meanings. For example, the primary form (pain) occurred 85% of the time whereas the secondary form (pane) occurred 15% of the time. In contrast, the different frequencies for "loan" and "lone" were 55% and 45%, respectively (Galbraith & Taschman, 1969). The former type of homophone pair was called 'polarized,' the latter type 'balanced.' The results of Kollasch & Kausler's study were that false recognitions (defined as falsely calling an old word new) were more frequent for the secondary than primary form of polarized homophones. Where the frequencies of the primary and secondary forms were more similar (balanced homophones), there was no difference in the false recognition rate. Kollasch & Kausler concluded that the amount of information activated or recency tagged at presentation must differ for polarized and balanced homophones. Both meanings of balanced homonyms may be activated, whereas polarized homonyms are processed in terms of a single meaning.

Using Kollasch & Kausler's (1972) distinction between polarized and balanced homonyms, Winograd & Geis (1974) employed a recognition task to test subjects' memory for homographs. Contrary to their prediction, based on Encoding Variability Theory (Martin, 1968), recognition memory for balanced homographs was greater than that for polarized homographs across all retention intervals tested. This finding, also, may point to processing differences for balanced and polarized homonyms. The more accurate recognition of balanced than polarized homonyms may well be due to the activation of both meanings of balanced homonyms, whereas only one meaning (the dominant one) was activated for polarized homonyms.

To summarize, it would appear that the data from recognition memory studies are reasonably consistent with a limited processing model such as the Prior Decision Model. The last two studies described, however, point to the possibility that for balanced homonyms, at least, more information may be activated.

It has been suggested (Conrad, 1974; Bever, Garrett, & Hurtig, 1973) that recognition studies may not provide an accurate measure of the information activated during homonym processing, since recognition tasks test the result of processing. Another group of techniques which has been used to study homonym comprehension is designed to measure the complexity of homonym processing while that processing is in progress.

On-going Processing Studies

The use of these techniques to study the amount of information activated during homonym comprehension depends upon the assumption of a limited-capacity, short-term (or working) memory. While there has been some recent questioning of this limited-capacity assumption (Neisser, 1976), it currently remains a component of most information processing models. As previously indicated, these models share the assumption that comprehension of a word involves the activation of its representation in semantic memory (Foss, 1969; Rubinstein, Garfield & Millikan, 1970). This information is then transferred to working memory where it is used for the particular task at hand. The greater the amount of information activated, and then transferred, the greater the demands placed on STM capacity.

The use of on-going processing techniques involves having subjects perform two tasks at once. The primary task is one involving language comprehension. The secondary task is one requiring some degree of attentional capacity. Often a reaction time (RT) task is used, with the signal being either a part of the sentence or an unrelated stimulus superimposed on the sentence. It is assumed that performance on the RT task will be a function of the processing load required by the comprehension task (Foss, 1969). As the amount of information activated from semantic memory increases, the processing demands on STM increase. This greater use of STM capacity will be reflected in delayed or impaired performance on the second task. In short, RT will vary as a function of processing complexity at the moment of occurrence of the RT signal.

Rubenstein, Garfield & Millikan (1970) employed an on-going processing technique in a study in which subjects were asked to distinguish between English and nonsense words. The response measured was the time from word presentation to the subject's response -- 'yes' or 'no.' Of particular interest to the present discussion was the authors' finding that homonyms were recognized more quickly than were nonhomonyms. This might have been the result of multiple representation of homonyms in the lexicon (semantic memory). The greater the number of entries in the lexicon, the more likely that one of these entries will be found quickly. The authors noted a trend for homonyms with more than two meanings to be recognized more quickly than homonyms with only two meanings. Thus, it would appear that the different meanings of homonyms may be represented independently in semantic memory. How many of these different entries are activated becomes an intriguing question.

Another method which has been used to examine this question is the Stroop task (Stroop, 1938; Warren, 1972). This technique involves the presentation of a triad of words belonging to a single category (e.g., aunt, uncle, cousin). Following this, a word printed in colored ink is presented to the subject, who is required to name the color as quickly as possible. If this word is one of those in the previously presented triad, or is the category name to which the triad belongs, the latency of color-naming exceeds that for unrelated control words. This led to the inference that category names are activated when such triads are presented. More generally, color-naming reaction time is increased for any word which was activated during triad presentation.

Conrad (1974) used a variation of the Stroop task, with sentences rather than triads, to examine how much information is activated in sentence comprehension. Conrad presented homonyms in sentences which biased their interpretation (e.g., The toy costs a nickel.). The test item, which was presented in colored ink, was either the homonym (nickel), the appropriate category name (money) or the inappropriate category name (metal). Her results provide support for the Choice Point Decision Model. Interference in color-naming was found for both the appropriate and inappropriate category names. In order for this to occur, both meanings of the homonym must have been activated during sentence comprehension, despite the fact that each sentence biased only one meaning of the homonym.

Another on-going processing technique which has been used to study homonym processing is phoneme monitoring (Foss, 1970; Foss & Jenkins, 1973). This technique assumes that in order to understand a sentence, the words within it must be analyzed, not only semantically, but phonologically and grammatically. These analyses however are not assumed to be independent. Rather, an overall analysis involves a number of inter-dependent subanalyses which take up STM capacity. Changes in the difficulty of one level of analysis result in increased use of STM capacity and therefore the speed and accuracy at other levels suffers. This assumption was supported by Foss (1969) and Foss & Lynch (1969), whose studies demonstrated that RT to a specific phoneme (/b/) varied as a function of word frequency, target position, and surface structure complexity. Foss (1970) also demonstrated that phoneme monitoring and ambiguity identification use dependent processes.

Foss & Jenkins (1973) used this technique to examine homonym processing. Following the above reasoning, the RT to a phoneme should vary as a function of the difficulty of semantic processing, which in turn is a function of the amount of information activated in semantic memory. Therefore, if the Prior Decision Model is correct, one would expect no difference in phoneme monitoring latency between homonyms and unambiguous control words. If, however, the Choice Point Decision Model is appropriate, then latency should be longer when the phoneme follows a homonym since the semantic processing load is greater and therefore uses up more STM capacity. Foss & Jenkins (1973) tested these predictions using sentences which either biased one meaning of the homonym or were neutral with respect to which meaning was appropriate. The results obtained did not provide support for the Prior Decision Model. Reaction times were longer following ambiguous words in both biased and neutral contexts.

Data from both the Conrad (1974) and Foss & Jenkins (1973) studies support the Choice Point Decision Model over the Prior Decision Model (in contrast to the previously mentioned recognition memory studies). Their data do not, however, rule out the Ordered Search Model of homonym processing since neither study determined the frequency of occurrence of the different meanings of the homonyms used. Hogaboam & Perfetti (1975) tested their model of homonym processing by requiring subjects to decide if a homonym presented in a sentence had another meaning. The Choice Point Decision Model does not predict any difference in this decision time across contexts, whereas the Ordered Search Model predicts longer latencies when the homonym occurs in its dominant context. The authors' data agreed with the prediction of the Ordered Search Model. Further, the difference in latencies was greater the more dominant the homonym's primary sense.

Finally, it should be noted that there has been some support for the Prior Decision Model using on-going processing techniques. Schvaneveldt, Meyer & Becker (1976) used a lexical decision task to evaluate the models of homonym processing. Subjects were presented with a number of triads of letters (either words or nonsense strings) and required to indicate whether each was a word. The latency of recognizing semantically related words (e.g., day-date-time) was found to be shorter than that for unrelated words (e.g., fig-bank-time). If a multiple meaning model (which the authors called nonselective access model) is appropriate, then recognition of triads such as RIVER-BANK-MONEY should be facilitated (since bank was processed in terms of both meanings). If the Prior Decision Model is more appropriate prior context (river) should limit the processing of the homonym (bank) and, therefore, restrict the relationship between bank and money -- decision times would be longer. The data supported the latter hypothesis. The presence of a homonym did facilitate the recognition of a word related to one of its meanings, however not when the initial word cued the inappropriate meaning of the homonym.

In contrast to recognition studies, results obtained using on-going processing techniques have generally (although not unanimously) supported the Choice Point Decision Model. The current study, to be described in the following section, attempts to resolve some of these discrepancies.

