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THE ROLE OF ACOUSTIC AND SEMANTIC DIMENSIONS OF MEMORY IN SENTENCE MEMORY AND COMPREHENSION

Donald A. Walter

Michigan University

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The Role of Acoustic and Semantic Dimensions of Memory in Sentence Memory and Comprehension

DONALD A. WALTER

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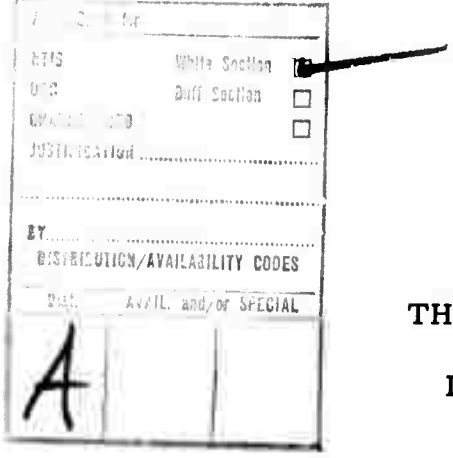

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Experiment II varied the imagery of a sentence noun. Two imagery-comprehension models state that either all sentence words are stored in one image or individual words serve as memory "anchors." These alternative possibilities, as well as the effects of imagery on phonemic and semantic memory, were examined over retention intervals of 4, 12, and 36 seconds. Results indicate that high imagery of one sentence noun has beneficial effects on semantic and total word memory of other sentence words at short retention intervals (4 and 12 seconds) but deleterious effects at relatively long intervals (36 seconds). No effect of imagery on homonym recognition was noted. This indicates that imagery in sentence memory is not unitary, that encoding attention may be transferred from low- to high-imagery words, and that only semantic information is transferred, not phonemic.

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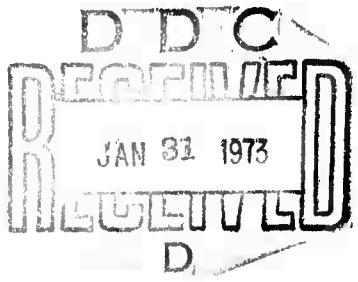

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PREFACE

This report is an independent contribution to the program of research of the Human Performance Center, Department of Psychology, on human information processing stress factors, supported by the Human Resources Research Office of the Advanced Research Projects Agency, under Order Nos. 461 and 1949, and monitored by the Behavioral Sciences Division, Air Force Office of Scientific Research, under Contract Nos. AF 49(638)-1736 and F44620-72-C-0019, respectively.

This report was also a dissertation submitted by the author in partial fulfillment of the degree of Doctor of Philosophy (Psychology) in the University of Michigan, 1972. The doctoral dissertation committee was: Drs. E. J. Martin, Chairman, J. G. Greeno, M. H. O'Malley, and R. G. Pachella.

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ABSTRACT

Following recent linguistic trends, most sentence memory studies have employed grammatical variables. However, relatively new findings indicate that semantic variables are much more powerful, but have been only superficially examined. In the present research, a special probe recognition technique is employed to examine the effects of semantic variables on semantic and phonemic dimensions of sentence words.

Experiment I assessed the relative contribution of phonemic and semantic dimensions of memory via a "yes"-"no" recognition test for homonyms, synonyms, and intact words. A word was presented as part of a sentence or as part of a scrambled list of words. One of three recognition tests was administered at retention intervals of 5 or 20 seconds. Results show that sentence context slowed the decline of synonym recognition as a function of retention interval. In contrast, homonym recognition was superior to synonym in scrambled context presentation. The latencies of "no" responses suggest that subjects may have been reconstructing phonemic information from semantic memory in order to reject probe and catch words as not having a phonemic match in the presentation list.

Experiment II varied the imagery of a sentence noun. Two imagery-comprehension models state that either all sentence words are stored in one image or individual words serve as memory "anchors." These alternative possibilities, as well as the effects of imagery on phonemic and semantic memory, were examined over retention intervals of 4, 12, and 36 seconds. Results indicate that high imagery of one sentence noun has beneficial effects on semantic and total word memory of other sentence words at short retention intervals (4 and 12 seconds) but deleterious effects at relatively long intervals (36 seconds). No effect of imagery on homonym recognition was noted. This indicates that imagery in sentence memory is not unitary, that encoding attention may be transferred from low- to high-imagery words, and that only semantic information is transferred, not phonemic.

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CHAPTER I

INTRODUCTION

A number of different methods have been used in the study of sentence memory. Most have involved varying some aspect of sentences with an eye toward determining what effect that variation would have on the recall of the sentence. Variables have included such sentence characteristics as sentence length and associative strength between sentence words. However, the great majority have explored aspects of theories adopted from linguistic concepts and models. For example, Mehler (1963), Mehler and Carey (1967), Slobin (1968), Savin and Perchonock (1965), and many others have varied transformational complexity and measured the resulting effect on recall of the sentences or material presented with them. Martin and Roberts (1966), Martin, Roberts, and Collins (1968), and Perfetti (1969a,b) have explored sentence recall as a function of surface structure complexity; and Perfetti (1969b) has used lexical density as an index of the difficulty of sentence recall.

These sentence memory studies have a common characteristic: They share a linguistic legacy and deal almost exclusively with grammatical aspects of sentences. To be sure, there are some authors who have examined other factors in recall. Johnson (1966) and Rosenberg (1966) have examined effects of intrasentence word associations. Others have employed various words in the sentence as prompters in recall (Blumenthal, 1967; Blumenthal & Boakes, 1967). The linguistic heritage, however, still dominates sentence memory research. This emphasis becomes

It is the purpose here to initiate an examination of semantic aspects of sentence memory at the level of the word in an effort to shed some light on the microprocesses involved in the encoding, memory, and possibly the comprehension of sentences. To do so, new experimental procedures will be needed.

In most sentence memory studies the dependent variable is the proportion correct recalls, either verbatim or in close paraphrase. Because of this, only gross properties of encoding, forgetting, and retaining the sentence can be assessed. This is because measured response variation is limited. Such responses, of course, reveal whether the sentence was, in fact, stored and retrieved, but indicate little about the microprocesses going on, semantic or grammatical. Examination of word-class recall is a step in the right direction, but effects at that level are still embedded in a great number of retrieval interdependencies.

In the two experiments presented here, I attempted to make an initial step toward a new methodological and theoretical point of view. Using existing models of word memory as a starting point, I utilized a specialized probe recognition technique to examine the effects of sentence context on the memory attributes of its component words.

Recently, a new class of models of the memory trace treat the trace of a single nominal unit, such as a letter or word, as a number of separate memories tied together. The storage of a unit consists of the activation of a set of attributes that are normally already in memory. Early statements of such models (Bower, 1967) were in

terms of mathematical learning theory, and they attempted to show that data concerning various learning and decay functions could be readily explained with a multicomponent or multiattribute memory representation. These models have been relatively successful in predicting such functions, but all have employed the simplifying assumption that each attribute has similar memory characteristics.

Information processing models of stimulus input, such as those of Sperling (1967, 1968) and Norman and Rummelhart (1970) posit a multi-level encoding process in which the form of the memory representation changes at each level. The primary levels in such models hold information of a primitive nature, normally iconic information of a phonemic or visual nature. The same general representations are also used in the familiar two-stage models of memory of Atkinson and Shiffrin (1965) and Waugh and Norman (1965). They assert that there are two separate memories, a short-term memory and a long-term memory. Although it is implied in such models that short-term memory holds primarily phonemic information and long-term memory, semantic information, the only explicit statements to this effect are those of Sperling.

Because of this, a great deal of research has surrounded the identification of characteristics of the memory trace at each level, especially in terms of phonemic and semantic representations. Also of interest has been the relation of one memory to the other, whether they are sequential or independent. It may be that encoding directly into semantic information is possible, or that some processing at a primitive level must precede integration with a relatively permanent

corpus of information. It may also be that the two systems are independent, each having different memory functions as in Wickelgren's (1970) multitrace model.

Studies addressed to the above problems have been carried out. Most have been concerned with measurement of phonemic or semantic memory, or have manipulated variables affecting the efficiency of encoding and retrieving in terms of each. A review of such studies may be found in Shulman (1971), but it would be worthwhile to mention some of the major findings here.

Conrad, Baddeley, and Hull (1966), Conrad (1967), and Wickelgren (1965) found, in separate studies, that the manipulation of phonemic similarity in a short list of letters had deleterious effects on the immediate recall of such lists, while semantic and graphic similarity had relatively small effects. In addition Wickelgren (1966) and Conrad (1964) found that intrusions in such recall protocols were phonemically related to the presented letters. Kintsch and Buschke (1962) used a sequential probe recognition technique to determine the retention interval at which an phonemic or semantic similarity between words in a list would have the greatest effect. With phonemic similarity, strong effects were found at small retention intervals, with semantic similarity, at large intervals.

Shulman (1970) used a modified probe recognition procedure that is capable of assessing not only the strength of the word memory, but the strength of the phonemic and semantic attributes of memory trace. In the ordinary probe recognition experiment a list of words is

presented to a subject and followed by a single, isolated word. The subject simply indicates whether the single word was a member of the list. The major reason for the adoption of this method, in word memory studies, is that output interference is virtually eliminated. Since only one word memory retrieval is required, the effects of retrieval of other words in the list presumably cannot interfere. Shulman presented subjects with a list of 10 words followed by a special probe recognition test. If he wanted the subject to make an ordinary recognition of the probe word an I, standing for identical, preceded the test. If the subject was to make a recognition of the semantic properties of the word an S, standing for synonym, was shown. For the phonemic dimension, an H for homonym served as the cue. So subjects were making recognitions sometimes on the basis of all available memory dimensions, sometimes on the basis of meaning only, and sometimes on the basis of the sound of the word. Recognition scores for the three tasks were then used to determine the saliency of the corresponding dimensions of the memory trace. This modified probe method is capable of more exact examination of the memory trace than is the ordinary probe procedure. For this reason it was this procedure that was used in the research reported in Chapters II and III.

Returning to the earlier discussion, our purpose is to determine how the memory of a word changes when it is part of a sentence. There are a number of possibilities. Common sense would dictate that a word in a sentence would eventually be encoded in terms of its semantic dimensions. However, consider the case in which short-term memory is

primarily phonemic and long-term memory, semantic. There is experimental evidence to indicate that higher order units like words and sentences are perceived faster than their subcomponents (Donald J. Foss, personal communication, 1971). This indicates that contact with long-term memory may be possible immediately and that a primitive encoding stage may be bypassed in sentence perception. Such contact may be possible because the sentence provides a great deal of information as to where to place individual words in the memory structure. If such is the case, retention of the word in phonemic form need not take place.

More likely, however, is the possibility that both phonemic and semantic attributes exist in short-term memory. Shulman (1970) found this to be the case for very short retention intervals. Under such a hypothesis, we will be interested in the extent to which semantic and phonemic memory dimension strengths are influenced by sentential context, and whether they can be independently manipulated. Does sentence context affect both? What happens to each over the retention interval?

CHAPTER II

EXPERIMENT I

The purpose of this experiment was to assess the relative contributions of semantic and phonemic dimensions to word memory as a function of the presence or absence of sentence context.

Method

Subjects. Seventy-two University of Michigan female undergraduates served as subjects. They were each paid $1.75 for their participation in the experiment. A performance bonus was additional. Each subject served for approximately one hour and was randomly assigned to a particular counterbalancing condition.

Experimental design. The basic experiment consisted of 72 probe recognition trials. The independent variables were word presentation context, retention interval, and dimension of the recognition test. These were employed in a completely within-subjects design. Presentation context was varied by presenting the to-be-recognized word in an intact sentence, or in a word string obtained by scrambling the sentence words surrounding the to-be-recognized word in a quasi-random fashion so as to eliminate meaningful sequences. Retention intervals of 5 and 20 seconds were filled with mathematics problems with a financial reward for their correct solution. Three recognition tasks were used, one based on recognition of phonemic identity, one on semantic identity, and the other on total identity of a probe word with a word in the presentation string.

Catch trials, on which "no" was the correct answer to the probe recognition test, comprised one-third of the recognition tests. Thus, out of the six trials for each combination of the three independent variables, two were catch trials.

