# THE LOW FREQUENCY SUPERIORITY EFFECT IN RECOGNITION MEMORY

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# IN RECOGNITION MEMORY

by

LINDA MUZZIN, B. A.

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AUTHOR: Linda Muzzin, B. A. (McMaster University)

SUPERVISOR: Dr. Betty Ann Levy

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SCOPE AND CONTENTS:

Two explanations for the low-frequency superiority effect in recognition memory are described and a third, distractor-type hypothesis is developed. The distractor-type hypothesis proposes that Ss have a preference for abstracting semantic features from high-frequency words and acoustic features from low-frequency words. It suggests that low-frequency superiority is a result of semantic interference with high-frequency words combined with a lack of acoustic interference with low-frequency words. The results of three experiments which support this hypothesis are reported. Experiments I & II showed that more acoustic than semantic-type errors are made with low-frequency words and more semantic than acoustic-type errors are made with high-frequency words in the recognition memory paradigm. Experiment III of this series examined the relationship of the distractor type and distractor frequency variables.

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## Tables

One variable which has traditionally been shown to affect the speed and accuracy with which lists of words are learned or remembered is that of the frequency of common usage of the words within the lists. Lists of words which vary in frequency of occurrence in written English can be easily constructed by use of the Thorndike-Lorge frequency tables (1944). The effects of manipulating Thorndike-Lorge frequency have proven to be complex, however, in that they vary from paradigm to paradigm and even from study to study within a single paradigm. For example, Ss usually do better with low-frequency (LF) words in recognition memory tasks, but better with high-frequency (HF) words in free recall. But within the free recall paradigm itself, studies also have found no effect of frequency on recall (Paivio, 1968) or better recall of LF words when the lists are composed to abstract words (Winnick & Kressel, 1965).

The present thesis is restricted to an investigation of frequency effects in the recognition memory paradigm. In this situation, the S is presented with a list of words to remember, and then is required to choose the words he saw from a list of the presented words combined with distractor words. In this case, more LF words are correctly chosen than HF words (Gorman, 1961;

Schwartz & Rouse, 1961; Shepard, 1967). This effect shall be referred to as LF superiority. One explanation of LF superiority has been proposed by Underwood & Freund (1970); another has been suggested by Kintsch (1970). The thesis consists of a brief description of these ideas, followed by a more extensive development and experimental test of a third hypothesis to explain LF superiority in recognition memory.

## Underwood & Freund's hypothesis

Underwood & Freund (1970) explain the LF superiority effect in recognition memory in terms of interference theory. According to interference theory, the greatest source of forgetting is due to unit-sequence interference, which is interference from pre-experimental associations between words. It is postulated that the amount of unit-sequence interference increases as a function of the frequency of occurrence of a unit in the language, such that the more frequently a unit is used, the more likely it is to acquire strong associates which compete with those prescribed in the experimental series (Postman, 1969).

Underwood & Freund propose that since HF words have a greater number of associations than do LF words, they are more open to interference from distractors in the recognition memory task than are LF words. They constructed 50-item lists of HF and LF words, and chose 50 HF and LF distractor items for these lists. Each S received either the HF or LF list at a 1 item/sec. rate, and then was required to choose the word he saw from each of 50 pairs, where the distractor items were either HF or LF. A significantly greater number of errors occurred when the HF words were paired with HF distractors than when they were paired with LF distractors. Underwood & Freund attribute this effect to the influence of implicit associational responses (IAR's) elicited by the test word. They argue that the IAR's for HF words are more likely to cause confusion with HF distractor items because HF words have more associations than do LF words, and these associations are more likely to be other HF words (Deese, 1960). Since IAR's to LF words are less likely to occur, fewer recognition errors are made with LF words, and therefore, recognition for these LF words appears superior. Their interference hypothesis, then, suggests that the only reason that recognition of LF words is superior to recognition of HF words is that LF words have fewer associates which interfere during the recognition test.

Kintsch's hypothesis

Although some studies have been cited which do not find superior performance with HF words in free recall tasks, Kintsch (1970) cites this as the major finding, and points out that it contrasts with the LF superiority found in recognition memory. He argues that this reversal in performance between HF and LF words for recall and recognition may reflect a basic difference between the two processes of recall and recognition. Dual-process theory questions the basic assumption that recall and recognition simply measure associational strength, and proposes that the two are qualitatively different processes. Recall is held to be dependent upon the facility with which subjects can organize material for retrieval, while recognition, which does not require retrieval, depends upon the ease with which items can be discriminated (Garner, 1962; Kintsch, 1970).