Rationale for Present Study

In attempting to explain the inconsistency of findings regarding homonym processing models, it seems reasonable to consider three possible sources: (1) differences in methods of measuring processing, (2) differences among homonyms with respect to frequencies of dominant meanings, and (3) differences in biasing contexts used. In what follows, each of these possible sources is examined. In general, recognition memory studies support a Prior Decision Model whereas on-going processing studies support a Choice Point Decision Model. It has been suggested (Garret, 1970) that this pattern of results is a function of the stage of processing tested. Those studies which look for effects of processing after it is complete tend to support one-meaning models; those which examine such effects while processing is still in progress support multiple-meaning models. Thus, it may not be unreasonable to suggest that the disparate results of recognition memory studies and on-going processing studies are in some sense not as contradictory as they first appear. For example, it may be that homonyms are processed in terms of more than one meaning but that any ambiguity which occurs is resolved by the time recognition memory studies test for processing effects. Specifically, it is possible that multiple meaning activation may occur at the time of presentation of a homonym, but that only the evidence of the finally selected meaning is preserved in LTM. It is this latter representation that is tapped in recognition memory studies. If this is so, it would not be surprising to find that on-going processing studies, which examine processing effects in progress, support the Choice Point Decision Model; whereas recognition studies which examine processing effects "after the fact," appear to support the Prior Decision Model. Each method examines the same phenomenon but at different stages in its evolution. One way of examining this possibility would be to test a group of subjects both during and following processing. Should these two sets of results differ, the foregoing hypothesis would be strengthened.

A second possible source of inconsistency in homonym processing studies has been most clearly articulated by Hogaboam & Perfetti (1975), who suggest that a clear understanding of homonym processing requires a classification of homonyms with respect to the degree of dominance of their primary meaning. As stated previously, polarized homonyms are those which have a large difference in frequency of usage between primary and secondary meanings; balanced homonyms are those whose meanings are about equiprobable (Winograd & Geis, 1974). Studies which have sorted items into polarized and balanced homonyms (Kollasch & Kausler, 1974; Winograd & Geis, 1974; Hogaboam & Perfetti, 1975), have typically concluded that homonyms of the latter type require more processing than the former. All other studies reviewed failed to distinguish homonyms on this dimension. It would seem prudent, therefore, for any study of homonym processing to consider the polarized - balanced dichotomy and its ramifications for appropriate explanatory models.

The final possible source of confusion in interpreting the results of homonym processing experiments relates to the manipulation of context. Models of homonym processing differ with respect to hypothesized effects of context. The Prior Decision Model suggests that context functions to disambiguate the homonym before lexical look-up; the Choice Point Decision Model has disambiguation occurring after lexical activation. In terms of on-going measures of processing, these differences would most probably be reflected in differences between homonym and control word latencies. The Prior Decision Model predicts no difference in these latencies; the Choice Point Decision Model predicts consistently longer latencies for homonyms than for control words. Further, in order for the Choice Point Decision Model to be supported, this difference in latencies must be consistent in both biased and neutral contexts (i.e., context cannot affect the amount of information processed). While Foss & Jenkins (1973) tested this assertion, it should be noted that their biased contexts did not preclude activation of the unintended meanings of homonyms. Either meaning of the homonym was possible in the biased context, but one meaning was judged to be more likely to be activated. A strong test of the Choice Point Decision Model requires that biased contexts be used in which only one meaning of the homonym would be appropriate.

The present study attempted to take account of the foregoing points in a design which was intended to clarify the effects on homonym processing of differences between polarized and balanced homonyms, and differences in biasing contexts. In addition, both recognition memory and on-going processing measures of homonym processing were employed. A list of sentences, containing a homonym or unambiguous control word was presented aurally. Subjects were required to perform a phoneme-monitoring task while listening to the sentences. This was followed immediately with a recognition memory task. The homonyms used were identified as polarized and balanced (using the Perfetti, Lindsey & Garson, 1971, Norms of Association and Uncertainty), and the biasing sentences were constructed so that only one meaning of the homonym was appropriate in any one sentence. This ensured a strong context condition within which to test the models.

Predictions

The specific predictions generated from the three models of homonym processing are presented separately for each model.

Prior Decision Model. Results of the recognition task will show no difference in the overall false alarm rate across context conditions. A higher false alarm rate will be observed to those associates related to the meaning of the homonym cued at study. Specifically, the dominant and ambiguous context conditions will show a greater false recognition rate to associates of the dominant than secondary meanings. The secondary context condition will produce a higher false recognition rate to associates of the secondary than dominant meanings.
The phoneme monitoring task will produce no difference in RT as a function of context. These predictions are based on the assumption that context determines the meaning activated when biased sentences are presented. In an ambiguous context, the most frequent (dominant) meaning will be processed.

Choice Point Decision Model. Since all meanings are processed, there will be no difference in false recognition rates across all contexts and no difference in the false alarm rate for associates of the dominant and secondary meanings. RT in the phoneme monitoring task will not differ across all contexts. RT will be longer for homonyms than for control words, since all meanings are activated regardless of context.

Ordered Search Model. The false alarm rate will be greater to associates of the dominant than secondary meanings of homonyms presented in the dominant context. False alarms will be equal to associates of dominant and secondary meanings for homonyms presented in secondary or ambiguous contexts. RTs will vary as a function of the context in which homonyms are presented. There will be no difference in RTs between polarized homonyms in their dominant context and control words. RTs for polarized homonyms presented in secondary and ambiguous contexts will be longer than those for control words. RTs for balanced homonyms will be longer than those for control words across all contexts.

Method

Subjects

Sixty subjects (27 males and 33 females) participated in the experiment. All were enrolled as undergraduate students at Simon Fraser University. Subjects volunteered to participate and were paid $2.00 for their services.

Stimulus Items

Phoneme Monitoring Task. Eighteen homonyms were selected from the Perfetti et al. (1971) Norms of Association to Ambiguous Words, according to the following criteria:

(1) A word was not used if the different meanings required it to be used in different grammatical categories. For example, the word 'water' can be used as a noun or a verb to convey different meanings. Words such as this were eliminated from the word pool.

(2) A word was not used if it contained the letter 'b.' This was necessary since the phoneme for which subjects would be listening during the phoneme monitoring task was 'b.'

(3) A word was not used if its meanings were judged by the author to overlap substantially (for example, mad -- angry or insane). This was

necessary since the advantage in studying homonyms over other words in an attempt to understand human information processing lies in the relative independence of a homonym's meanings.

The 39 words remaining after applying the above restrictions were divided into polarized and balanced categories. Those words whose dominant meaning was indicated by at least 60% of the subjects tested by Perfetti et al. (1971) were labelled polarized homonyms. Those whose dominant meaning was indicated by less than 60% of subjects tested were labelled balanced homonyms. Nine polarized and nine balanced homonyms were chosen from these categories.

Three sentences were constructed for each homonym. One sentence biased the meaning of the homonym to its dominant meaning [dominant context], a second sentence was biased toward the secondary meaning [secondary context], and a third sentence was ambiguous [amgibuous context] (i.e., either meaning of the homonym provided a possible and appropriate interpretation of the sentence). The sentences were constructed so that the first part of the sentence biased the homonym, which occurred in the middle of the sentence. The homonym was followed immediately by a word beginning with the letter 'b.' This 'b' word began a phrase that completed the sentence. Sentences in these three context classes were matched as closely as possible on the number of words preceding the homonym, and grammatical structure, to minimize any differences in sentence complexity. Thus, a total of 54 sentences were constructed, three for each of 18 homonyms.

To permit the construction of additional sentences which would act as controls for the homonym sentences, control words were selected which matched the 18 homonyms on frequency of occurrence. Frequency measures for the homonyms were obtained from the Kucera and Francis (1967) norms. One control word was selected for each homonym such that the control word and homonym matched as closely as possible on frequency. When more than one control word was available, the word selected was that one which was: (1) unambiguous, (2) in the same grammatical class as the homonym, and (3) nearest in physical proximity to the homonym (on the Kucera and Francis lists). Finally, one sentence was constructed for each of the 18 control words. The control sentences were constructed to match the appropriate group of homonym sentences (i.e., the group of three context sentences for the frequency-matched homonym) on number of words and grammatical complexity. In total, 72 sentences were constructed; 3 context sentences and 1 control sentence for each of 18 homonyms. An example may serve to clarify this. The sentences for the balanced homonym PUPIL and its matched control word PIONEER were:

In strong light the pupil became smaller. [Dominant]

In exam rooms the pupil became nervous. [Secondary]

In a moment the pupil began to react. [Ambiguous]

In the winter the pioneer became inactive. [Control]

The ambiguous sentences were tested on a group of five pilot subjects to ensure that both interpretations of each sentence were in fact possible and plausible. If all subjects indicated the same interpretation of a sentence it was not considered ambiguous. If, however, at least one subject indicated the alternate interpretation of the sentence, it was considered to be ambiguous. Using this criterion, 6 sentences were determined to be unsatisfactory (i.e., they were not ambiguous). These sentences were changed, and all sentences were tested on a further group of five subjects. At the second testing, all 18 sentences were judged to be ambiguous.