Two orders of the presentation of conditions were randomly selected. Each was used for one-half of the 72 subjects. The counterbalancing of materials within conditions was complete. Over the 72 subjects, each word string appeared in each combination of retention interval, context, and recognition test.

Procedure. Each subject was seated in front of a cathode-ray-tube display device. His exact instructions are given in Appendix A. After he was read the instructions he was given 78 trials of the type shown in Table 1. The first six of the trials were practice. As can be

TABLE 1

SAMPLE TRIAL IN EXPERIMENT I

Event	Duration
READY	1 second
WORD STRING	7 seconds
RETENTION INTERVAL (math. problems)	5 or 20 seconds
READY	1 second
PROBE CUE	.5 second
PROBE OR CATCH WORD	Variable
RESPONSES	Variable
REST	5 seconds

seen from Table 1 each trial consisted of the following sequence: A ready signal appeared on the screen and was followed in 1 second by the whole presentation of a twelve word string, either a sentence or scrambled word string. The subject read this string aloud at a 2-second rate, paced by a metronome quietly "plinking" in the background. The presentation time was such that the entire string disappeared 1 second after the twelfth "plink." This gave the subject a starting lag of 1 second to insure he read the entire string. A retention interval of 5 or 20 seconds followed the string and was filled with arithmetic problems of the type $(\underline{x} \cdot \underline{y}) - \underline{z}$, which appeared at the rate of one every 2.3 seconds. The subject was paid .5 cent for each problem he solved correctly. He said his answer aloud over an intercom.

After the last problem in the retention interval another ready signal appeared on the screen. This signalled the subject to stop doing the arithmetic problems and to prepare for a recognition test. One second later a large H, S, or I appeared on the screen. The subject had been told previously that these stand for homonym, synonym and identical, respectively. This letter, the probe cue, indicated to the subject which of three types of recognition he was to make of the probe word, which appeared to the right of the probe cue .5 second later. The subject simply had to decide whether the probe word had the cued relationship to any of the words in the preceding word string. He responded by pressing either a "yes" or "no" key in front of him. In addition, after this response, he pressed one of three keys to indicate his response confidence as "probably," "sure," or "very sure."

The subject was told that the incidence of correct "no" answers would be one-third. This information tends to stabilize response bias (see Parks, 1966). In addition, since latencies for the "yes" and "no" responses were recorded, the subject was told to respond not only with his "first impulse," but to guess if 4 seconds had passed since the appearance of the probe word (judgment of this interval was left to the subject). This was done primarily to ensure that the latency distribution would not be overly skewed and to raise the error rate in the easier conditions. Five seconds after he made his confidence response the start of the next trial was signalled by another ready signal.

Apparatus. A cathode-ray-tube display coupled to a PDP-1 computer was used to present the stimuli and order the conditions. Responses and their latencies were automatically recorded on paper tape with a list of the experimental conditions. The subject was isolated in a dimly lit room. After the six practice sentences, only verbal contact was maintained. An intercom was used to assure that the subject was reading the word strings properly and to answer any questions he might have during the experiment.

Materials. Seventy-two words were selected with one restriction in mind, that they must have both unambiguous synonyms and homonyms. These varied widely in word class and frequency of usage. Of these words, called critical words, 48 were nouns and 24 were adjectives or verbs. For each word a 12-word sentence was constructed using words of the same general frequency to hide the identity of the critical word.

The sentences were constructed so that six nouns and three adjectives or verbs occurred in each of the middle eight serial positions.

Each sentence was scrambled randomly to produce an ungrammatical string of words. If the scrambling resulted in meaningful combinations of adjacent words, words were displaced to eliminate this. The critical word, however, retained its serial position in the scrambled version. Although each critical word was used in only one serial position, the Thorndike-Lorge frequency of usage was equated across positions.

For each of the 72 critical words, catch words were selected that duplicated the appropriate homonym or synonym in all respects except their relationship to the critical word. So, for example, the critical word pain had a synonym hurt and a homonym pane. For catch trials in the homonym recognition task the word core would appear instead of the word pane. The former has the same number of syllables, belongs to the same word class, and is a homonym itself. This last requirement was important because the subject could respond only to the "homonymity" of the probe word without making any contact with his memory for the critical word. The same type of restrictions were made for catch words in the case of synonym tests. For identical recognition tests, synonym catch words were used. (These words were not, of course, synonymous with any word in the presentation string.) Since the characteristics of the identical probe words (the critical words) and their synonyms were quite similar, the catch words were used for each test so a comparison of latencies could be made across the two recognition tests. So, in the above case, the synonym hurt

had as its catch word dust which was also the catch word for the identical probe word, the critical word itself, pain. Notice that dust duplicates the dual use of hurt, which could be used as a verb or a noun in an appropriate context. All efforts were made to duplicate these probe word characteristics as exactly as possible.

A complete list of the 72 sentences, their scrambled versions, and the homonyms and synonyms with catch words, is shown in Appendix B.

The arithmetic problems that filled the retention intervals were drawn at random, excepting easy combinations involving computation with 5s, 0s, and 1s. In such lists some duplications were inevitable since the number of problems presented during a typical session was over 400.

Results

There are three dependent variables of interest, correct recognitions, confidence ratings, and response latencies.

The proportion correct "yes" responses, hit rates, are shown in Figure 1. Figure 1a, the left panel, shows the hit rates for the condition in which the critical word is presented as part of a sentence, and Figure 1b, the right panel, for the scrambled context condition. Analysis of variance showed that all three main effects were highly significant as well as the interaction of context and recognition test: For context, $F(1, 71) = 94.6$, $p < .001$; for retention interval, $F(1,71) = 15.9$, $p < .001$; for recognition test, $F(2, 71) = 3.21$,

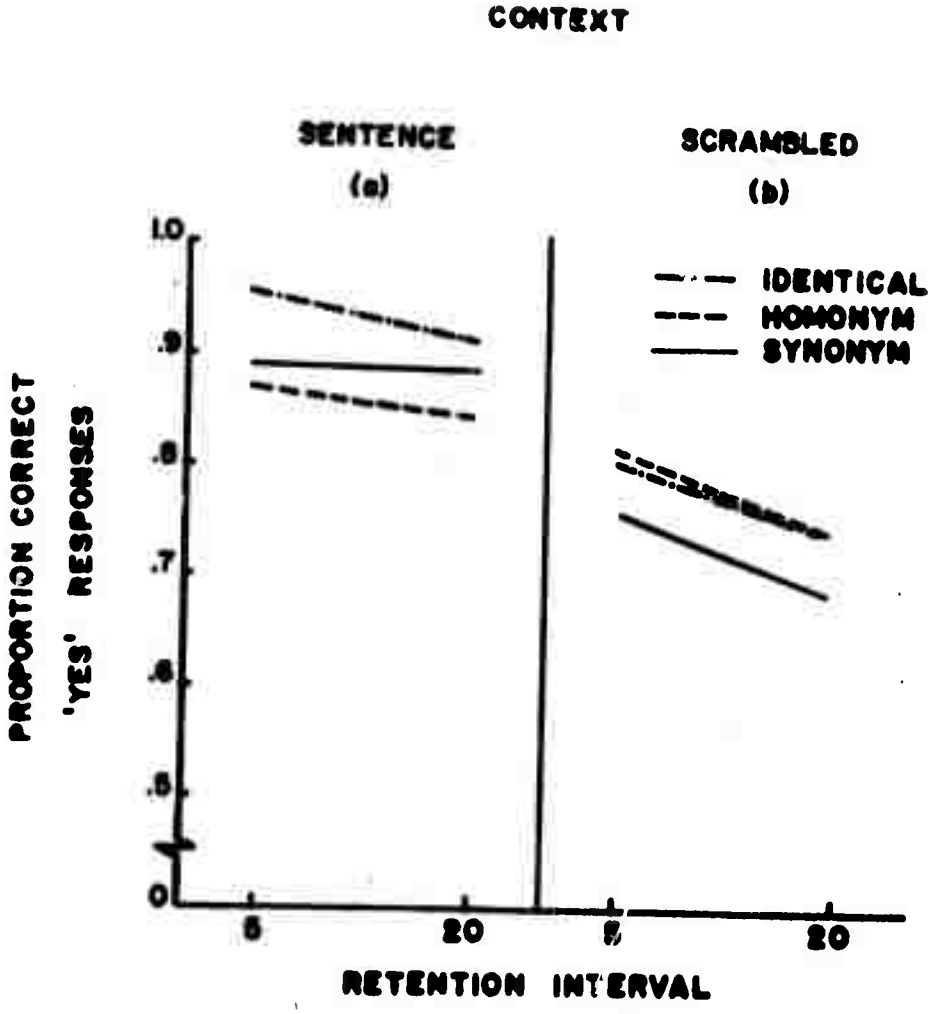

Fig. 1. Proportion correct "yes" responses for three recognition tests as a function of context and retention interval, Experiment I.

$p < .05$; and for the interaction between context and recognition test, $F(2,142) = 6.84$, $p < .005$. Neither the interaction of recognition test and retention interval, context and retention interval, nor the triple interaction approached significance.

Thus, correct recognition was greater at the 5-second retention interval, and greater when the critical word was presented as part of a sentence. There was a general superiority of identical recognition over that of both homonym and synonym recognition. Note that in Figure 1a the order of hit rates is identical, synonym, and homonym, reflecting the order of encoding in terms of these dimensions. In Figure 2b, however, homonym recognition is slightly better than identical and synonym is inferior to both. This shows a reversal of phonemic and semantic recognition as a function of context, as well as a smaller reversal of identical and phonemic.

One problem in using hit rates to estimate the strength of a memory is that response bias differences must be assumed negligible. This is not the case in these three recognition tests, as is obvious by the slight but anomalous superiority of homonym recognition over identical recognition reflected in the hit rates for the scrambled condition (Fig. 1b). False positive rates are used to estimate the amount of response bias. These are the proportion "yes" responses to catch words, or false recognitions. These false positives rates are shown in Figure 2. Again all three main effects were significant: $F(1,71) = 32.8$, $p < .001$, for context; $F(1,71) = 19.0$, $p < .001$, for retention interval; and $F(2,142) = 28.0$, $p < .001$ for recognition task.

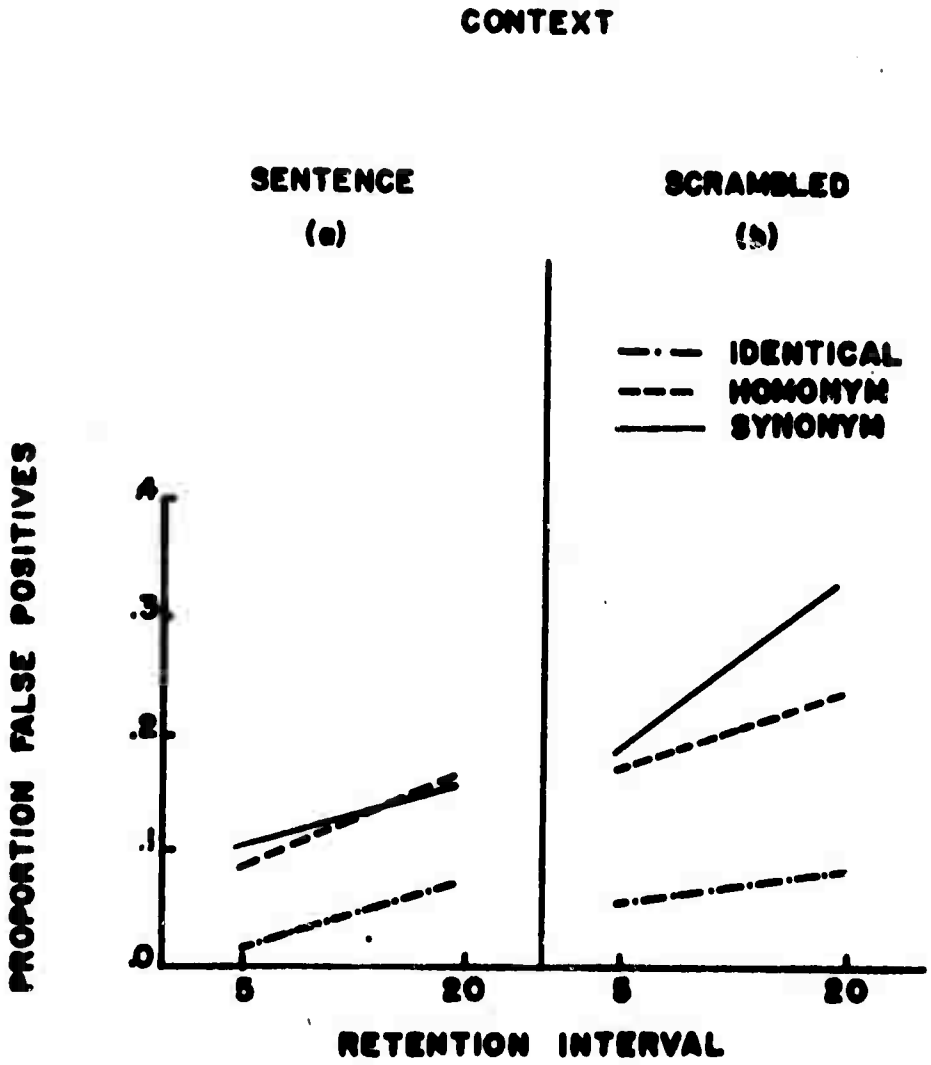

Fig. 2. Proportion false positives for three recognition tests as a function of context and retention interval, Experiment I.