The hypothesis is that HF words are better recalled because they are more easily organized for retrieval, while LF words are better recognized because they are more distinctive, and more easily discriminated in the recognition task. Kintsch (1968) has presented convincing evidence that recall but not recognition is sensitive to variations in the organizational level of memory lists. At the present time, however, there is no way to evaluate the contribution of this factor to the LF superiority effect in recognition memory.

Development of a third alternative: the distractor-type hypothesis

A third explanation for the LF superiority effect in recognition memory can be developed from consideration of some recent work by two-stage memory theorists. Duplexity theorists describe memory by a two-stage model, which consists of primary memory (PM), a relatively transient "echo-box" stage in which acoustic properties of verbal material are retained, while secondary memory (SM) is a more permanent stage in which semantic and other properties of verbal material are retained (Kintsch & Buschke, 1969; Baddeley, 1970). Further, they propose that superior performance in the recency portion of serial position curves in list-learning experiments reflects the contribution of PM, while a flat serial postion curve reflects the contribution of SM (Glanzer & Cunitz, 1966).

There are basic differences in the serial position curves for learning of HF and LF lists to a criterion of one correct recital per list. Sumby (1963) has found that if Ss are required to learn HF lists, the serial position curves for the first few trials are essentially bow-shaped. On the other hand, if Ss are required to learn LF lists, the serial position curves for the first few trials show high recency. As well, Ss tend to recall their first few words from the beginning of the list for HF words, but closer to the end of the list for LF words. Both of these observations suggest that HF and LF words are differentially processed into permanent storage.

If HF words reach SM faster than LF words, and are better represented in SM, then HF words should be favoured over LF words in both long-term recognition and recall situations. This is inconsistent with the finding that superior performance with LF words was obtained with lists as long as 540 words (Shepard, 1967), in which the contribution of SM should virtually account for all of the recognized words. The value of the idea that HF words reach SM faster than LF words, although it cannot account for frequency effects in recognition memory, is in suggesting that there may be a difference in the way in which HF and LF words are processed. This difference cannot be expressed in terms of a greater number of HF words relative to LF words in SM, but it might be expressed in terms of a different type of representation of HF words than

LF words in SM.

There have been many demonstrations that at least two types of features, semantic and acoustic, are retained from words at a long-term memory level (Baddeley, 1966; Brown & McNeill, 1966; Bruce & Crowley, 1970). Although both types of features are probably important in remembering both HF and LF words, there is some indication that semantic features of HF words are salient, while acoustic or graphological features of LF words are salient in memory. Sumby (1963), for example, noted that the most frequently occurring word pairs recalled in his list-learning experiment were semantic for HF words (lip-touch; kiss-lip; dark-black), but were acoustically-related for LF words (wert-weft; shrew-shrike; prate-pard). That semantic representation is important for HF words is supported by Noble's (1952) demonstration that HF words have more associates than LF words, the majority of which are semantically-related words. That acoustic representation is important for LF words is also evident from the ability of <u>Ss</u> to offer words similar in structure when read the definition of a LF word which they are unable to recall (Brown & McNeill, 1966).

If it is assumed that semantic features of HF words are better represented in SM than acoustic features, and that acoustic features of LF words are better represented in SM than semantic features, then the LF superiority effect in recognition memory reported in previous studies may have occurred because of the type of distractors used. In the Underwood & Freund (1970) study, for example, HF and LF lists were paired with either HF or LF distractors. As Underwood & Freund have argued, the HF distractors will be likely to be semantic associates of the HF words, and poor performance will occur in this condition. On the other hand, it could be argued that LF words escape interference from both HF and LF distractors, since neither tend to be acoustically-similar to the test word. In other words, a maximum amount of forgetting of HF words should result when distractors are chosen which are not merely HF, but which are true semantic associates of the test words. This should be true, regardless of the frequency of the distractor. Conversely, if acoustic features are the important ones in remembering LF words, then inferior performance with LF words should result when acoustically-similar distractors are used in the recognition memory task. Again, this should be true, regardless of the frequency of the distractor. It is essentially being argued that the lack of acoustically-similar distractors in the Underwood & Freund study may have produced the LF superiority effect.