Finally, ten filler sentences were constructed which were unrelated in meaning to the other 72 sentences and in which the 'b' phoneme occurred in either the first or the last part of the sentence. These were included to decrease the predictability of the location of the 'b' phoneme in the sentences and thus to decrease a bias toward responding in the middle of a sentence whether or not a 'b' phoneme was heard. These filler sentences brought the total number of sentences to 82: three context sentences per homonym (54), 18 control sentences, and 10 filler sentences. Any one subject in the experiment heard 46 of these sentences: 18 context sentences of a specific context type, 18 control sentences, and 10 filler sentences.

To determine the order in which sentences were presented to subjects, the 82 sentences were labelled numerically. The three context sentences per homonym were labelled with the same number, but different subscripts -- e.g., 1_1 was the dominant context sentence for homonym 1, 1_2 was the secondary context sentence for homonym 1, and 1_3 was the ambiguous context sentence for homonym 1. The labels for the context sentences, thus, ran from 1 to 18 with three subscripts per number. Control sentences were labelled 19 to 36 and filler sentences were labelled 37 to 46.

Forty-six paper squares, each bearing a number from 1 to 46, were selected randomly without replacement and the numbers recorded in the order of selection with the constraint that no more than five of any one sentence type (i.e., balanced homonym, polarized homonym, control, or filler) occurred in each half of the list. This was deemed necessary to minimize the possibility of practice and fatigue effects confounding any differences in sentence types. This order became the order in which the sentences were presented to one-half of the subjects. A second order was obtained by splitting the first order in half, and moving the second half to the beginning. In this manner, it was assumed that practice and fatigue effects would be counterbalanced across the two presentation orders. Each subject heard only the 18 context sentences of the specific context type to which he had been assigned. But while different sets of context sentences were presented to different subjects, the generic (numerical) order of these was constant across subjects within each order.

Recognition Memory Task. Stimuli for the recognition memory part of the experiment consisted of 108 words. For each of the 18 homonyms used in the phoneme monitoring task, the most frequent associate (i.e., the most frequently given response to the homonym) for each homonym meaning was taken from the Perfetti et al. (1971) norms. Nine of these associates were homonyms themselves, and had therefore to be replaced with a less frequent associate. Thus, 36 words, 2 for each homonym were labelled as "new associates." An additional 36 words served as a baseline for false recognitions (saying "old" to a new word) in the recognition memory task. This baseline provided a measure of "unexplained" or "guessing" false recognitions against which the false recognitions to new associates were compared. These "unrelated new words," which were obtained by selecting one word to match each new associate on frequency of occurrence (Kucera & Francis, 1967), were unrelated to the meanings of the sentences in the phoneme monitoring task. Finally, 36 words were taken at random from the control sentences to serve as "old words" in the recognition memory task. (Articles and pronouns were not included.)

Each word was assigned a number from 1 to 108, and these numbers were picked randomly without replacement to obtain an order of presentation. This initial order was adjusted to obtain an equivalent number of old and new words in each half. A second order was obtained by splitting the first list in half and interchanging the order of the halves.

Taping and Equipment

Phoneme Monitoring Task. Six different tapes were made, each containing 46 sentences: one tape for each combination of two sentence orders and three context types. All tapes were recorded by the author on a Sony reel-to-reel tape recorder, Model No. 252. A signal was then placed on the second channel using a Kodal Carousel Sound Synchronizer, Model 2. The signal was placed simultaneously with the occurrence of each 'b' phoneme on the first channel. This signal started a Datel DSC 8200 Digital Stop Clock which was stopped by the subject's pressing a hand-held button. The simultaneity of the signals and the 'b' phonemes was checked auditorially by playing both channels through speakers. If they occurred simultaneously, the 'b' phoneme was inaudible because it was obscured by the louder signal.

A five second pause occurred between the end of one sentence and the beginning of the next.

Recognition Memory Task. Two recognition tapes were recorded on a Sony cassette recorder, Model No. 110B, one for each recognition order. A five second delay occurred between words.

Procedure

Subjects were assigned a number which corresponded to their order of appearance for the experiment. The particular context and order combinations they received for the phoneme monitoring and recognition memory tasks were predetermined by the unsystematic assignment of subject numbers to conditions. Subject numbers 1 to 60 were selected randomly without replacement and assigned to a condition with the constraint that all conditions received the same number of subjects.

All subjects were asked to read a brief description of the experiment and instructions for participating in the experiment. The phoneme monitoring task required that subjects listen to each sentence for the phoneme 'b.' Upon hearing this phoneme, subjects pressed a button as quickly as possible. A set of nine practice sentences was played during which subjects pressed the button upon hearing 'b.' Following this practice, any questions about the task were answered, a consent form was signed, and subjects were reminded that they would later be asked to recognize some of the words in the sentences.

One of the tapes of 46 sentences was played for each subject during which the subject performed the phoneme monitoring task. Upon completion of this task, the subject was reminded of the nature of the recognition task. One of the tapes of 108 words was played and the subject was required to respond OLD if the word had occurred in the previous tape, NEW if the word had not. Guessing was encouraged by instructing subjects to guess either OLD or NEW whenever they were uncertain.

The two parts of the experiment occupied a total of thirty minutes. All responses were recorded by the experimenter.

Design

The experiment employed a five-way mixed design. The factors and their levels were: Context (Dominant, Secondary, Ambiguous), Sentence Order (Order 1, Order 2), Recognition Task Word Order (Order 1, Order 2), Word Type (Homonym, Control), and Dominance (Balanced, Polarized). Subjects were nested under Context, Sentence Order, and Word Order, and crossed with Word Type and Dominance. The dependent variables were latency of the button press for the phoneme monitoring task, and hit and false alarm probabilities for the recognition memory task.

Results

The results for the recognition memory and phoneme monitoring tasks will be treated separately.

Recognition Memory Task

Subjects' responses to words in the recognition list were identified as hits (saying "old" to an old word) or false alarms (saying "old" to a new word). Six different types of false alarms were possible, differentiated by the characteristics of the new words. These six types of false alarms resulted from the six combinations of three levels of Dominance (Balanced Homonym, Polarized Homonym, Control) and two Associate Types (Dominant Meaning Associate, Secondary Meaning Associate). For each subject, the probability of a hit and six false alarm probabilities were calculated.

Mean false alarm probabilities (pFA) are presented in Table I as a function of Context, Dominance, and Associate Type. An examination of this table reveals that false alarms occurred more often to associates of homonyms than to unrelated control words. In addition, dominant meaning associates produced more false alarms than secondary meaning associates.

Table I. Mean pFA as a function of Context, Dominance, and Associate Type.

Context	Associate Type	Balanced	Polarized	Control	Row Means
			Dominance		
Dominant	Dominant	.63	.38	.26	.42
	Secondary	.25	.49	.22	.32
Secondary	Dominant	.60	.44	.33	.46
	Secondary	.39	.52	.25	.39
Ambiguous	Dominant	.53	.34	.25	.37
	Secondary	.28	.32	.22	.27
Column Means		.45	.41	.26	

In order to test the significance of these trends a five-way analysis of variance was performed on the false alarm probabilities. The five independent variables and their levels were: Context (Dominant, Secondary, Ambiguous), Sentence Order (Order 1, Order 2), Word Order (Order 1, Order 2), Dominance (Balanced, Polarized, Control), and Associate Type (Dominant Meaning Associate, Secondary Meaning Associate). The results of this analysis are summarized in Table II.

Both trends noted above were found to be significant. Furthermore, a significant Dominance by Associate Type interaction was observed, resulting from the fact that false recognitions occurred most often to the Dominant Meaning Associates of Balanced Homonyms, and to the Secondary Meaning Associates of Polarized Homonyms. The three-way interaction of Context, Dominance and Associate Type appears to have resulted principally from the decreased false alarm rate to Secondary Meaning Associates of Polarized Homonyms heard in the Ambiguous Context as compared to their false alarm rate in the Dominant and Secondary Contexts.