The interactions of context and recognition test approached significance, $F(2,142) = 2.67$, $p > .05$, as did the triple interaction, $F(2,142) = 2.2$, $p > .10$.

A comparison of Figures 1 and 2 shows that false positive rates are not the strict inverse of their corresponding hit rates. With regard to synonym and homonym recognition tasks there is no crossover as a function of context. In addition, the difference between identical and homonym recognition is quite substantial, indicating that subjects showed a large tendency to respond "yes" in the homonym recognition task. Thus, the apparent superiority of homonym over identical recognition reflected in the hit rates is due partially to response bias, and therefore overestimates the actual memory strength of phonemic dimensions.

A recognition score that corrects for such response bias is a score derived from the high-threshold theory (Luce, 1963). This involves application of the formula

$$\frac{\text{Hit Rate - False Positive Rate}}{\text{1 - False Positive Rate}}$$

The corrected, "true" recognition scores derived from application of this formula are shown in Figure 3. In the scrambled context condition, Figure 3b, identical recognition is superior to homonym recognition, which in turn is superior to synonym. When the critical word is in sentence context, Figure 3a, there is a reversal of synonym and homonym recognition and a decrease in the amount of forgetting during the retention interval, especially for synonym recognition.

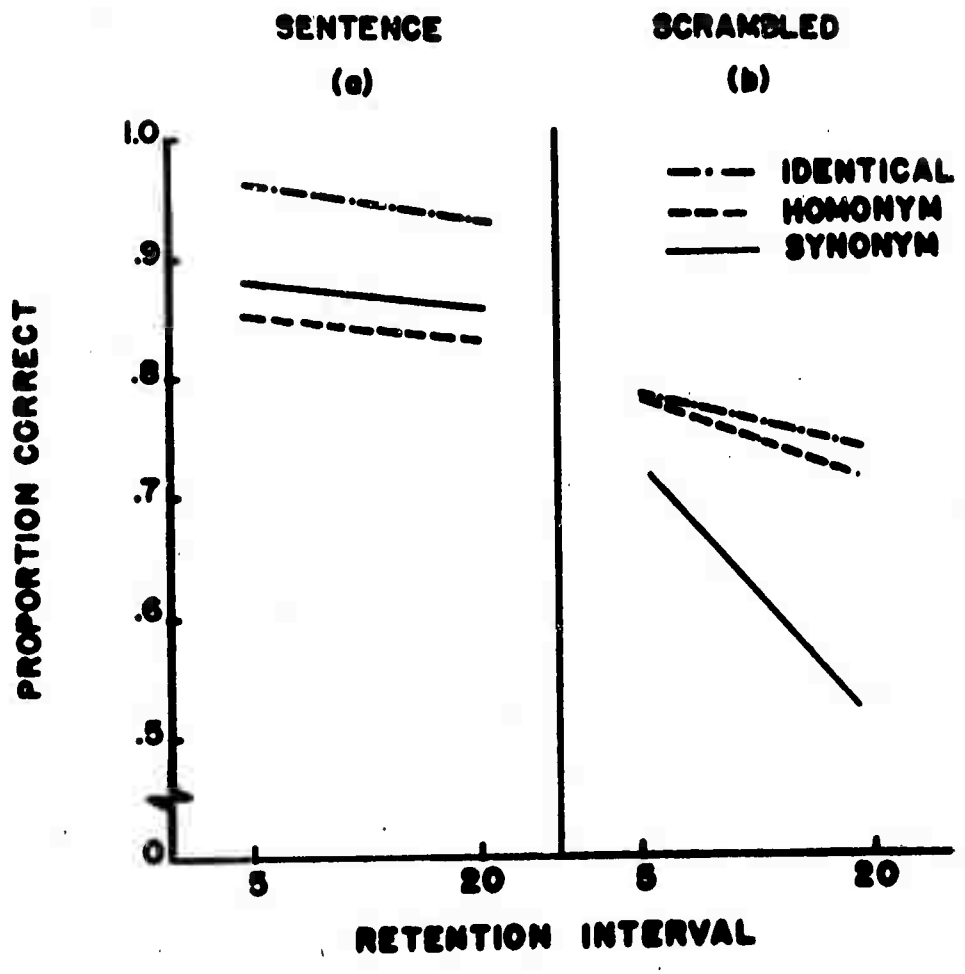

Fig. 3. Proportion correct (corrected for guessing) for three recognition tests as a function of context and retention interval, Experiment I.

The taking of confidence ratings for "yes" and "no" responses was originally intended to generate points for a signal-detectability type analysis. Because of the very low false positive rates in identical recognition, this analysis was impossible. It serves no purpose to discuss the mean confidence ratings as a function of the independent variables, since they duplicated the trends in hit and false positive rates exactly, except that the interaction of context and recognition test was significant, $F(2,142) = 5.64$, $p < .005$.

Even though all efforts were made in instructing subjects to respond soon after the probe or catch word appeared, some were unable to do so. There were no very long latencies, but the overall distribution of latencies was skewed. Because of this a log transformation was applied to each latency prior to the analysis of variance. All means included in the subsequent text are actually antilogs of the means of these transformed scores. However, they are not unrepresentative of the data because they vary little from their respective medians and are thereby representative of central tendencies.

Shown in Figure 4 are the reaction times in seconds for correct "yes" answers. Again significant main effects are found for the three independent variables: context, $F(1,71) = 39.7$, $p < .001$; recognition, $F(2,142) = 101.8$, $p < .001$; and retention interval, $F(1,71) = 6.2$, $p < .025$. Of the interactions, only Retention Interval x Recognition Test was significant, $F(2,142) = 4.42$, $p < .025$.

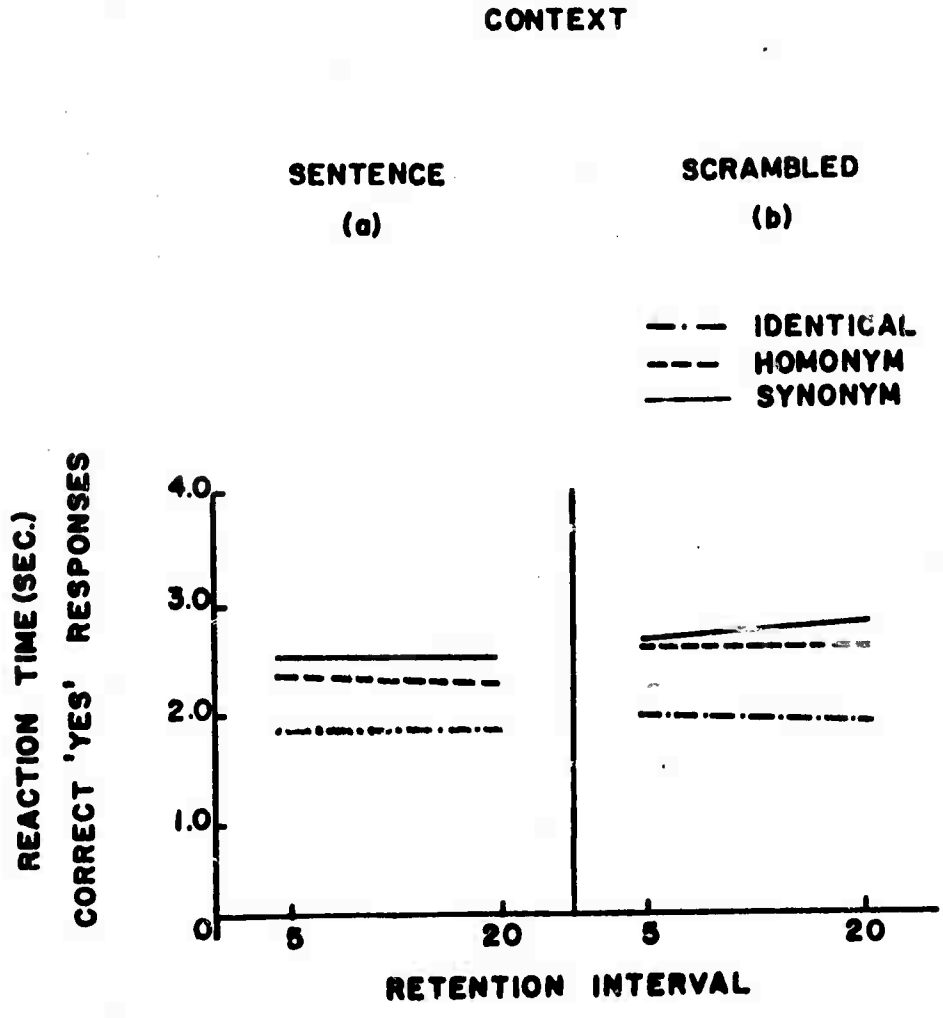

Fig. 4. Reaction times for correct "yes" responses for three recognition tests as a function of context and retention interval, Experiment I.

The salient feature of Figure 4 is that there is no reversal of homonym and synonym recognition latencies as a function of presentation context. Synonym recognition takes the same time regardless of whether the critical word is presented in a sentence or a scrambled string of words. The effects here are quite small but nevertheless significant. For example, the overall effect of retention interval is a reaction time difference of only 2361-2276 = 85 milliseconds.

Latencies for responses to catch words differed from those of probe words. These means are plotted in Figure 5. Significant main effects were presentation context, $F(1,71) = 9.4$, $p < .005$, retention interval, $F(1,71) = 26.3$, $p < .001$, and recognition test, $F(2,142) = 113.4$, $p < .001$. Two interactions were significant, those of context and recognition test, $F(2,142) = 8.5$, $p < .001$, and context and retention interval, $F(1,71) = 7.0$, $p < .025$.

The outstanding feature of Figure 5 is the dramatic increase in homonym recognition latencies in the sentence presentation context, a full half-second. There is a smaller increase for identical recognition, but synonym latencies decrease slightly in sentential context.