Experiments I & II of the present thesis test this possibility by pairing HF and LF words with semantically-similar and acoustically-similar distractors in the recognition memory paradigm. It is predicted that LF words will be recognized better than HF words when semantically-similar distractors are used, but that the recognition of HF words will be superior when acoustically-similar distractors are used.

Experiment III of the present series is a further attempt to evaluate the importance of Underwood & Freund's distractor frequency variable in relation to the semantic and acoustic variables described in this section. The hypothesis which has been developed suggests that Underwood & Freund observed a LF superiority effect, not because of the frequency of the distractors used, but because of: (1) the lack of acoustic interference with LF words; and (2) semantic interference with HF words as a concomitant of the pairing of HF words with other HF words. This aspect of the distractor-type hypothesis is discussed in further detail below, and is tested in Experiment III.

# EXPERIMENT I

## METHOD

Design and Materials.- Two sets of 100 test words were chosen from the Thorndike-Lorge Word Book (1944), such that one set contained words occurring with a frequency of at least 100 per million while the other contained words occurring with a frequency of only one per million. The words were chosen randomly from alternate pages of the frequency tables when a word of the appropriate frequency class appeared on these pages. For each test word chosen, a semantically-similar and an acoustically-similar distractor were found. Semantically-similar distractors were chosen from a version of Roget's Thesaurus (1966) which presents lists of words related in meaning. The test word was located in one of these word lists, and a distractor word was chosen from the same list in which the test word appeared. Acoustically-similar distractors were generated to rhyme with the test words and they approximated the test words in length and number of syllables. For example, the semantically-similar distractor for the HF word "battle" was "war", while its acoustically-similar distractor was "cattle." For the LF word "starling", the distractors were "blackbird" and "starving", respectively. The two sets of words and their distractors appear in Appendix VI.

Each set of 100 test words was divided into 5 lists of 20 words each; there were two orders of the resulting 10 lists (5 HF, 5 LF) with HF and LF lists occurring randomly in each set. This variable will be referred to as the Order of Lists variable. Half of the subjects received one order of lists, while the other half received the other order of lists.

The recognition test was designed so that a score could be obtained for each S according to Test Word Frequency (High vs. Low) and Distractor Type (Semantic vs. Acoustic). Distractor Type was counterbalanced across Ss, since each S was tested with only one distractor per word. Half of the words in each list were paired with acoustically-similar distractors, and the other half were paired with semantically-similar distractors. Order of the test word in the pair and occurrence of pairs in each list were randomized.

Procedure.- All lists were presented over a closed-circuit TV system with each word appearing serially on the TV monitor at a rate of 2 items/sec. The S's task was to silently read the items as they appeared on the screen. At the end of each list, he added one to each number in a list of two-digit numbers called out rapidly by E. This delay was instituted in order to eliminate items which might be output from short-term memory (Peterson & Peterson, 1959), since the LF superiority effect in recognition memory is a SM effect.

After the filled delay for each list, the S attempted to circle the correct member of each of 20 pairs of words. The next list was presented when all Ss in the group had completed this task.

Subjects.- Twenty undergraduates from an introductory psychology course served as subjects, and were paid for their participation. They were tested in small groups of 2-3 persons.

RESULTS

Recognition scores for HF and LF words paired with each type of distractor are shown in Table I. Since a few ommissions occurred, scores are reported in terms of the number of possible items correct, rather than the number of errors. Better recognition scores were obtained for LF words paired with semantically-similar distractors, than for LF words paired with

Table I

Number of correct choices in all conditions, Experiment I (N = 1000)

| | Test Word Frequency | |
| --- | --- | --- |
| | High Frequency | Low Frequency |
| Distractor Type: | | |
| Semantically-similar | 754 | 830 |
| Acoustically-similar | 818 | 776 |

acoustically-similar distractors. As well, better recognition scores were obtained for HF words paired with acoustically-similar distractors than for HF words paired with semantically-similar distractors.

An analysis of variance for the main effects in this experiment (Appendix I) shows that this interaction of Test Word Frequency X Distractor Type was the only effect to reach significance ($\underline{F} = 44.54$; df = 1,18; $\underline{p} < .001$).

DISCUSSION

Experiment I provides clear-cut support of the distractor-type hypothesis. As predicted by the hypothesis, LF words are better recognized than HF words when semantically-similar distractors are used, but HF words are better recognized than LF words when acoustically-similar distractors are used. The reversal is stable and highly significant across subjects.