Table II. Source Table for Analysis of Variance of pFA as a function of Context, Sentence Order, Word Order, Dominance, and Associate Type.

Source	SS	df	MS	F	p
Between Subjects					
Context (C)	0.58	2	0.29	2.22	-
Sentence Order (O)	0.93(E-03)	1	0.93(E-03)	0.01	-
Word Order (R)	0.17	1	0.17	1.27	-
CO	0.36	2	0.18	1.36	-
CR	0.79(E-01)	2	0.39(E-01)	0.30	-
OR	0.54(E-01)	1	0.54(E-01)	0.41	-
COR	0.11	2	0.55(E-01)	0.42	-
S(COR)	6.31	48	0.13		
Within Subjects					
Dominance (D)	2.46	2	1.23	71.88	<.001
CD	0.14	4	0.35(E-01)	2.04	-
OD	0.23(E-01)	2	0.11(E-01)	0.67	-
RD	0.79(E-01)	2	0.39(E-01)	2.30	-
COD	0.53(E-01)	4	0.13(E-01)	0.77	-
CRD	0.29(E-01)	4	0.72(E-02)	0.42	-
ORD	0.42(E-01)	2	0.21(E-01)	1.24	-
CORD	0.16	4	0.39(E-01)	2.30	-
SD(COR)	1.64	96	0.17(E-01)		
Associate Type (A)	0.76	1	0.76	45.40	<.001
CA	0.22(E-01)	2	0.11(E-01)	0.64	-
OA	0.36(E-02)	1	0.36(E-02)	0.21	-
RA	0.16(E-04)	1	0.16(E-04)	0.001	-
COA	0.10	2	0.50(E-01)	3.07	-
CRA	0.80(E-01)	2	0.40(E-01)	2.38	-
ORA	0.63(E-01)	1	0.63(E-01)	3.77	-
CORA	0.73(E-01)	2	0.36(E-01)	2.16	-
SA(COR)	0.81	48	0.17(E-01)		
DA	1.77	2	0.88	53.83	<.001
CDA	0.23	4	0.59(E-01)	3.57	<.05
ODA	0.11(E-01)	2	0.55(E-02)	0.34	-
RDA	0.61(E-01)	2	0.31(E-01)	1.87	-
CODA	0.18(E-01)	4	0.44(E-02)	0.27	-
CRDA	0.31(E-01)	4	0.79(E-02)	0.48	-
ORDA	0.87(E-01)	2	0.43(E-01)	2.65	-
CORDA	0.25(E-01)	4	0.62(E-02)	0.38	-
SDA(COR)	1.58	96	0.16(E-01)		

Phoneme Monitoring Task

Each subject heard forty-six sentences; nine contained a balanced homonym, nine contained a polarized homonym, nine were control sentences matched to balanced homonym sentences, nine were control sentences matched to polarized homonym sentences, and ten were filler sentences. Reaction times (RTs) to the 'b' phoneme in these sentences were recorded. RTs for filler sentences were discarded. From the remaining thirty-six RTs for each subject, median RTs were computed for each subject for each of the four word types (balanced/polarized homonym/control words).

Choice of measure. Because RT distributions often display a high degree of positive skew, a preliminary analysis was carried out to investigate whether the distribution of mean RTs satisfied the assumption of homogeneity of variance necessary for analyses of variance. F max tests revealed a violation of this assumption. When the same tests were applied to the distribution of median RTs, the homogeneity of variance assumption was fully satisfied. For this reason, median RT was chosen as the dependent variable for the phoneme monitoring task. (To avoid cumbersome phrasing, the terms "RT" and "average RT" will be used to signify "median RT" and "the arithmetic mean of the median RTs", respectively.)

Missing data. On a few occasions, either a subject offered no response or the response was insufficient to stop the timer, and no RT was measured. This occurred on approximately 2.7% of all trials. Fifty-seven of the sixty subjects had two or fewer missing RTs, while the remaining three subjects each had three missing RTs. The effect of these missing data was thus to reduce the number of measures contributing to each median RT from nine to no fewer than six. Since this occurred on so few trials, no attempt was made to estimate or replace these missing RTs.

Analyses of variance of RT. The context factor (dominant, secondary, ambiguous) differed in the definition of its levels for the control and experimental (homonym) sentences. For control sentences, context refers to the particular group of forty-six sentences assigned to a subject. The control sentences themselves did not vary from one context level to another. For sentences containing homonyms, however, context refers to a characteristic of the specific sentence in which the homonym was embedded. That is, subjects in different context conditions heard different sentences for homonyms, but the same control sentences. Because of this difference, it was deemed appropriate to apply two separate analyses of variance to the RTs for the control and experimental sentences.

(i) Control sentences. A 3x2x2 analysis of variance was applied to control sentence RTs, the factors being context (C: Dominant, Secondary, Ambiguous), Sentence Order (O: Order 1, Order 2) and Dominance (D: Balanced, Polarized). Note that the levels of the Dominance factor define control words that were matched to balanced or polarized homonyms. Average RTs for these three factors for control sentences are shown in Figure 1. The results of the analysis of variance, which are summarized in Table III, show that both Context and Sentence Order produced significant effects on RT. Subjects assigned to the Dominant Context produced slower RTs (average 348 msec.) than those assigned to the Secondary (average 297 msec.) or Ambiguous (average 304 msec.) Context conditions. Subjects receiving Sentence Order 1 produced longer RTs on average (336 msec.) than those receiving Sentence Order 2 (298 msec.). In addition, a significant Context by Dominance interaction was obtained. RTs to polarized control words were longer in the Dominant and Secondary Context conditions than in the Ambiguous Context condition, while for balanced control words longer RTs were found to occur in the Dominant and Ambiguous Context conditions than in the Secondary Context condition.