Discussion

The questions to which this experiment was directed were the following: How does the inclusion of a word in a sentence influence the memory attributes of that word? More specifically, what are the

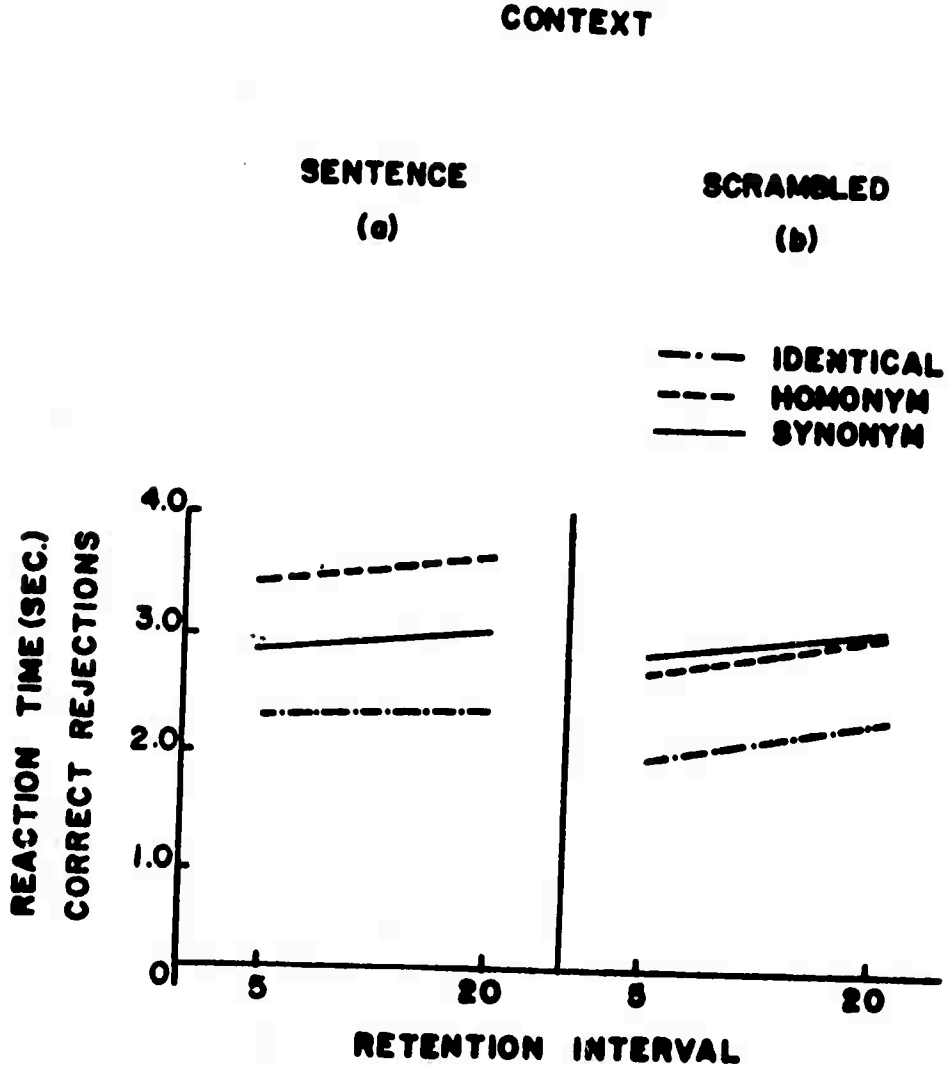

Fig. 5. Reaction times for correct rejections for three recognition tests as a function of context and retention interval, Experiment I.

relative changes in phonemic and semantic dimensions of the memory trace? What happens to phonemic dimensions of the word memory over the 20-second retention interval?

It is clear that the presentation of a word in a sentence has a large effect on the semantic dimension of memory. The interaction of presentation context and recognition test shown in Figure 3 attests to this; here, there is a reversal of homonym and synonym recognition as context is changed as well as a radical reduction in synonym forgetting. It is also true that sentence context has a general facilitative effect on all three recognition tests, more so for identical and synonym than homonym. On the other hand, even though there is an apparent general tendency for sentence context to reduce forgetting rates, this tendency is not significant.

If the recognition score for identical recognition is taken as a baseline for the general improvement due to sentence context, there is a reduction in homonym (phonemic) recognition for sentence context relative to scrambled context. What makes this interpretation more compelling is that identical recognition is subject to a ceiling effect in sentence context, thereby underestimating the actual improvement in recognition.

This apparent superiority of the semantic dimensions of memory over phonemic does not appear, however, when response latencies are considered, except in the case of catch words. In Figure 4 are the latencies for correct recognitions of probe words. There is a general effect of sentence context, recognition task, and retention interval, but the interaction of recognition task and context is missing. In

both context conditions identical recognition was most rapid, followed by homonym and synonym in that order.

In all cases except synonym recognition in sentence context, probe word latencies complement recognition scores. This indicates that effects of sentence context are not to provide a quicker route to the semantic dimension of the word memory, but, possibly, to elaborate the number of routes, the selection of which may take some time. Thus, it is easier to decide whether adequate semantic information is there, but it takes longer, when the context is sentential. Evidence that a different process may be occurring can be seen in Figure 5, where the latencies for catch words are shown. The reduction of latencies as a function of sentence context occurs only for synonym recognition (50 msec.), while identical latencies show a small increase (163 msec.), and homonym latencies, a full 522 millisecond increase. Evidently the subject is engaging in some additional real-time activity in order to reject homonym catch words. It is possible that some responses are being made by reconstructing the sentence and searching through the generated words. If such were the case, this latency difference should show up in correct recognitions of probe words, some of which would have involved this strategy. There is no such effect in Figure 4. However, such a difference may be masked by the fact that the proportion of futile searches is much lower in the case of probe words (.144) than in the case of catch words (.872) in the sentence

context condition. A plot of the latencies for misses ("no" answers to probe words) reveals the same relative latency for homonym recognition in the sentence context conditions. Thus, the data indicate that the subject may engage in some reconstruction when he is unable to find a phonemic dimension match. As he can do this only in the condition where there is raw material out of which to reconstruct something (sentence context), this long latency tendency shows up only when the critical word is part of a sentence. If this is the case, recognition rates for homonyms include some items which underwent this strategy. For this reason the homonym recognition score shown in Figure 3a is most likely an overestimate of the relative strength of the phonemic dimension.

As for the properties of phonemic and semantic memory dimensions, this study replicates Shulman's (1970) finding that phonemic dimensions dominate in noncontextual short-term word memory, here out to 20 seconds. Not only is there no evidence for a sequential memory model of any kind, since the slope of the homonym recognition function was less than that of synonym recognition, but the rapid decline of synonym recognition contradicts popular notions that long-term memory is semantic, at least at these retention intervals. In fact, these data indicate that the shorter memory of an hypothesized two memory system is semantic and the longer, phonemic.

Although semantic and phonemic dimensions are obviously differentially affected by sentence context, the direction of the effect on

phonemic dimensions is rather uncertain. Experiment II was designed to assess this direction, as well as further examine sentence memory effects.

CHAPTER III

EXPERIMENT II

Experiment II uses a different method to assess the relative contributions of semantic and acoustic dimensions to sentence encoding. What is needed is an independent variable that is known to have a very large effect on sentence meaning comprehension. If the effect of this variable is selective with regard to the three recognition tests used in Experiment I, then the mechanism of comprehension can be further identified. In addition, since the maximum retention interval of 20 seconds failed to produce any significant interactions, larger retention intervals may have to be used.

A independent variable that produces extremely large effects on sentence meaning comprehension is imagery. Begg and Paivio (1971) had subjects rate a number of sentences as to how easy it is to form an image of what each sentence meant. They then took the extremes of the rated sentences and used them in a recognition task like Sach's (1967). The sentences were presented one at a time in a continuous string. The subject's task was to say whether a signalled sentence differed from an earlier sentence in meaning or grammatical structure, or both. The results were very dramatic. Low-imagery sentences were more accurately judged as different in grammatical structure than in meaning. The results were reversed for high-imagery sentences, where

judgments were more accurate for meaning than grammatical discrepancies. It should be emphasized that these were not small effects; they were very substantial. It is for this reason that the independent variable of imagery was introduced in Experiment II. Instead of varying the context of presentation in a sentence-versus-scrambled fasion, as in Experiment I, the imagery of one noun in the sentence was varied. This was done for two reasons: First, a change of the entire sentence obsfucates the source of any effects obtained. Second, there are two possible effects of changing imagery of one noun and which one obtains reflects on the memory or encoding processes involved in sentence memory. The issue is whether sentence nouns serve as an anchor for comprehension or memory.

It is well known that sentence nouns, especially the subject, are of paramount importance in sentence recall. Not only are they recalled better than other sentence words (Martin & Walter, 1969), but they serve as the best prompters for sentence recall (Blumenthal, 1967; Blumenthal & Boakes, 1967) and are the best locus for sentence generation (Clark, 1966). To the extent that this anchor effect is a result of high-imagery noun usage, a reduction in imagery should force the subject to other sentence words, especially the other noun. If, on the other hand, sentence memory is not organized around a single word, but is an image that comprises several words, as Begg and Paivio maintain, critical word recognition should be facilitated by the high-imagery of other sentence words, expecially nouns. In either case, the interaction of recognition task, imagery, and possibly

retention interval will indicate the dimensional locus of the memory. If, for example, high-imagery facilitates synonym recognition and not homonym we can conclude not only that the image comprises several sentence words but also that it can be decoded only into semantic information.

Method

Subjects. Seventy-two University of Michigan female undergraduates served as subjects. They were each paid $1.75 for their participation in the experiment, and an additional performance bonus was awarded. Subjects served for approximately 1 hour and were randomly assigned to a particular counterbalancing of experimental conditions.

Experimental design. The experimental design was almost identical to that of Experiment I. Three retention intervals, 4, 12, and 36 seconds, were used instead of two.

The context variable in Experiment I was replaced by an imagery condition. All word strings were sentences, but each sentence had two versions, one with a high imagery noun and one with a low imagery noun (never the critical word). The arithmetic problems that subjects solved during the retention intervals were simple addition problems.

For each subject, 144 observations were taken, 72 "yes"-"no" response choices and 72 latencies. No confidence judgments were taken. For each combination of retention interval, imagery level, and recognition test (identical, homonym, synonym), there were four trials per subject, half of which were catch trials.

Procedure. Change to a different display apparatus allowed testing up to five subjects simultaneously. Thus, the instructions were read by the subject, rather than read to the subject by the experimenter. The instructions are reproduced in Appendix C. After it was determined that each subject understood the instructions completely, the subjects initiated the experimental sequence themselves. The first 10 trials were practice, during which the experimenter made sure the subjects were following instructions. Changes in the procedure from Experiment I were as follows: The sentence appeared in a cumulative sequence across the screen. The subjects were not told to read the words aloud, but they were told to pay attention only to the most recently appearing word. The presentation rate was again two words per second. The retention interval was filled with addition problems, the answers to which the subject typed into a keyboard under the screen. He was paid .5¢ for each correct answer. Because of the additional time taken to type the three-digit answer, only one problem appeared each 4 seconds. The termination of the retention interval was signalled by a "Ready" written on the screen, which preceded the probe cue by 1 second. The probe cues used were not the letters H, S, and I, but the words sound, meaning, and identical. The subjects were instructed to push one of two push-buttons ("yes" or "no") within 4 seconds of the appearance of the word to be recognized.

Apparatus. An IBM 1800 computer with five cathode-ray-tube display terminals was used. Accompanying each display was a typewriter keyboard as well as two pushbuttons for "yes" and "no" responses. Although the subjects were tested in groups up to five, they were isolated from each other in booths. The typewriter keyboard was used to type in the answers to the addition problems, as well as to stop and start the experiment.

Materials. Seventy-two short, simple sentences were constructed in the same way as Experiment I. These sentences ranged in length from five to eight words. Forty-eight nouns and 24 adjectives and verbs were used as critical words. Twenty-four of the nouns were used as sentence subjects and 24 as objects. For each sentence a low and high imagery noun was selected from the Paivio, Yuille, and Madigan (1968) nouns. Mean imagery ratings (on a six point scale) were 4.93 for high and 2.54 for low imagery. All efforts were made to equate the low- and high-imagery noun selections with regard to frequency and meaningfulness. In the case where nouns and adjectives served as critical words, the imagery noun was placed as far away as possible in the sentence from the critical word. In the case of verbs as critical words, nine of the sentences were varied in imagery via the first noun and nine via the second. A complete list of the sentences with high-and low-imagery nouns and recognition test words is given in Appendix D.

Criteria for the selection of catch words were the same as in Experiment I except that different catch words were used for synonym and identical recognition tests.

The addition problems that filled the retention interval involved the addition of two two-digit numbers whose sum was greater than 100. These were randomly generated by the computer during the experimental session.

Results

Again the dependent variables are recognition scores and latencies. The latencies were transformed to logs to normalize their distribution.

Shown in Figure 6 are the proportion correct "yes" responses, or hits, for the three recognition tests, three retention intervals, and two imagery conditions. Significant main effects were recognition test, $F(2,142) = 20.8$, $p < .001$, and retention interval, $F(2,142) = 40.85$, $p < .001$. Of the interactions, Imagery x Retention Interval was significant, $F(2,142) = 8.48$, $p < .001$, as well as Recognition Test x Retention Interval, $F(4,284) = 6.123$, $p < .001$, and the triple interaction Imagery x Recognition Test x Retention Interval, $F(4,284) = 13.27$, $p < .001$. Figure 6a shows the hit rate for high-imagery sentences; Figure 6b, for low-imagery sentences. The effects of imagery were unexpected. There was no main effect, but imagery interacted with retention interval in a way opposite to expectations.