When the test words were paired with semantically-similar distractors, a LF superiority effect occurred. This result indicates that semantic similarity of the distractor is one variable which contributes to the LF superiority effect. The fact that more LF than HF errors were made when the words were paired with acoustically-similar distractors indicates that memory for acoustic features is important for LF words. It is to be expected that when memory for such features is not interfered with by the use of acoustically-similar distractors, the absence of acoustic interference will contribute to a LF superiority effect.

## EXPERIMENT II

### METHOD

Experiment II was an attempt to replicate Experiment I, but with two changes: in the first place, rate of presentation was slowed from 2 items/sec. to 1 item/sec., to determine whether the effects of Experiment I were peculiar to a high rate of presentation, which induced Ss to code the words by acoustic features. Secondly, lists were presented such that Ss received either all of the HF lists first or all of the LF lists first. This was used as an alternate method to the randomization-of-lists procedure used in Experiment I.

Subjects.- Twenty subjects, obtained through a local Manpower Centre, were paid for their participation in the experiment. They were tested in small groups of 2-3 people.

### RESULTS

Table 2 presents the number of errors made

Table 2

Number of errors for all conditions, Experiment II (N = 500)

| | Order of Lists | | | |
|---|---|---|---|---|
| | HF lists first | | LF lists first | |
| Test Word Frequency: | HF | LF | HF | LF |
| Distractor Type: | | | | |
| Semantically-similar | 87 | 59 | 92 | 45 |
| Acoustically-similar | 47 | 87 | 71 | 93 |

HF = High frequency

LF = Low frequency

with HF and LF words paired with both types of distractors and for both types of list order. Since care was taken to avoid omissions, the data is presented in terms of errors. For both the condition in which all of the HF lists were presented first and the condition in which all of the LF lists were presented first, more errors were made with HF words paired with semantically-similar distractors than with the same HF words paired with acoustically-similar distractors. Further, for both conditions, more errors were made with LF words paired with acoustically-similar distractors than with the same LF words paired with semantically-similar distractors.

An analysis of variance for the main effects of this experiment (Appendix II) showed that this interaction of Test Word Frequency X Distractor Type was highly significant ($\underline{F}$ = 38.51; df = 1,18; $\underline{p} < .001$). That is, as in Experiment I, significantly more semantic than acoustic errors occurred with HF words, and significantly more acoustic than semantic errors occurred with LF words.

The only other variable to reach significance was the Order of Lists X Test Word Frequency X Distractor Type interaction ($\underline{F}$ = 27.98; df = 1,18; $\underline{p} < .001$).

Subjects apparently made more semantic errors with HF words when HF lists were presented first, and more acoustic errors with LF words when LF lists were presented first. Despite this curious order effect, however, the Test Word Frequency X Distractor Type interaction was in the same direction for both orders of list presentation. This can be verified by inspection of Table 2.

DISCUSSION

Experiment II provides further support for the distractor-type hypothesis and demonstrates that the results of Experiment I are replicable, despite differences in the order of lists and rate of presentation variables. The essential finding is that LF words are better recognized than HF words when the words are paired with semantically-similar distractors, while HF words are better recognized than LF words when the words are paired with acoustically-similar distractors in the recognition memory paradigm.

There are at least two possible explanations for these observed results: (1) There is a preference for remembering acoustic features of LF words, and a preference for remembering semantic features of HF words, such that semantically-similar distractors interfere most with recognition of HF words and acoustically-similar distractors interfere most with recognition of LF words; (2) Rhymes such as those chosen in Experiments I & II might tend to be LF while the semantically-similar distractors might tend to be HF. Since the frequency class of the distractors chosen in both of these experiments was not controlled, it is possible that more semantic than acoustic errors with HF words because the distractors tended to be HF, and that more acoustic than semantic errors occurred with LF words because the rhymes tended to be LF. Distractor Frequency, then, rather than Distractor Type, might be the relevant variable in these two experiments.

Experiment III was undertaken to decide between these two possibilities. High and low frequency words were paired with semantically and acoustically-similar distractors, half of which were HF and half of which were LF. Explanation (1) predicts that lower recognition scores should be obtained for LF words paired with acoustically-similar distractors, whether these distractors are HF or whether they are LF. Similarly, it predicts that lower recognition scores should be obtained for HF words paired with semantically-similar distractors, whether they are HF or whether they are LF. On the other hand, explanation (2) predicts that lower recognition scores should be obtained for LF words paired with LF distractors, whether these distractors are acoustically or semantically-similar. Similarly, it predicts that lower recognition scores should be obtained for HF words paired with HF distractors, whether these distractors are acoustically or semantically-similar to the test words.