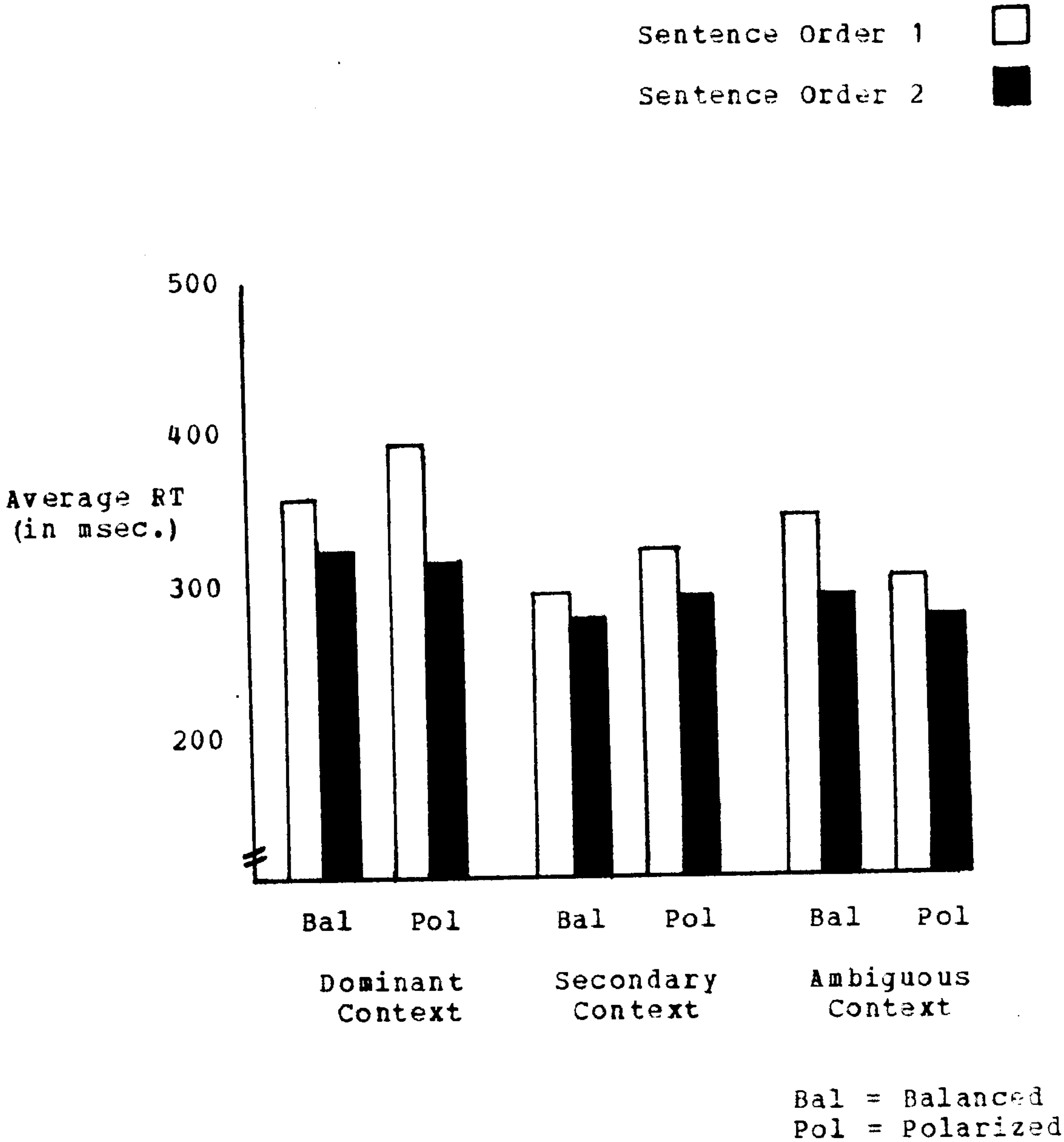

Figure 1. Average RT for Control Sentences as a function of Context, Sentence Order, and Dominance.

Table III. Source Table for Analysis of Variance of RT for Control Sentences as a function of Context, Sentence Order, and Dominance.

Source	SS	df	MS	F	p
Between Subjects					
Context (C)	60,960.5	2	30,480.2	5.60	<.01
Sentence Order (O)	43,358.0	1	43,358.0	7.92	<.01
CO	5,095.9	2	2,548.0	0.47	-
S(CO)	295,503.8	54	5,472.3		
Within Subjects					
Dominance (D)	161.0	1	161.0	0.17	-
CD	14,517.8	2	7,258.9	7.73	<.01
OD	310.4	1	310.4	0.33	-
COD	5,678.7	2	2,839.3	3.02	-
SD(CO)	50,720.0	54	939.3		

(ii) Experimental Sentences. A corresponding 3 (Context) x 2 (Sentence Order) x 2 (Dominance) analysis of variance of RT was carried out for the experimental (homonym) sentences. Figure 2 shows the pattern of average RTs as a function of these factors, while Table IV summarizes the results of the analysis of variance. As was the case with control sentences, latencies were significantly slower in Sentence Order 1 (386 msec.) than Sentence Order 2 (343 msec.). The magnitude of this effect was similar for the two sets of sentences (control: 38 msec., experimental: 43 msec.). The longer average RT for balanced homonyms (379 msec.) than polarized homonyms (350 msec.) was reflected in a significant main effect of Dominance. The size of this difference varied across contexts, however, as indicated by the significant Context by Dominance interaction. Inspection of Figure 2 reveals that RTs for Balanced Homonyms were longer than those for Polarized Homonyms in the Dominant and Ambiguous Contexts, but not in the Secondary Context. Finally, the fact that this latter pattern of results was much more pronounced in Order 1 than Order 2 led to a significant triple interaction of Context, Sentence Order, and Dominance.

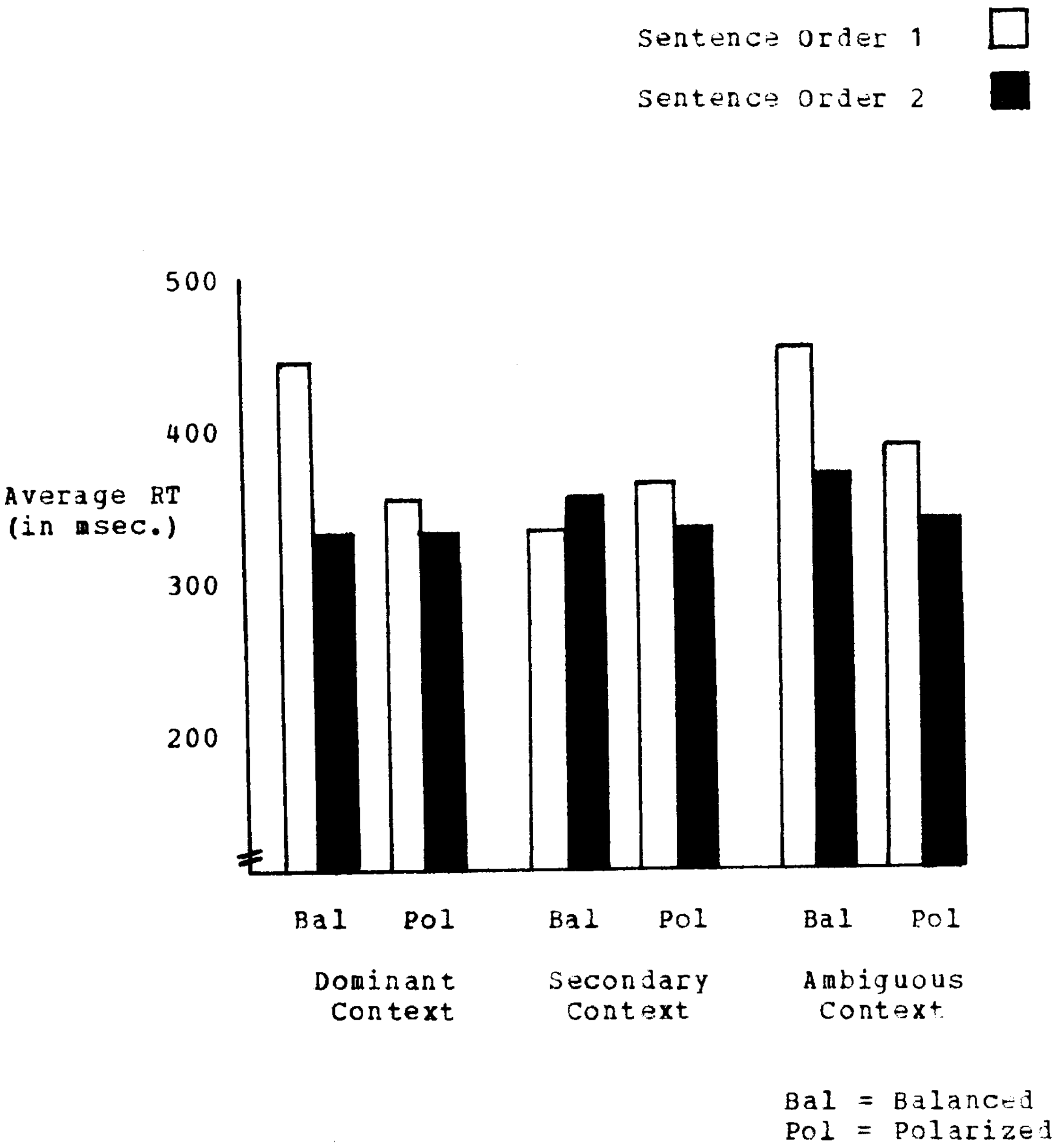

Figure 2. Average RT for Experimental Sentences as a function of Context, Sentence Order, and Dominance.

Table IV. Source Table for Analysis of Variance of RT for Experimental Sentences as a function of Context, Sentence Order, and Dominance.

Source	SS	df	MS	F	p
Between Subjects					
Context (C)	35,537.9	2	17,769.0	1.64	-
Sentence Order (O)	57,465.6	1	57,465.6	5.32	<.05
CO	25,112.5	2	12,556.3	1.16	-
S(CO)	583,430.4	54	10,804.3		
Within Subjects					
Dominance (D)	25,637.6	1	25,637.6	10.58	<.01
CD	15,457.8	2	7,728.9	3.19	<.05
OD	7,873.2	1	7,873.2	3.25	-
COD	23,155.0	2	11,577.5	4.78	<.05
SD(CO)	130,872.1	54	2,423.6		

In order to provide a direct comparison of RTs for experimental and control sentences, it was intended to apply a four-factor analysis of variance to the RT data, with the factors being Context (Dominant, Secondary, Ambiguous), Sentence Order (Order 1, Order 2), Word Type (Homonym, Control), and Dominance (Balanced, Polarized). However, since the previous analyses both showed Sentence Order to have a significant effect on RT, it was decided to separate the planned four-factor analysis into two three-factor analyses, one for each Sentence Order.