False positives, or incorrect "yes" responses to catch words, show a similar pattern in Figure 7. Significant effects were recognition task, $F(2,142) = 17.315$, $p < .001$, retention interval, $F(2,142) = 6.1557$, $p < .005$, and the triple interaction, $F(4,285) = 3.69$, $p < .01$.

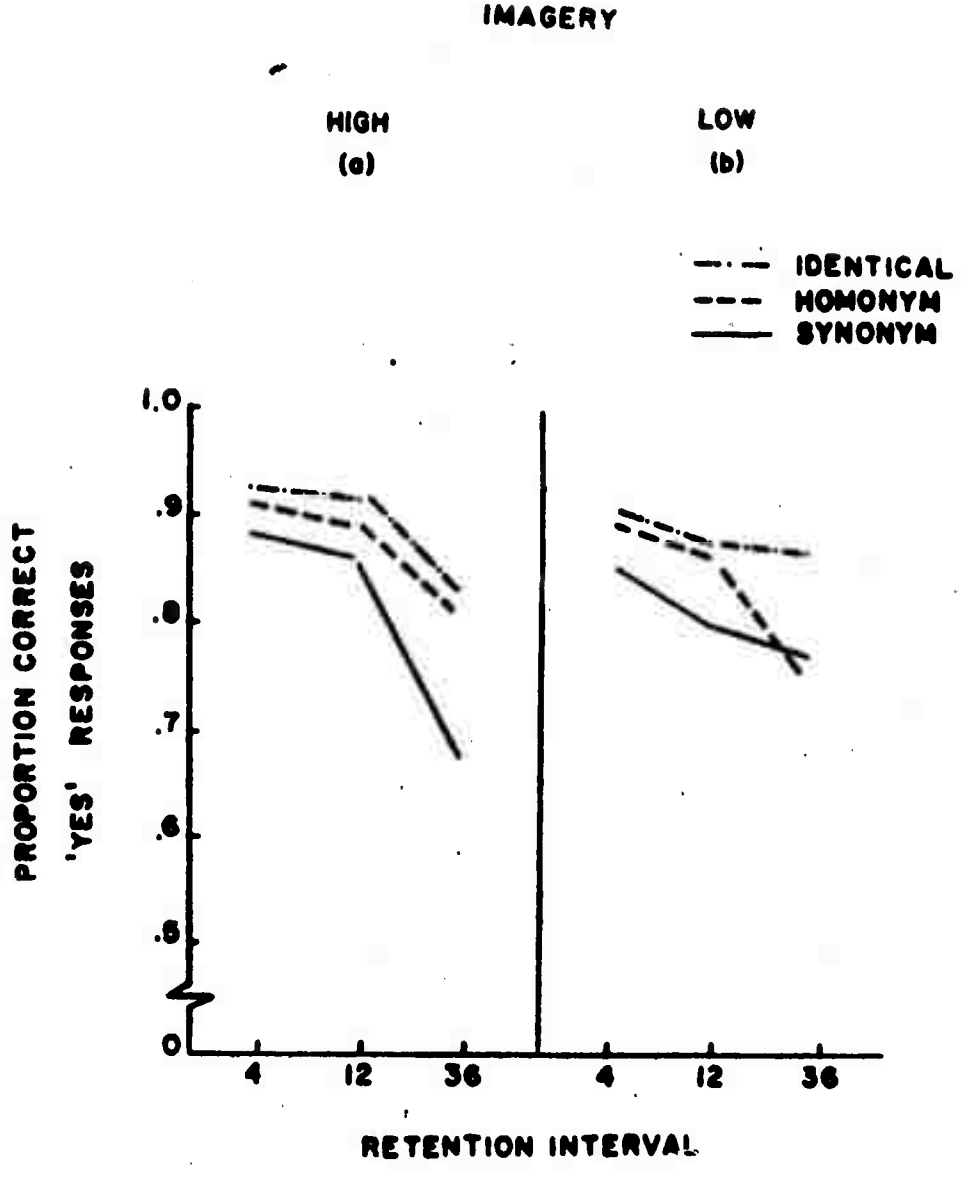

Fig. 6. Proportion correct "yes" responses for three recognition tests as a function of imagery and retention interval, Experiment II.

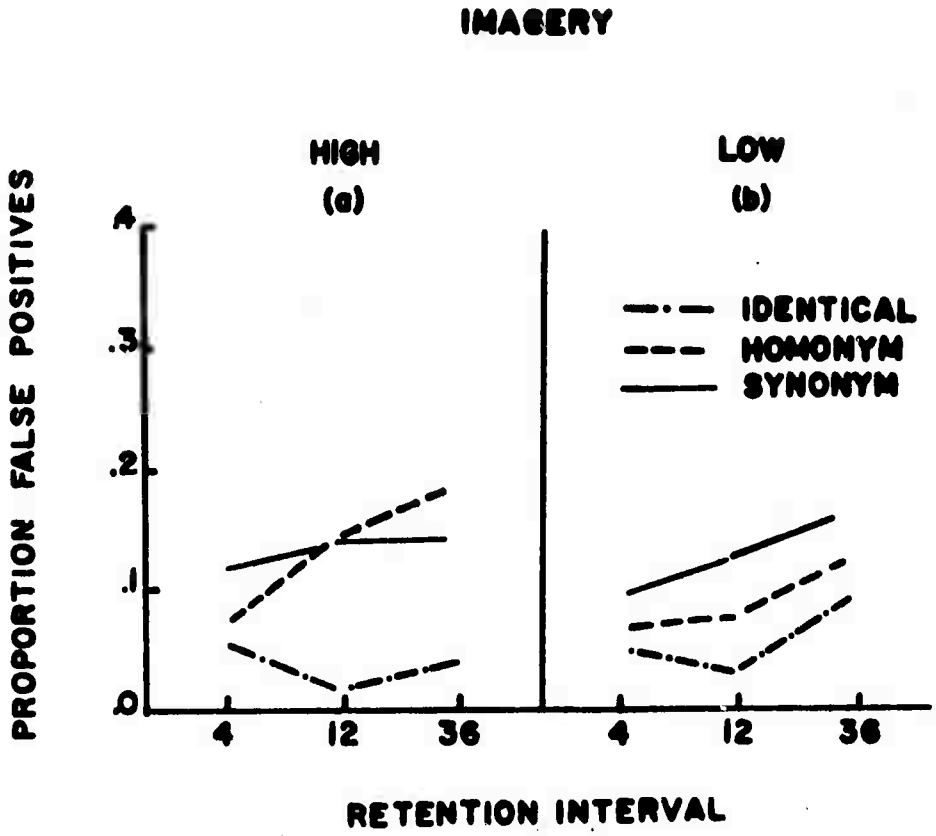

Fig. 7. Proportion false positives for three recognition tests as a function of imagery and retention interval, Experiment II.

As in Experiment I, the hit rates and false positives were transformed according to the high-threshold correction for guessing to obtain corrected recognition scores. These are shown in Figure 8.

The corrected recognition scores are quite similar to the uncorrected hit rates. Unexpected is the order of recognition tests. In Experiment I, in sentence presentation context, identical recognition was best, followed by synonym and then homonym. Identical recognition is superior here, also, but homonym is second. The pattern, in fact, is quite like the scrambled condition in Experiment I, except that recognition here is much superior overall.

The log transformation was applied to latencies in all conditions. In all the following figures the plotted means are antilogs of the mean of the transformed scores. Analyses of variance were done on these transformed scores. As in Experiment I, small differences in response latencies turned out to be significant. In Figures 9 and 10 are plotted the latency means for hits and correct rejections. The analyses of variance were done on latencies to probe and catch words separately. In the former, all effects yielded significant Fs at the $p < .01$ significance level, except imagery, retention interval x recognition task, and the triple interaction of imagery, recognition test, and retention interval. In the latter, the only significant main effect was recognition task, while all interactions except imagery x recognition task were significant at the $p < .025$ level. There are two interesting features in the latency data. In Experiment I, hit response latencies were fastest for identical and slowest for synonym, but

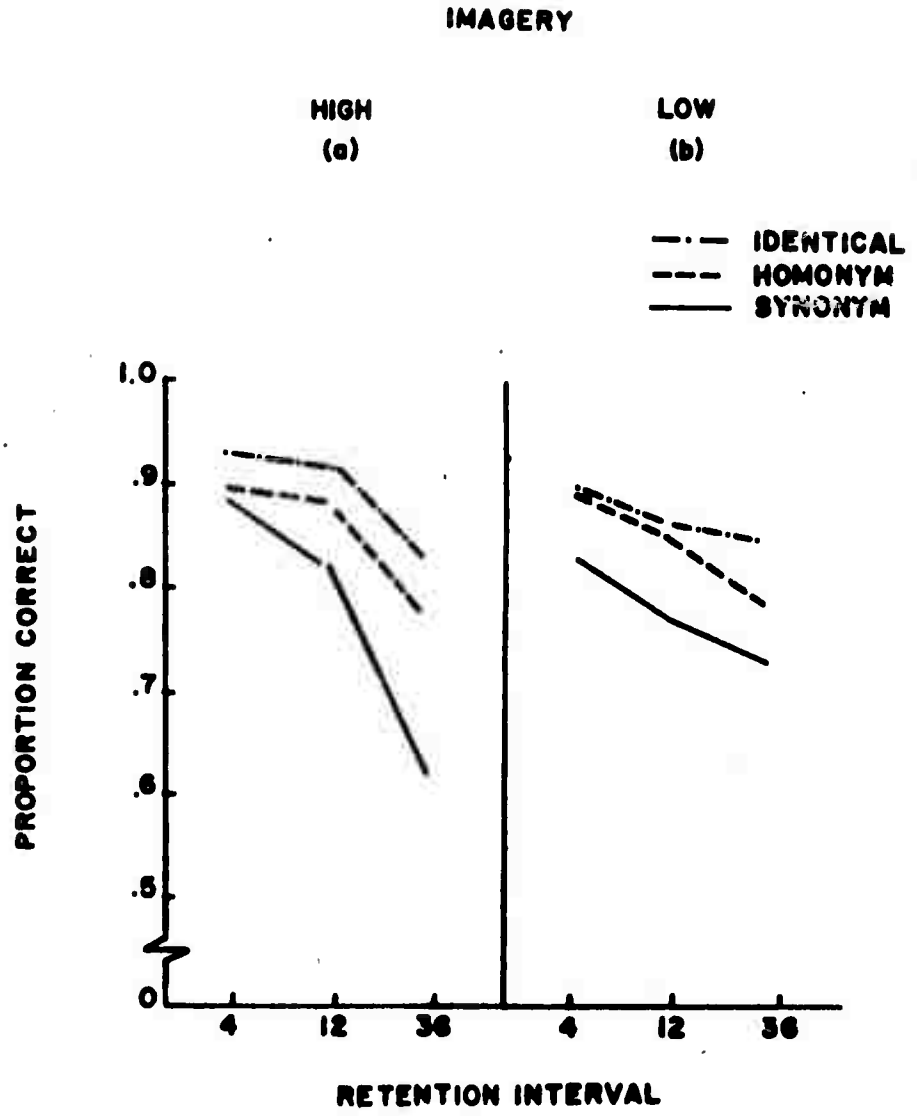

Fig. 8. Proportion correct (corrected for guessing) for three recognition tasks as a function of imagery and retention interval.