## EXPERIMENT III

### METHOD

Design and Materials.- Eight sets of 100 words were chosen from the Thorndike-Lorge Word Book, such that 4 sets contained words occurring with a frequency of at least 50 per million (HF sets) and the other 4 sets contained words occurring with a frequency of approximately 10 per million or less (LF sets). Distractors were then chosen for each HF word in the following way: for set I, the distractors were HF (50 per million) and semantically-similar to the test words. Semantically-similar distractors were chosen from a thesaurus as in Experiment I. Examples of HF words and their distractors from set I are "begin-start" and "almost-nearly". For set II, the distractors were LF (10 per million) and semantically-similar to the test words.

Examples are "knight-vassal" and "praise-laud". For set III, the distractors were HF and acoustically-similar to the test words. An attempt was made to control acoustic similarity more precisely than in Experiments I & II by changing only one letter in the test word to form the distractor, where possible. This procedure produces highly acoustically-similar distractors. Examples are "fellow-follow" and "master-matter". And for set IV, the distractors were LF and acoustically-similar, examples being "morning-moaning" and "department-deportment".

Distractors for the 4 sets of LF words were chosen in a similar way, with set V composed of HF semantically-similar distractors (vassal-knight; laud-praise); set VI composed of LF semantically-similar distractors (ardent-zealous; bandit-outlaw); set VII composed of HF acoustically-similar distractors (moaning-morning; deportment-department); and set VIII composed of LF acoustically-similar distractors (baronet-bayonet; contrition-contortion). Conveniently, sets V and VII for the LF words were identical to sets II and IV for the HF words, with the distractor from the first two sets serving as the test word in the second two sets. The resulting six sets of words and their distractors are listed in Appendix VII."

Because distractors were chosen which fulfilled both a distractor frequency and a distractor type criterion," the number of very high and very low frequency words which could be used was smaller than in Experiments I & II. Where possible, an attempt was made to minimize this dilution of the frequency variable by choosing the highest and lowest frequency words available.

The four sets of HF words were divided into 20 lists of 20 words each. Similarly, the four sets of LF words were divided into 20 lists of 20 words each. Half of the Ss received the HF lists, and the other half received the LF lists, in order to avoid the order effect in Experiment II.

In the recognition task, five of the 20 lists seen by each S were tested with HF semantic distractors, five were tested with HF lookalikes, five were tested with LF lookalikes, and the remaining five were tested with LF semantic distractors. The order of the set of five lists tested with each distractor type was controlled by using a balanced Latin square design. A sample order was as follows: the first five lists tested with LF semantic distractors, the second five lists each tested with HF semantic distractors, the third five lists each tested with LF lookalikes, and the final five lists each tested with HF lookalikes. Three other groups received different orders.

Thus a measure of the recognition of the words could be obtained according to Distractor Frequency (High vs. Low) and Distractor Type (Semantic vs. Acoustic). Order of the group of lists tested with each distractor type and Test Word Frequency (High vs. Low) were measured between Ss.

Procedure.- The procedure was identical to that used in Experiments I & II. The S saw each list at a rate of 2 items/sec., and then attempted to circle the correct member of each of 20 pairs of words in the recognition task, following a filled delay.

Subjects.- Sixteen high-school students served as subjects, and were paid for their participation. They were tested individually.

RESULTS AND DISCUSSION

The major finding of Experiment III was, as predicted by the distractor-type hypothesis, that acoustic similarity is a potent factor in recognition memory for LF words. Table 3, which presents the total number of errors for HF and LF words paired with

Table 3

Number of errors made in Experiment III, all conditions (N = 800)

| | Test Word Frequency: | |
|---|---|---|
| | High Frequency | Low Frequency |
| Distractor Type: | | |
| HF, semantically-similar | 185 | 146 |
| LF, semantically-similar | 98 | 185 |
| HF, acoustically-similar | 214 | 201 |
| LF, acoustically-similar | 43 | 244 |

HF = High frequency

LF = Low frequency

each of the four types of distractors, shows that more acoustic than semantic errors were made with LF words, regardless of distractor frequency. A separate analysis of variance for the LF data (Appendix V) supports this contention, in that Distractor Type was the only important variable, and it was highly significant ($\underline{F}$ = 40.36; df = 1,4; $\underline{p} < .005$). The point that acoustic similarity of distractors as defined in these experiments is a major source of errors in recognition memory for LF words, then, can be taken as adequately demonstrated, since this effect occurred consistently in all three experiments reported in this paper. Although the acoustic similarity variable may be related in some way to the distractor frequency variable, these experiments give no suggestions about the nature of this relationship.