(iii) Sentence Orders 1 and 2. The results of the 3 (Context) x 2 (Word Type) x 2 (Dominance) analyses of variance of RT for Sentence Orders 1 and 2 are provided in Tables V and VI, respectively. Both analyses showed a significant main effect for Word Type and a significant Context and Word Type interaction. Average RT was longer for homonyms than control words for both sentence orders (Order 1: Homonyms, 386 msec.; Control words, 336 msec./Order 2: Homonyms, 343 msec.; Control words, 298 msec.). However, as indicated by the significant Context by Word Type interaction, this difference in average RT between homonyms and control words varied as a function of context, increasing in magnitude from the Dominant to Secondary to

Table V. Source Table for Analysis of Variance of RT as a function of Context, Word Type, and Dominance for Sentence Order 1.

Source	SS	df	MS	F	p
Between Subjects					
Context (C)	70,566.3	2	35,283.1	1.72	-
S(C)	552,724.3	27	20,471.3		
Within Subjects					
Word Type (W)	77,266.8	1	77,266.8	44.27	<.001
CW	33,879.1	2	15,939.6	9.71	<.001
SW(C)	47,122.1	27	1,745.3		
Dominance (D)	11,940.1	1	11,940.1	4.10	-
CD	33,377.2	2	16,688.6	5.73	<.01
SD(C)	78,663.2	27	2,913.5		
WD	19,482.0	1	19,482.0	13.16	<.01
CWD	20,730.8	2	10,365.4	7.00	<.01
SWD(C)	39,961.0	27	1,480.0		

Table VI. Source Table for Analysis of Variance of RT as a function of Context, Word Type, and Dominance for Sentence Order 2.

Source	SS	df	MS	F	p
Between Subjects					
Context (C)	2,282.5	2	1,141.3	0.13	-
S(C)	243,878.8	27	9,032.4		
Within Subjects					
Word Type (W)	60,750.0	1	60,750.0	46.59	<.001
CW	19,979.0	2	9,989.5	7.66	<.01
SW(C)	35,203.6	27	1,303.8		
Dominance (D)	1,456.0	1	1,456.0	1.12	-
CD	2,120.5	2	1,060.3	0.82	-
SD(C)	35,108.7	27	1,300.3		
WD	1,104.1	1	1,104.1	1.07	-
CWD	2,581.1	2	1,290.6	1.25	-
SWD(C)	27,864.9	27	1,032.0		

Ambiguous Contexts. Finally, Orders 1 and 2 differed with respect to the effect of the Dominance factor. Only in Order 1 did this factor reach significance in its interaction with Context and Word Type. To facilitate inspection of the various trends reported above, Table VII presents the average RTs for the various levels of Context, Word Type, and Dominance for Sentence Orders 1 and 2.

Clearly, the significantly different patterns of RT data found for Sentence Orders 1 and 2 present a problem for the interpretation of the phoneme monitoring results. In the hope that the origin of the significant Sentence Order effects could be determined, so that a more confident interpretation of the effects of the theoretically interesting variables could be advanced, RT data were examined more closely.

(iv) The Sentence Order Effects. Two orders of presentation of sentences were used in the phoneme monitoring task to guard against the possible confounding of temporal effects (practice, fatigue, etc.) with those attributable to the manipulations of Context, Word Type, and Dominance. To briefly recapitulate the nature of the significant effects of this variable, the subjects assigned to Order 2 had a faster average RT than those assigned to

Table VII. Average RT (in msec.) as a function of Context, Word Type, and Dominance for Sentence Orders 1 and 2.

	Order 1				Order 2				
	Homonym		Control		Homonym		Control		Row
	Bal	Pol	Bal	Pol	Bal	Pol	Bal	Pol	Means
Context									
Dominant	439	349	359	393	329	331	324	317	355
Secondary	335	358	297	322	353	335	276	295	321
Ambiguous	454	384	343	301	366	343	294	280	346
Column Means	409	364	333	339	349	370	298	297	

Bal = Balanced
Pol = Polarized

Order 1 in all of the twelve Context x Word Type X Dominance combinations except one (Balanced Homonyms in the Secondary Context). This difference was generally more pronounced for the Dominant and Ambiguous Contexts than for the Secondary Context. The most prominent difference between the patterns of average RT for Orders 1 and 2 occurred for Balanced Homonyms. In the Dominant and Ambiguous Contexts, Order 2 subjects responded roughly 100 msec. faster on Balanced Homonym trials than did Order 1 subjects. In the Secondary Context, however, Order 1 subjects were faster on these trials than Order 2 subjects by roughly 20 msec. The second prominant difference between Orders 1 and 2 occurred for Polarized Control sentences. Average RT to Polarized Control sentences was 76 msec. longer in Order 1 than in Order 2 for the Dominant Context condition, whereas the difference in average RT between Orders 1 and 2 for the Secondary and Ambiguous Contexts was 27 and 21 msec., respectively.

Since subjects were nested in a particular Context by Sentence Order combination, it seemed reasonable to consider the contribution of subject differences to the observed Sentence Order effects. With random assignment of subjects to orders it is possible that the main effect of Sentence

Order reflected an overall imbalance in the between-subjects characteristic, response speed. An examination of median RT across Word Types indicated that the five slowest subjects all received Sentence Order 1 (three in the Dominant Context, two in the Ambiguous Context). Nevertheless, after dropping out scores for the five slowest subjects in each order, Sentence Orders 1 and 2 remained significantly different ($t_{48} = 2.28$, $p < .05$).

An examination of the two Sentence Orders indicated that sentences for the four combinations of Word Type and Dominance were approximately equally distributed across thirds of the list with one exception. Six of the nine Polarized Control sentences occurred in the first third of the list in Sentence Order 1. Two factors, however, argue against suggesting that list characteristics produced the order effects observed. Firstly, while average RT was longer to Polarized Control sentences in Order 1 than Order 2, the magnitude of this difference varied considerably across contexts, as mentioned earlier. Any effect on RT produced by the unequal distribution of Polarized Control sentences across the two lists should be approximately equal across contexts. Secondly, while average RTs to Balanced Homonyms also differed substantially between Orders 1 and 2, however

Balanced Homonym sentences were distributed evenly in both Sentence Orders.

It appears that the observed effects of Sentence Order in the current study were not attributable to any single factor. While an adequate description and/or explanation of their source(s) is not possible, the remaining results of the experiment can be examined regarding their implications for the three models of homonym processing. Any generalizations made, however, must be carefully considered in light of the order effects to guard against reaching erroneous conclusions.

To summarize, the results of the phoneme monitoring task which transcend the Sentence Order effects indicate that average RTs were significantly longer to homonyms than to control words, with the difference being in the order of forty-five to fifty msecs. This difference between homonyms and control words varied as a function of the context condition to which subjects were assigned. Average RTs to homonyms and control words were approximately equal in the Dominant Context condition; average RTs to homonyms were approximately 45 msec. longer in the Secondary Context, and about 85 msec. longer in the Ambiguous Context condition (see Table VII).

Discussion

A comparison of the predictions of the three homonym processing models and the results obtained will be discussed separately for each task prior to summarizing the conclusions resulting from the current study.

Recognition Memory Task

Before discussing the results obtained in the recognition task, it will be helpful to recapitulate the predictions generated from the three models of homonym processing. The Prior Decision Model predicted that false recognitions would be observed to that meaning of the homonym which was cued at study. If homonyms were heard in their dominant context, the rate of false alarms should have been higher for dominant meaning associates than for secondary meaning associates. The same pattern of false recognitions should have occurred when the context did not bias meaning (i.e., ambiguous context). However, the reverse pattern was predicted when homonyms were heard in their secondary contexts. These predictions were based on the assumption that only one meaning of a homonym is processed. Which meaning is processed is determined by the context cues provided by the sentence in which the homonym is embedded or, in the absence of any biasing context, by frequency of occurrence, with the most frequently used meaning being activated.

The Choice Point Decision Model predicted that the false alarm rate would not vary as a function of the context in which a homonym was heard. According to this model, both (all) meanings of a homonym are activated and subsequently compared with context cues. Thus, the likelihood of false recognitions occurring to associates of the different meanings should be similar, regardless of the context in which the homonyms were heard. Both (all) meanings are activated during the initial study of homonyms, and it is this activation (or recency-tagging) upon which recognition memory performance is assumed to depend.