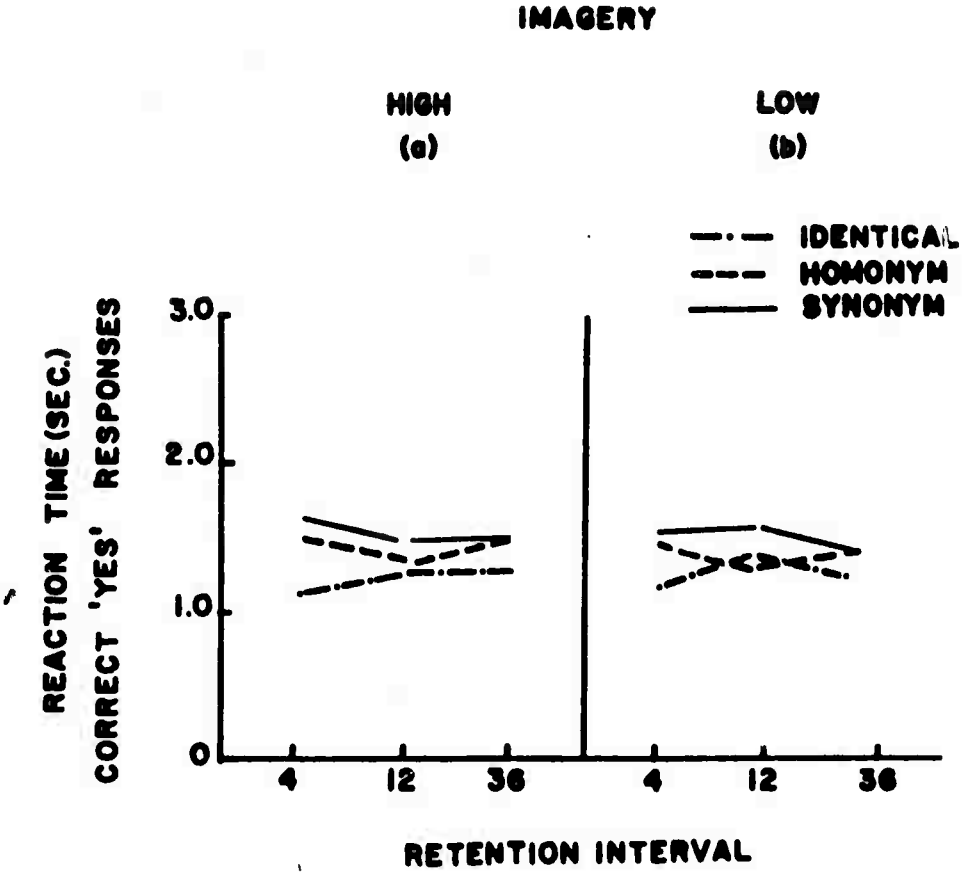

Fig. 9. Reaction times for correct "yes" responses for three recognition tasks as a function of imagery and retention interval.

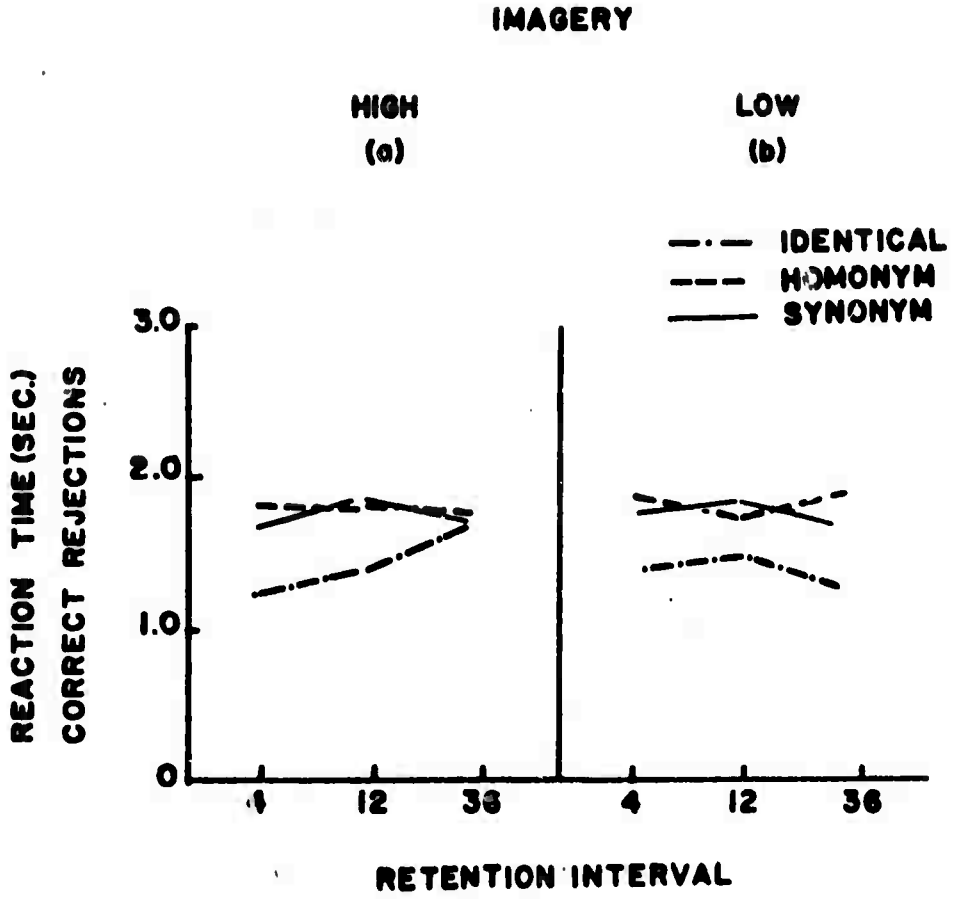

Fig. 10. Reaction times for correct rejection for three recognition tasks as a function of imagery and retention interval.

homonym and synonym latencies showed a reversal when correct rejections were analyzed. The same tendency appears here, but is very slight. In Figure 9, synonym hit response latencies are slower than homonym, but in Figure 10, they are approximately the same. The other feature is the failure of response latencies for both hits and correct rejections to vary monotonically with retention interval. This is further complicated by the fact that homonym latencies show a relative reduction at the 12-second interval while synonym and identical latencies are reduced at 4- and 36-second intervals.

Discussion

The purpose of Experiment II was two-fold. First, the effect of imagery on the semantic and phonemic dimensions of memory was considered. Second, two possible imagery-memory effects were examined. The most likely outcome was that high-imagery of a sentence noun would facilitate recognition of the critical word, usually the other noun. This prediction was derived from Begg and Paivio (1970) who suggest that more-or-less the entire sentence is tied up in the memory image, from which semantic information is derived. An alternative idea is that a single sentence word, normally a noun, serves as an anchor or "peg" for recall, and that properties for a preferred anchor are high-imagery, animacy, and distinctiveness. A prediction from this hypothesis is that high-imagery would depress critical word recognition.

The effects of imagery in this experiment were two interactions, one with retention interval, the other with retention interval and

recognition test in combination. Figure 6 shows the differential effects of noun imagery on the forgetting functions of the three recognition tasks. If one considers only the 4- and 12-second retention intervals, neither hypothesis is supported, for there are only slight differences in any of the recognition tasks. However, inclusion of the 36-second interval complicates the picture, for at this interval the "single-word anchor" hypothesis is supported. This is because synonym recognition benefits from low imagery relative to homonym. An analyses of variance for synonym hit rates showed the interaction of retention interval and imagery to be significant, $F(2,142 = 5.31$, $p < .001$. This substantiates a differential effect of imagery on synonym recognition at short and long retention intervals.

As for the latency data, there are some interesting trends. The first involves the nonmonotonicity of latencies over the retention intervals. For both probe and catch words homonym and synonym recognition latencies are approximately the same at the 4- and 36-second intervals, but at 12-seconds, the former is reduced and the latter increased. Because of a strong general tendency for latencies to follow proportion correct in recognition tasks (see Shulman, 1970; Martin, 1970), this odd lack of monotonicity somewhat clarifies the equally odd effects of imagery on memory dimensions. It indicates a possible retrieval route change as a function of retention interval, a contention in line with the

reversal of imagery effects at short and long intervals. Exactly what these routes may be is certainly not obvious at this point.

CHAPTER IV

SUMMARY AND CONCLUSIONS

The purpose of both experiments was to determine the relative contribution of phonemic and semantic memory dimensions to the encoding of sentence words. Also, to the extent that phonemic dimensions were exclusively short-term, whether such an encoding stage is bypassed in sentence encoding. In Experiment II the locus of sentence "comprehension" was sought by noting the effects of a variable causing large "meaning discrepancy" recognition effects (Begg & Paivio, 1970) on phonemic and semantic memory dimensions.

The results of Experiment I were clear. The effect of embedding a word in a sentence is to increase the relative contribution of the semantic memory dimension of the word memory as well as to reduce its rate of loss over a 20 second retention interval. In the scrambled context presentation condition, homonym recognition was superior to synonym recognition, and a rapid loss of synonym recognition occurred over 20 seconds. When the critical word was in a sentence, synonym recognition exceeded homonym recognition and the former showed a decreased forgetting rate from 5 to 20 seconds. Even though indirect evidence from latency data indicated that homonym recognition in sentence context presentation might be an overestimate, it was still quite substantial. Certainly, it could not be said that any phonemic dimensions were short-term only or were bypassed in sentence encoding.

In fact, in Experiment II homonym recognition exceeded synonym in all conditions. Presumably this superiority was due to using shorter sentences and sequential presentation. Sentences used in Experiment I were loaded with context, having multiple clauses and phrases. Sentences in Experiment II normally had two nouns, a verb, and one adjective. Whatever the reason, phonemic memory dimensions are certainly not eliminated even when sentences are used as stimuli. However, this does not imply that they are in any way integral to meaning comprehension. That issue was examined in Experiment II by including a variable with strong effects on meaning recognition, noun imagery. However, instead of varying the rated imagery of the entire sentence as has been done in the past, the imagery of only one noun was varied, for in this way two possible sentence memory mechanisms could be examined. Imagery had little or no effect on homonym recognition, the differences between high- and low-imagery conditions at the 4- , 12- , and 36-second retention intervals being .000, .023, and .018 respectively. Large effects, however, were observed in some synonym and identical recognition conditions. The same differences were +.053, +.055, and -.130 for synonym recognition, and +.021, +.041, and -.053 for identical, respectively, high-imagery minus low. What was unexpected was that the imagery effect showed up only at the longest retention interval. In effect the "whole sentence image" hypothesis received only slight support at short intervals, but the "single word image" hypothesis received strong support at the longest. The difference can be parsimoniously explained by a "selective memory mechanism," the explanation of which follows.

It is reasonable to assume that images behave like other memories in that they are eventually forgotten. It is also likely that the details of such images are the first to go. If they are organized with the highest imagery word in the sentence as their nucleus, the results of Experiment II may be readily explained. At relatively short retention intervals, all the information in the whole sentence image including the critical word, is available. In the high-imagery condition critical word information would be subsidiary, but in the low it would be likely to comprise the nucleus of the image. As more details were forgotten only the nucleus would remain, in the former case, an image noun, in the latter, the critical word image. Such a simple mechanism would explain why imagery had different effects on critical word synonym (and identical) recognition at long and short retention intervals. Thus, the evidence indicates a selective encoding and retention mechanism which is sensitive to rated imagery, or some correlate of it. Phonemic encoding dimensions seem to be relatively unaffected by either sentence context or imagery and evidently do not contribute to sentence meaning comprehension, although they may be integral to verbatim recall.

These two experiments and the Paivio studies indicate that imagery is a variable which has strong effects on the meaning of sentences and sentence words. Here, differential effects were obtained for semantic and phonemic memory dimensions. Paivio found differential effects for semantic and grammatical memories. The problem is now to determine

how grammatical, semantic, and possibly phonemic memories combine to produce a verbatim sentence protocol. Such a process may take place on a variety of levels, not just grammatical, and utilize different amounts of each, depending on characteristics of the stimulus sentence.

APPENDIX A

INSTRUCTIONS FOR EXPERIMENT I

This is an experiment in sentence memory. It involves recognizing words you have seen before. However, it involves not only recognizing words, but also the sound and meaning of the words.

Everything you will have to watch in the experiment will appear on the screen in front of you. Here is the exact sequence of events. First a READY will appear in the center of the screen. Then a string of words will appear on the screen. Either this string will be a sentence or a sentence which has been scrambled up. In either case, what you are to do is read the sentence aloud in time to this metronome. In other words, read one word each time the metronome beats. When you get to the last word, the string of words will disappear. At this time you will see a mathematics problem on the screen. Your task is simply to solve the problem while it is on the screen and say the answer aloud. You will have to be quick because you have only two seconds. Actually there is a series of such problems; you just solve them as they come up. You will be paid one-half cent for each problem you solve correctly. This can amount to a great deal of money, for there are many problems in the experiment. When the mathematics problems are replaced by another READY signal, stop doing the problems, for you will not be paid for any problems you do after the READY appears and you will have to get ready for the recognition test.

One second after the READY appears, a large "H," "S," or "I" will appear on the screen. These stand for homonym, synonym, and identical, respectively. They are cues to tell you what kind of recognition you must make to a word which will appear one-half second after the cue. For example, if an "H" appears you must judge whether the word sounds the same as any of the words in the word string. If an "S" comes up, you must determine whether the following word means the same as any of the words in the word string and if an "I" appears, the judgment you must make is identity of the word and any word in the string. You indicate your decision by pressing either the "yes"- or "no"-key in front of you. Now, I want you to respond according to your first impulse. In other words, don't hee-haw around about an answer. If you haven't decided upon an answer in four seconds, take a guess. I don't want any response times that are very long. After you make your response, I want you to press one of the keys next to the yes-no keys to indicate how sure you were of your answer. When you press one of these keys, five seconds will elapse and then the next trial will start.

There are many trials, each consisting of the READY signal; word string, which you read aloud with the metronome, mathematics problems, another READY, and a recognition test for sound, meaning, or identity. Respond with your first impulse, and within four seconds. Five seconds after you indicate your confidence in your answer the next trial will start. Remember to read the word string in time with the metronome.

If you have any trouble or have questions during the experiment, just tell me over the intercom for I can stop the experiment temporarily.

Are there any questions?

The first six trials are for practice. I will stay here and assist you during the practice.

APPENDIX B

EXPERIMENTAL MATERIALS FOR EXPERIMENT I

Each word string has two versions. Shown in this appendix are the seventy-two strings used. First the sentence is shown, then the scrambled version, and third, the homonym, synonym, and identical probe words, and the three catch words for the homonym, synonym, and identical conditions, respectively.

1. On the road stood four fluffy white cats with bright blue collars.
   With white road on collars the stood four blue bright fluffy cats.

   rode street road need store store

2. One type of urn represents the entire history of ancient Greek culture.
   Greek type the urn one history culture represents of ancient of entire.

   earn vase urn lean stripe stripe

3. Few natives of the isle thought the port should be built elsewhere.
   Should natives the built isle few the of elsewhere thought port be.

   aisle island isle esay powder powder

4. A hard bearing and tart manner place him aloof from his friends.
   Him from bearing hard friends manner tart a aloof placed his end.

   manor way manner hour term term

5. Cruel laws of survival dictate that weak animals succumb to the strong.
   The of curel survival to succumb weak dictate that laws strong animals.

   week feeble weak mode partial partial

6. The haul was so rich that to steal more gold was fruitless.
   Fruitless more was haul so rich the steal was gold to that.

   steel rob steal fur serve serve

7. The thief cares little about cuasing the grim pain his victims suffer.
   Grim his little thief suffer cares the about pain causing victims the.

   pane hurt pain core dust glacier

8. My aunt scooped up water by hand because our pail leaked badly.
   By scooped badly up leaked hand aunt our my pail water because.

   pale bucket pail worse glacier glacier

9. As our symbol of peace we gave ten acres of fertile prarie.
   Gave ten symbol prarie of as fertile peace our we of acres.

   cymbal sign symbol altar crest crest

10. Very few fairy tales take longer to read than classic novels do.
    Read then novels tales to very fairy few do take classic longer.

    tails stories tales gates colors colors

11. It's humiliating having to sell your car to a cheap junk yard.
    To cheap humiliating car sell its yard a having junk your to.

    cell vend sell toe brew brew

12. The prisoner said that to flee was the wisest choice to make.
    Choice prisoner said make the flee to wisest was to that the.

    flea escape flee nun damage damage

13. Very rarely do tourists find an inn filled during the off season.
    Rarely season very the tourists off inn an do during filled find.

    in hotel inn but steamer steamer

14. Amateur actors rarely refuse playing in minor roles if they want fame.
    Rarely fame amateur in they playing want roles actors minor in refuse.

    rolls parts roles nose facts facts.

15. The snow fell hard last night but the sleigh has broken runner.
    Fell the last night but broken has snow sleigh the runners hard.

    slay sled sleigh haul cane cane

16. Businessmen who fail in product sales are likely to gamble badly also.
    Sales also who product businessmen to fail badly are gamble likely in.

    gambol wager gamble parish forsake forsake

17. After he threw the first ball they knew he could pitch today.
He the threw ball he today after first knew could pitch they.

through hurled threw down asked asked

18. If fields are sown in early spring crop yield is never large.
Spring yield in sown large fields in early is never crop are.

sewn planted sown graze broken broken

19. With fish and most fowl white wines are usually served with dinner.
Are fish most white fowl with served with wines dinner usually and.

foul birds fowl reel men men

20. Rural towns sometimes believe a witch is able to cast evil spells.
Towns cast a is witch able rural evil spells sometimes believe.

which sorceress witch all bridegroom bridegroom

21. One the east coast of England mist causes the icy cold weather.
East on causes cold the weather mist coast the England icy of.

missed haze mist choose broom broom

22. Because of big losses last spring we couldn't loan the club anything.
Club the last couldn't anything losses of because loan big we spring.

lone lend loan land dine dine

23. If nurses have daily contact with infared rays they are well shielded.
Daily have they well nurses infared with rays contact are shielded if.

raise beams rays waste baths baths

24. Reforms in tax laws now provide the money that poor farmers need.
Need the tax now that farmers reforms laws money poor provide in.

pore destitute poor wax irrational irrational

25. Such a feat was impossible just a few years before war struck.
Impossible years feat a struck before such was a just few war.

feet accomplishment feat guest prominence promiennce

26. A long deep groan came from the corner of the rose garden.
Corner deep came groan the garden rose the a from of long.

grown moan groan soared stock stock

27. When school officials condone dissent they yield to the whims of fools.
All to condone the dissent school of officials yield when whims they.

descent disagreement dissent lesson sweetness sweetness

28. At early dawn dogs are allowed to run free on our farm.
Dawn free farm to on allowed early dogs at the run were.

aloud permitted allowed minor dramatize dramatize

29. When father appears completely relaxed we rap very softly on his door.
Appears hard we relaxed completely his rap door on very father when.

wrap knock rap ease ease bruise bruise

30. To hold high wage work long a maid must prove herself worthy.
Hold must a high long herself work maid to worthy wage prove.

made housekeeper maid paced comrade comrade

31. Major ports tend to be exciting sites for seamen to spend leave.
Sites major be ports to exciting spend for seamen leaves tend to.

semen sailors seamen quarry workers workers

32. Living in a cozy shack near a clean water creek is fine.
Clean a fine water shack in a is near creek cozy living.

creak stream creek wring blouse blouse

33. Next to pier number six runs a fence made of old posts.
Made to pier next a six of posts old number fence runs.

peer dock pier seam wreath wreath

34. Parents should never meddle in the lives of married and settled children.
Settled married the meddle parents and children in of should never lives.

medal interfere meddle carrot duplicate duplicate

35. Concrete floors seem too coarse to paint if common brushes are used.
To floors in paint coarse too common are used brushes seem conrete.

course rough coarse base rare rare

36. Patients seldom stay in a daze during recovery in the surgery ward.
Stay surgery patients in during daze in seldom ward the recovery a.

days stupor daze teams ransom ransom

37. Bubble gum which sold for a cent costs five times more now.
More for now gum a five cent which sold bubble times costs.

scent penny cent peek bracelet bracelet

38. After the spear was invented a stone axe was the next step.
The was stone next invented a was axe after step spear the.

39. Marrying an Asian alien is complicated by a maze of red tape.
A marrying alien complicated a tape red of maze by is Asian.

maize labyrinth maze ark observatory observatory

40. Each time he falls off his new tricycle he bawls even louder.
Falls louder he off he even time his tricycle bawls each new.

balls cries bawls rose toils toils

41. A somewhat bizzare series of events led to his partners quick demise.
Partner to bizzare quick his events of a series led somewhat demise.

bazaar unusual bizarre borough disorderly disorderly

42. Having a wholesome idol helps children mature more than young friends do.
Mature a helps idol than having do children friends wholesome more young.

idle hero idol merry hermit hermit

43. We shot a wild hare because we hadn't eaten for thirty hours.
Hours wild because for hare we thirty a hadn't shot we eaten.

hair rabbit hare owl parent parent

44. A medieval lord assures a serf only protection from some hostile groups.
Hostile from only some protection serf a groups assures lord a medieval.

surf peasant serf prey escort escort

45. He displayed knowledge and used tact and skill dealing with voters.
Used he and voters with and tact dealing skill knowledge displayed.

tacked finesse tact heard dismay dismay

46. In some states obscene books are still banned even from private homes.
Are homes some still states even private banned in books from obscene.

band forbidden banned poll distinctive distinctive

47. Our local guide felt too ill so the whole trip was ruined.
Our too local ruined was guide the ill whole felt trip so.

hole entire whole red drastic drastic

48. The working pioneers in early America loved each piece of hard land.
Early the America pioneers in working loved land of piece each hard.

peace section piece reign disguise disguise

49. If my borders were rich I would charge many times normal rent.
Charge would boarders many I times rich were rent normal my if.

borders roomers boarders lyres subject subject

50. The white horses bridle hurt him enough to impede his training pace.
Him hurt enough bridle impede to horses his pace training white the.

bridal halter bridle flower headlight headlight

51. Many jars in the cellar had rotted due to air leaking in.
Rotted had due the cellar to jar air many in leaking in.

seller basement cellar boulder grassland grassland

52. The cows were milked before dawn to save time for other chores.
Before save to time milked dawn for the chores were other cows.

don daybreak dawn buy force force

53. Low heat was common where small ducts carried chilly fresh air uphill.
Small carried where chilly fresh common ducts was air uphill heat low.

ducks vents ducts lain step step

54. Despite incompetence in line work he showed flair for handy type jobs.
Showed but work for line handy in flair despite type jobs incompetence.

flare aptitude flair sail quantity quantity

55. Many years of wet cold storage can make jam taste too tart.
Storage make can cold wet of tart taste jam many too years.

jamb jelly jam dough student student

56. Without any income striking families were loath to give presents this season.
Striking were families income give this without loathe presents season to give.

presence gifts presents cereal fleet fleet

57. For the friar prayer took the place of food fun and frolic.
Place the friar food took of fun the prayer for frolic and.

fryer monk friar sucker clown clown

58. Fred said that the sum was less than eight hundred at any rate.
Eight then any said sum Fred the hundred less rate at that.

some total sum ought abuse abuse

59. It's not true that wax keeps a glossy sheen on tile floors.
Glossy that a keeps wax tile on true not floors sheen it's.

whacks polish wax gaze jacket jacket

60. The lower house passed a tax on luxuried like sports events tickets.
Sports like luxuries house events tax the passed lower on a tickets.

tacks tariff tax wits cold cold

61. The motor scarcely ran and deep rot had rendered the hull useless.
Ran and deep rendered had motor rot useless the hull the scarcely.

wrought decay rot awed top top

62. In tiny towns a smile seals a pact and binds both parties.
Seals and binds a parties tiny both pact a towns both smile.

packed agreement pact rumored illusion illusion

63. I arranged to help pour concrete but the guys failed to arrive.
Concrete but the pour failed help to arrange guys failed I arrive.

guise fellows guys sole player player

64. Smart politicians leave issues alone and preach to their herd of followers.
Alone issues and leave preach politicians their followers herd smart to and.

heard flock herd hue mound mound

65. The steeple tolled eight loud gongs to warn children to stay inside.
Warn to tolled eight children gongs stay to steeple the inside loud.

told chimed tolled gained smoked smoked

66. The team got tense when the ready gun fired for the sprints.
Ready the first tense when gun the sprints team for the got.

tents nervous tense masts grand grand

67. Spotting the bear he whirled and fired from pure self defense instincts.
Fired from and pure whirled he bear defense instincts self spotting the.

world spun whirled cased sent sent

68. Laws decree that homes be leased on a short nine month basis.
Short basis a homes nine leased be that month decree on laws.

least rented leased odd kicked kicked

69. Eastern religious sects retain in their holy orders too many ancient myths.
Their in retain orders to eastern holy ancient many sects myths religious.

wholly sacred holy altered mellow mellow

70. Bad situations are reduced by trying to lessen the most likely cause.
To trying to reduced the are most lessen likely cause situations bad.

lesson reduce lessen bury bargain bargain

71. Many votes are lost because large numbers only choose the best party.
Numbers because only large lost the are votes choose best many party.

chews select choose heals carry carry

72. Dials and gauges measure stress points when the weights flex steel sheets.
Measure stress gauges points when dials and steel the flex and steel weights.

flecks bend flex cut drive drive

APPENDIX C

INSTRUCTIONS FOR EXPERIMENT II

The experiment in which you are about to take part is concerned with how people remember words they read in sentences. Your full co-operation is essential if the experiment is to be useful. Even though the following instructions may seem quite complex as you read them, the experiment is quite simple once you get into it. It is important, however, to read the instructions carefully.