The Ordered Search Model predicted that the pattern of false recognitions of associates of the different meanings of homonyms would vary as a function of the context in which homonyms were heard. For those homonyms heard in their dominant context, false alarms would be more frequent to associates of the dominant meaning than to associates of the secondary meaning. Hearing homonyms in secondary and ambiguous contexts would result in comparable false recognition rates to associates of dominant and secondary meanings. While the Prior Decision and Ordered Search Models both predict an effect of context on the pattern of false recognitions, the models differ regarding the stage of processing at which context is assumed to have its effect. The Prior Decision Model holds that context has its influence before the activation of information in LTM; the Ordered Search Model, in contrast, suggests that context operates following the activation of information in LTM. According to the Ordered Search Model, upon hearing a homonym the most frequently occurring meaning is activated and compared with available context cues. If a match occurs (as when homonyms are presented in their dominant context) processing terminates with the activation of a single meaning. If, however, a match does not occur (e.g., when a homonym is presented in its secondary context or an ambiguous context), the next most frequently occurring meaning is activated and compared. Processing continues until a match occurs -- resulting in the activation of more than one meaning of the homonym. The Ordered Search Model also predicted that differences in false alarm rates between the dominant context condition and the secondary and ambiguous context conditions would be greater for polarized homonyms than for balanced homonyms, since the different meanings of the latter occur with nearly equal frequencies.

The results of the recognition memory task in the current study are not fully consistent with the predictions of any of the models. Contrary to the Prior Decision Model, a large number of false alarms occurred to associates of noncued meanings. The pattern of false recognitions appeared to be largely unaffected by the context in which homonyms were heard. While this result is most consistent with the Choice Point Decision Model, it must be remembered that Context did enter into a significant three-way interaction with Dominance and Associate Type. A closer examination of this triple interaction indicated that, contrary to the predictions of the Ordered Search Model, the pattern of false alarms differed in the ambiguous context condition from that in the dominant and secondary context conditions. Finally, the predicted difference between balanced and polarized homonyms was not observed.

The results of the recognition task appear to be most consistent with the Choice Point Decision Model. This result has seldom occurred with this task, as mentioned earlier. Some speculation on the differences in the current study which may be related to this outcome will be offered following a discussion of the phoneme monitoring results.

Phoneme Monitoring Task

The three models of homonym processing differed with respect to their predictions regarding the effect of context on RTs in the phoneme monitoring task. The Prior Decision Model predicted no effect of Word Type (Homonym, Control), Context (Dominant, Secondary, Ambiguous), or Dominance (Balanced, Polarized) on the latency of response to the occurrence of the 'b' phoneme. Since this model assumes all homonyms are processed in terms of only a single meaning, altering the context in which the homonym occurs should not alter the amount of processing necessary for comprehension. Furthermore, the complexity of processing for homonyms should not differ from that required for comprehension of unambiguous control words and, therefore, no effect of Word Type was predicted.

The Choice Point Decision Model, similarly, predicted no effect of Dominance or Context. Predictions from this model, however, are based on the assumption that context has its effect following the activation of both (all) meanings. A significant effect for Word Type was predicted. Since both (all) meanings are activated for homonym comprehension, the processing load is assumed to be greater for homonyms than for unambiguous control words.

The Ordered Search Model did predict a Dominance effect. Since balanced homonyms are assumed to require more extensive processing than polarized homonyms, RTs were predicted to be slower following balanced than polarized homonyms. Furthermore, this difference between balanced and polarized homonyms was assumed to depend upon the context in which words were presented. RTs to balanced homonyms would not differ across contexts whereas RTs to polarized homonyms would be shorted in the dominant context than in the secondary and ambiguous contexts.

The results obtained were not consistent with the Prior Decision Model, since homonyms were observed to produce significantly longer RTs than control words. Any comparison between the Choice Point Decision and Ordered Search Models is complicated by the Sentence Order effect. Performance with Order 1 showed significant interactions of Dominant with Context and Word Type (suggestive of the Ordered Search Model). Order 2, however, provided RT data which showed neither a main effect of Dominance nor an interaction with Context or Word Type (suggestive of the Choice Point Decision Model). The strongest conclusion which can be made on the basis of the phoneme monitoring results is that the Prior Decision Model is inappropriate as a model of the amount of processing required for comprehension of homonyms.

One of the questions which the current study was designed to examine was whether the inconsistency of findings of recognition memory and on-going processing studies was related to the fact that these techniques tested at different times. Suggestions that the two tasks measure different stages of processing raise the possibility that the activity evaluated during later recognition is different from that which occurred at the time of comprehension. Specifically, it is assumed that upon comprehending a word or sentence, this information is coded into LTM and the activity leading to comprehension is "erased." As mentioned earlier, recognition and on-going processing studies differ in their inferences about the amount of information activated for comprehension of ambiguous words. Recognition studies tend, for the most part, to support limited-processing models; whereas on-going or probe studies tend to support more exhaustive processing. It was suggested that using both methods of testing on the same group of subjects would be helpful in examining this question. To that end, subjects in the current study were required to both press a button upon hearing a 'b' phoneme and remember the words they heard to be able to later recognize them.

The current study, however, did not strongly support this suggested source of inconsistency in the literature. Results of the phoneme monitoring task allowed for a rejection of the Prior Decision Model. Results of the recognition memory task, while not clearly consistent with any of the models, tended to lend partial support to the Choice Point Decision Model. Thus, the similarity in the general pattern of results with the two tasks makes task difference an unlikely account of the inconsistencies found in previous research on homonym processing. Some aspects of the present findings suggest, however, that it might be premature to regard this matter as closed. If one compares the absolute level of performance on the two tasks obtained in the present study with those observed in previous research, some interesting differences emerge. The RTs observed in the present experiment were surprisingly fast (in the order of 340 msec.) compared with those obtained in other studies (Foss, 1969 -- 629 msec.; Foss & Jenkins, 1973 -- 538 msec.). On the other hand, recognition performance in the present study was quite poor (pHit = .565).

The probability of saying 'old' to associates of the dominant meanings of balanced homonyms was in some instances greater than that to old words. While Perfetti & Goodman (1970), who also used sentences as the study list, found a comparably low hit rate (pHit = .59), they did not observe the probability of false alarms to be greater than the probability of hits in any instance. Combining the two tasks could have resulted in a trade-off between RT and memory performance. If a subject concentrated on performing well on the RT task, his/her attention to the memory task may be lessened. One may speculate that subjects faced with the demands of the current study chose to concentrate their efforts on the immediate phoneme monitoring task, leaving the later recognition task to 'chance.' That is, in monitoring the sentences for the 'b' phoneme, subjects may not have processed the words in the sentences as completely (or in the same manner) as they would have, had they been instructed only for a recognition task. As suggested by Craik & Lockhart (1972), the level or depth of information processing produces dramatic effects on memory performance. The nature of the phoneme monitoring task may have required subjects to process the information at a lesser depth than would have resulted had only recognition memory been examined. While this level of processing produced very fast responses to the occurrence of the 'b' phoneme, it was not useful for later recognition of items. In this way, the combining of the two tasks, rather than merely permitting the probing of different stages of processing, may have modified the processing itself. This possibility certainly warrants consideration before any decision to discard the theoretically more interesting question of whether the two tasks provide different information about the nature of homonym processing.

Neither of the tasks used to test the models of homonym processing produced clear support for a single model. In both cases it was possible to reject the Prior Decision Model (in particular, for the phoneme monitoring task); however, it was not possible to choose between the Choice Point Decision and Ordered Search Models on the basis of the current study. It should be noted that the distinction between these two models rests heavily upon the joint effects of context and dominance. To repeat, the Ordered Search Model states that more than one meaning of a homonym will be processed in those instances where the less frequent meaning is required. Where the dominant or most frequent meaning is required, only a single meaning will be activated. Furthermore, since with balanced homonyms the frequency of occurrence of the different meanings is about equal, the comprehension of these words may often require activation of more than one meaning. This is largely due to the fact that the order of search (i.e., most frequent, next most frequent, etc.) may vary considerably for these words since one meaning is not dominant. Polarized homonyms, in contrast, have one much more frequent meaning which is always (or nearly always) activated first and compared with context. So, when polarized homonyms are presented in their dominant context, processing terminates with activation of a single meaning. The Choice Point Decision Model states that both (all) meanings will be activated regardless of which meaning is required by context.