Essentially, the experiment is a word recognition experiment. You will be called upon to tell whether you have seen a given word before or not. It is, however, a bit different because you will not only make recognitions on the basis of the identity of a word and an earlier presented word, but on the basis of the sound of the two words or the meaning of the words. Thus, you will have three kinds or recognitions to make in this experiment: The first on the basis of the identity of a word and an earlier word, the second type on the basis of the sound identity of the two words, and the third on the basis of the meaning identity of two words. With this in mind, let's look at the exact procedure.

There are a number of "trials" in the experiment. Each trial follows this procedure: On the screen in front of you you will see a large "READY." Two seconds later a sentence will appear in the center of the screen, one word at a time from left to right. As the sentence words appear concentrate on the word which just appeared. Try not to

look back at previous words in the sentence unless you missed them for some reason (a sneeze, etc.).

Just after the final word of the sentence appears, the entire sentence will disappear and will be replaced by an addition problem. Either one, or a number of such problems will appear, one each five seconds. Your task is simply to solve these problems as they come up, for you will be paid a half a cent for each one you solve correctly. Over the entire experiment there are a great number of such problems so you can make a good deal of money in addition to your hourly rate if you solve them all correctly. For each problem you have five seconds to solve the problem, type in your answer on the top line of the typewriter, and enter the answer by pressing the enter and shift keys of the typewriter at the same time. You must do all of this while the problem is still on the screen, for anything you do after it is replaced by another problem will count for that second problem. Continue to solve the addition problems until you see another "READY" on the screen. When you see this signal stop doing the problems immediately and put your hands on the pushbuttons on either side of the typewriter, for you will use these to make your next response.

After this READY goes off the screen, one of three words will appear in the center, "//sound//," "//meaning//," or "//identical//." These words are "cues" and tell you which of the three types of recognition you will have to make of a word which will follow immediately. If a "//sound//" appears, followed by a word, you have to determine

whether that word "sounds like" any of the words in the sentence which appeared before the addition problems. You make your response by pressing one of the pushbuttons you have your hands on, the "yes" button or the "no" button. If the "cue" is "//meaning//" you have to recognize whether the following word has the same meaning as any of the sentence words, and if the "cue" is "//identical//", whether the word is identical to any in the sentence. As an example, take the sentence "The long lost son was in grave peril." If you saw a "//sound//" followed by the word "sun" you would press the "yes" button, because "sun" sounds like "son." You would also give "yes" answers to "//meaning//" - "danger" and "//identical//" - "long" because "danger" means the same as "peril" and "long" is identical to "long." On the other hand, if you saw the word "gull" following any of the three "cues" your proper answer would be "no" and you would press the "no" pushbutton. After you make your answer by pressing one of the two pushbuttons, the screen will go blank for five seconds before the next trial starts. It will follow the same sequence consisting of a sentence, addition problems, and a recognition test.

During the five seconds between the response for one trial and the "READY" for the next you can stop the experiment for questions or to take a break. You simply press the "s" key on the typewriter and then enter it by pressing the "enter" and "shift" keys at the same time. Do this only between a pushbutton response and the start of the next trial. To restart the experiment press the "g" key and enter it by pressing the "enter" and "shift" at the same time.

Although you should attempt to make as correct recognition as you can, I would also like you to press the pushbuttons as soon as the answer "pops" into your head. In other words, obey your first impulse. The reason for placing your hands on the pushbuttons at the beginning of each recognition test (the "READY") is so there is no delay between the time you make your decision and the time you press the appropriate ubtton. This is important because I am interested in how fast you come to a decision. If you haven't come to a decision within four seconds after the word to be recognized appears, take a guess. I don't want any reaction times over two seconds if possible.

To review the procedure - you will see a sentence and concentrate on each word as it appears. The sentence will be replaced by a number of addition problems which you are to solve, typing the correct answer into the top row on the keyboard and then pressing the "enter" and "shift" keys simultaneously. This must be done while the problem is still on the screen. When another "READY" appears put each hand on the pushbuttons at the sides of the typewriter immediately. You will then see a "cue" which will tell you what kind of recognition you are to make to the following word. If you think the word has the "cued" relationship to a word in the last sentence, press "yes" - otherwise press "no." Make these responses within four seconds and according to your first impulse. Following the response there is a five second rest before the next trial begins. If you wish to stop the experiment for any reason you can do it during this interval only. Simply press the

"s" key of the typewriter and follow it by pressing the "enter" and "shift" keys at the same time. To restart, the same procedure is followed except the "g" key is pushed instead of the "s" key.

It will be helpful to you to know that the correct answer on one half of the trials is "no," so if you are perfect you will have answered one half "yes" and one-half "no" answers.

If you feel that you understand the instructions, go ahead and start the experiment. The first eight sentences (in the first eight trials) are practice sentences. This gives you a chance to get accustomed to the procedure. Before you start, check and make sure that the right hand pushbutton is "yes" and the left hand one "no." During the first few sentences practice stopping the experiment in the interval between your answer and the next trial, because you will probably want to at some point in the experiment. If you have any questions during the experiment, wave your hand at me.

If you have no questions now, start the experiment by pressing the "enter" and "shift" keys at the same time. When the experiment is completed, the screen will give you further instructions.

APPENDIX D

EXPERIMENTAL MATERIALS FOR EXPERIMENT II

Each sentence has two versions, a high- and low-imagery. In the high-imagery condition the first noun after the asterisk is used; in the low-imagery condition, the second noun. Following each sentence in the list are the probe words for the sound, meaning, and identical recognition tasks and catch words in the same order.

1. A safe road is free of * grass fault.

   rode street road need store bench

2. Making an urn required much * iron effort.

   earn vase urn lean stripe jem

3. A major * disaster misconception threathen the isle.

   aisle island isle essay powder galley

4. A tart manner affects a hard earned * friend position.

   manor way manner hour term number

5. An atheist * ambassador belief breeds weak morals.

   week feeble weak mode partial blank

6. Some cruel * priests deceits steal the mortal soul.

   steel rob steal fur serve blame

7. An injured * limb ego can cause grim pain.

   pane hurt pain core dust night

8. A red pail carried our last * tools substitute.

   pale bucket pail worse glacier door

9. The peace symbol has a liberal * origin sentiment.

cymbal sign symbol altar crest revenge

10. The tale indicates a serious * underworld unreality.

tails stories tales gates colors feast

11. A drug pusher sells his own * agony malady.

cells vends sells toes brews want

12. A wanted man flees his own * grief thoughts.

fleas escapes flees nuns damages patch

13. The tired * henchman charlatan found a quaint inn.

in hotel inn but steamer sock

14. His varied roles shows confused * passions interests.

rolls parts roles nose facts cramps

15. The late * storm hour slowed the speedy sleigh.

slay sled sleigh haul cane house

16. A stupid gamble shows a bad * sickness weakness.

gambol wager gamble parish forsake slope

17. The young * admiral owner threw the long line.

through hurled threw down asked held

18. The couple had sown their own * valley hardship.

sewn planted sown graze broken felt

19. Some rare * animal event killed the local fowl.

foul birds fowl reel men gent

20. A real witch causes a severe * delerium distraction.

which sorceress witch all bridegroom boss

21. The weird * pollution occasion caused dense mist.

missed haze mist heel broom beet

22. The city * library franchise will loan old copies.

lone lend loan coin dine chase

23. An atomic * missle diffusion produces gamma rays.

raise beams rays waste baths colds

24. The lucky poor have a little * happiness knowledge.

pore destitute poor left irrational clerk

25. A world * railway law was a major feat.

feet task feat guest prominence gleam

26. An ugly groan shook the serene * hotel silence.

grown moan groan soared stock glow

27. Great * speakers majorities experss passive dissent.

descent disagreement dissent lesson sweetness headway

28. The local * village opinion allowed a wild party.

aloud permitted allowed minor dramatize landed

29. A loud rap stopped the old * gaiety memory.

wrap knock rap ease bruise lack

30. Our last maid lost her old * bungalow competence.

made housekeeper maid paced comrade prince

31. A decent * bar attitude cheats a common seamen.

semen sailor seamen quarry workers pastor

32. The fresh creek is a constant * amazement reminder.

creak stream creek wring blouse peg

33. The rotten pier held some small * steamers virtue.

peer dock pier seam wreath knob

34. Parents meddle in a childs * fantasies opportunitites.

medal interfere meddle carrot duplicate kidnap

35. A good * cigar vegetable has a coarse surface.

course rough coarse base rare glum

36. The only * maiden inhabitant fought a near daze.

days stupor daze teams ransom kilt

37. The critical * machine evidence cost a few cents.

scents pennies cents cures bracelets fact

38. The stone axe was mans best * toy idea.

acts hatchet axe bores faucet dot

39. A tricky maze creates a tough * impact session.

maize labyrinth maze ark observer flint

40. A normal * officer replacement uses a small plane.

plain aircraft plane rose toils floor

41. Bizarre events bothered the * graduation prayer.

bazaar unusual bizarre borough foolish drowsy

42. An older idol assures a stable * pupil direction.

idle hero idol merry hermit tumbler

43. The cave * dweller creature lived on the whild hare.

hair rabbit hare owl parent tusk

44. The hostile serfs got a greater * salary advantage.

surf peasant serf prey escort jerks

45. A superb * lecturer intellect uses a conning tact.

tacked finesse tact heard dismay loss

46. The rural town banned the * procession investigation.

band forbid banned poll distinct lunged

47. The new * poster evidence proved the whole thing.

hole entire whole red drastic loose

48. Each intricate piece was a small * circle unit.

peace section piece reign disguise load

49. The rich boarders had a final * meeting theory.

borders roomers boarders lyres subject loafer

50. A nosy group peeked at the noisy * glutton episode.

peaked looked peeked glowered headlight incited

51. The heavy * storn atmosphere ruined the cellar.

seller basement cellar boulder grassland hurdle

52. The actual & assault beginning was at early dawn.

don daybreak dawn buy force gust

53. The escaped * prisoner air followed the duct.

ducked vent dust lain step grub

54. The foreign * juggler falconer had the right flair.

flare aptitude flair sail quantity drag

55. Crazy * leaflets moments grate the deep feelings.

great irritate grate dough student

56. The * mantle backyward was filled with presents.

presence gifts presents cereal fleet orchard

57. Older friars condone no secular * jealousy thought.

fryers monks friars suckers clowns drummer

58. The * boss management ignored the latest sum.

some total sum ought abuse pawn

59. Most tiny * animals beings burrow a living space.

borough dig burrow gaze win ransack

60. Prevailing * competition attitudes abhored the tax.

tacks tariff tax wits cold saw

61. The fungal rot ruined their good * skin health.

wrought decay rot awed top scar

62. A simple * truce pledge equals a binding pact.

packed agreement pact rumored illusion twitch

63. A few guys encouraged constant * insanity irony.

guise fellows guys sole player whales

64. The final * atrocity outcome yielded a small herd.

heard flock herd hue mound weed

65. The church tolled the second * hour reminder.

told chimed tolled gained smoked stewed

66. A declining * star ability split the tense team.

tents nervous tense masts grand strict

67. The serious * beast incident whirled him around.

world spun whirled cased sent sprang

68. The * passage unit was leased to the group.

least rented leased odd kicked sliced

69. Extreme * griefs morals start some holy sects.

wholly sacred holy altered mellow scenic

70. The * decorations fantasies lessen holiday tension.

lesson reduce lessen bury bargain ravage

71. Senior members will choose the * boulder advice.

chews select choose heals carry prick

72. Some strong men can flex a narrow * pipe mind.

flecks bend flex cut drive junk

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