Manipulation of context requires knowledge of the frequency with which the different meanings of a homonym are used. In the current study this was achieved by consulting norms of association to homonyms. It was assumed that the percentages of subjects indicating a particular meaning of a homonym reflected the relative positions of the different meanings with respect to their frequency of occurrence within the typical subject's experience. For example, 62% of the responses to the homonym 'country' indicated the 'rural area' meaning, while 37% indicated 'nation' as the meaning. These percentages, obtained across subjects, were taken to reflect the relative frequency of occurrence of the different meanings within subjects, with the dominant meaning being defined as 'rural area,' the secondary meaning as 'nation.' Using norms obtained across subjects as a measure of a within-subjects variable assumes that averaging over a large number of subjects will minimize the influence of idiosyncratic subjects. Defining 'rural area' as the dominant context will result in a match between nominal and functional stimuli for most subjects. For some subjects, however, what is defined as the dominant context will in fact function as the secondary context (i.e., for those subjects whose dominant meaning is actually 'nation').

Since the distinction between the Ordered Search and Choice Point Decision Models rests upon processing differences in the dominant and secondary contexts, it would seem advisable to test one's sample directly to determine which meaning is dominant for each subject. If the levels of context are defined in this manner, systematic variation of the levels of context should provide much clearer information about the effect of context on amount of processing.

Consideration of the degree of dominance of the dominant meaning reveals a further complication. The current study treated dominance as a dichotomous variable -- homonyms were classified as either balanced or polarized, and processing differences were hypothesized upon the basis of homonym type. This, almost surely, is an oversimplification. Dominance is most probably a continuous variable which measures the stability of the ordering of a homonym's meanings. High dominance words (called polarized homonyms in this study) would be characterized by a consistent ordering of meanings with repeated testing whereas low dominance words would show different orderings from one test to the next in the same subject. That is, dominance might be thought of as reflecting variability in the order in which different meanings would be activated during homonym processing. Where dominance is high, the same meaning is consistently accessed first; where dominance is low, the order of activation varies both within and between subjects.

Defining both context and dominance on the basis of within-subjects tests seems highly advisable for a critical test of the Choice Point Decision and Ordered Search Models of homonym processing. It is likely that the shortcomings in operationally defining these variables in the present study were partially responsible for the relative weaknesses of the conclusions regarding these two models.

An intriguing result of the current study was the effect of context on RT to control sentences. Since the words employed in the control sentences were unambiguous (at least they were not homonyms), it was expected that manipulation of 'context' would have no systematic effect on RT to control words. However, average RT to control sentences was shorter in secondary and ambiguous contexts than in the dominant context for polarized control sentences. Some speculation on the source of this effect seems permissable.

Consider a construct which might be labelled "uncertainty" or "cognitive ambiguity" (as distinct from context ambiguity), jointly determined by past experience and present context. It would be expected to vary across homonym sentences of differing contexts as follows: Dominant context -- uncertainty would be very low since a word which has most often been used in a particular sense is once again heard in that context. Secondary context -- uncertainty would be moderate since a word most often used to convey one meaning is now used to convey a different meaning. Ambiguous context -- uncertainty would be high since no context cues are available and the word has been used to convey different meanings in the past. The manipulation of context in the current study would be expected to result in different levels of uncertainty for subjects receiving different levels of context, as indicated above.

An examination of RTs to control sentences indicates that RTs to polarized control sentences decreased as uncertainty of experimental sentences increased. Since control sentences were identical across context conditions, the possibility exists that the presence and nature of experimental sentences influenced the way in which subjects treated the control sentences. Specifically, it is possible that the contrast in uncertainty between experimental and control sentences varied across context conditions. As this 'uncertainty contrast' increased, by virtue of increasing uncertainty of experimental sentences, control sentences became easier (more quickly processed). Any such systematic variation in the ease of control sentences would be very important since support for more complex processing of homonyms depends upon finding longer RTs to experimental than control words. While speculative, these considerations do suggest that it is important to determine whether any difference in RT between word types results from increasing RTs to homonyms or from decreasing RTs to control words.

In summary, the results of the current study lend support to those models of homonym processing which assume that context has its effect after the activation of information in LTM. A more thorough understanding of the effect of context, however, would seem to require that the levels of context (dominant, secondary) be defined on an individual rather than group basis. As suggested by Hogaboam & Perfetti (1975), which meaning is dominant may vary from one individual to the next. Having obtained information with respect to which meanings are dominant for each of the subjects to be tested, the systematic variation of levels of context should provide information concerning the appropriateness of the Choice Point Decision and Ordered Search Models.

Appendix

Sentences used in the Phoneme Monitoring Task

Balanced Homonyms

case (54/44)* f=362**   face f=371

1. The social worker said each case became harder.
2. The delivery man put the case behind the door.
3. The gentleman made his case but it was flimsy.

C. The young girl washed her face before dinner.

charge (45/40) f=122   running f=123

1. The dentist didn't charge because a filling wasn't necessary
2. The animal didn't charge because it didn't notice us.
3. The natives didn't charge because it wasn't necessary.

C. The athlete wasn't running because his leg hadn't healed.

mass (35/22) f=110   wish f=110

1. The priests discussed mass before going home.
2. The physicists discussed mass before going home.
3. The study group discussed mass before anything else.

C. The child made a wish before going home.

organ (57/40) f=12 outline f=12

1. The musician played the organ beautifully at the recital.
2. The doctor removed the organ because it was diseased.
3. The witness saw the organ before it was removed.

C. The writer made an outline before starting his essay.

play (58/36) f=200 surface f=200

1. The referee stopped the play because of a penalty.
2. The actor read the play before accepting the part.
3. The reporter saw the play but couldn't explain it.

C. The carpenter sanded the surface before starting to paint.

pupil (59/39) f=20 pioneer f=20

1. In strong light the pupil became smaller.
2. In exam rooms the pupil became nervous.
3. In a moment the pupil began to react.

C. In the winter the pioneer became inactive.

second (52/43) f=373 form f=370

1. Fred won a second but nothing else.
2. Fred waited a second before going.
3. Fred took a second but that was all.

C. John completed the form before his interview.

spring (50/40) f=127 treatment f=127

1. The weatherman noticed when the spring began to appear.
2. The upholsterer noticed when the spring began to appear.
3. The young man noticed when the spring began to appear.

C. The psychiatrist noticed when the treatment began to work.

tip (44/42) f=22 joke f=22

1. The waiter saw the tip before anyone else did.
2. The artist sharpened the tip because it was dull.
3. Helen saw the tip before anyone else did.

C. Lois told the joke before anyone was ready.

Polarized Homonyms

yarn (79/19) f=14 shoe f=14

1. The knitting yarn became tangled.
2. The old man's yarn became confused.
3. The youngster's yarn became twisted.

C. The little girl's shoe became scuffed.

sentence (83/13) f=34 mistake f=34

1. The student's sentence began with "why".
2. The prison sentence began immediately.
3. John's sentence became aversive.

C. The clerk's mistake became costly.

pen (87/12) f=18 cats f=18

1. The writer's pen broke apart.

2. The animal's pen became muddy.

3. The child's pen broke apart.

C. The stray cats became noisy.

palm (62/32) f=22 soap f=22

1. The fortuneteller examined my palm before speaking.

2. The florist examined my palm before speaking.

3. The children examined my palm before speaking.

C. The traveller unwrapped the soap before washing.

letter (87/8) f=145 food f=147

1. The journalist edited each letter before printing it.

2. The painter sketched each letter before painting it.

3. The secretary read each letter before typing it.

C. The gourmand examined the food before tasting it.

drill (65/34) f=33 gift f=33

1. The dentist used the drill before filling the cavity.

2. The players ran the drill before starting the game.

3. My friend stopped the drill by giving a command.

C. The woman purchased the gift before leaving the store.

country (62/37) f=324 family f=331

1. A cottage in the country became their home.
2. The king of the country beckoned his jester.
3. The people in the country became more friendly.

C. The adults in the family began the discussion.

cell (61/37) f=65 desk f=65

1. The jailer locked the cell before leaving the area.
2. The scientist stained the cell before looking at it.
3. The students looked at the cell before continuing the tour.

C. The student tidied her desk before leaving for home.

right (80/8) f=613 three f=610

1. The student got all the answers right before recess.
2. The motorist turned to the right before the corner.
3. The voter put his ticket in the right box after voting.

C. The researcher returned the three books after work.

* Percentage of responses indicating the dominant and secondary meanings, respectively in the Perfetti et al. (1971) norms.

** Frequency of occurence (Kucera & Francis, 1967).

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