An examination of Table 3 shows that similar distractor frequency, and not semantic similarity of distractors, appeared to be the important variable in recognition memory for HF words. That is, more errors were made with HF words paired with other HF words than with HF words paired with LF words, regardless of distractor type.

A closer investigation of Table 3 reveals that although distractor type was the significant variable in recognition memory for LF words, slightly more LF than HF distractors were actually confused with the LF words. As well, although similar distractor frequency appeared to be the significant variable in recognition memory for HF words, more semantic than acoustic distractors were actually confused with the HF words. Thus, an analysis of variance for all of the data (Appendix III) yielded highly significant interactions between Test Word Frequency X Distractor Type ($F$ = 85.31; df = 1,14; $p < .001$) and Test Word Frequency X Distractor Frequency ($F$ = 22.83; df = 1,14; $p < .001$). That is, significantly more semantic than acoustic errors were made with HF words, while more acoustic than semantic errors were made with LF words. However, more HF than LF distractors were confused with HF words, and more LF than HF distractors were confused with LF words.

The direction of these interactions between test word frequency, distractor type, and distractor frequency, suggest that a triple interaction of Test Word Frequency X Distractor Type X Distractor Frequency should occur. That is, it should be true that significantly more semantic than acoustic, and more HF than LF distractors are confused with HF words, while significantly more acoustic than semantic and more LF than HF distractors are confused with LF words. Appendix III, however, shows that this triple interaction was not significant.

The source of this complication is clear from an inspection of the data for each of the four different order of distractor types encountered in the recognition task for HF words (hereafter referred to as the Order variable). For two of the order, more semantic than acoustic errors were made, while for the other two orders, the reverse results were obtained. A separate analysis of variance for the HF data (Appendix IV) verified that this order effect was important: Order X Distractor Type was significant at the .025 level ($F = 10.62$; df = 3,4) and Order X Distractor Type X Distractor Frequency was also significant ($F = 8.50$; df = 3,4; $p < .05$).

In this separate analysis of the HF data, the Distractor Frequency variable was highly significant ($F = 51.39$; df = 1,4; $p < .005$), while Distractor Type failed to reach significance. That is, significantly more HF than LF distractors were confused with the HF words. A comparison of the separate analyses for HF and LF data (Appendices IV & V) suggests that the significant Test Word Frequency X Distractor Type interaction in the main analysis (Appendix III) stemmed from the LF data, while the significant Test Word Frequency X Distractor Frequency interaction in the main analysis stemmed from the LF data. The complicating effects of order with the HF data, however, do not allow the conclusion that similar distractor frequency is more important than semantic similarity in recognition memory for HF words. It should be emphasized here that no such order effects appeared in the separate analysis of the LF data, in which acoustic similarity of the distractor was the only significant variable. There is thus a strong possibility that distractor type is the important variable in recognition memory of HF as well as LF words.

Although analysis of the HF data does not warrant a conclusive statement about the relative importance of distractor type and distractor frequency in the recognition of HF words, at least two alternatives to the distractor-type hypothesis remain within the realm of possibility. For example, it is possible that distractor frequency is the significant variable in recognition memory, but that the distractor frequency was too dilute in Experiment III to produce consistent effects. As noted previously, the difference in frequency between HF and LF test words was of the magnitude of only 50 per million occurrences in Experiment III, while it was about 100 per million in Experiments I & II, a dilution of the effect by one-half for the test words and another one-half for the HF and LF distractors. Thus, the frequency variable might have been sufficiently dilute to disappear with the LF words. If this is the case, however, it is curious that distractor frequency was so highly significant with the HF words, but failed to reach significance with the LF words.

A second, more convincing possibility is that the distractor frequency variable is related in some manner to the variable which has been termed semantic in this paper. One type of possible relationship of distractor frequency to semantic similarity is suggested by the Underwood & Freund hypothesis described earlier. Underwood & Freund have pointed out that probability of association is an important variable which affects recognition memory such that when the distractor is a high associate of the test word, maximal interference occurs. This is how they explain the finding that more errors are made with HF word-HF distractor pairs than with any of the other three types of word-distractor pairs in their experiment. If probability of association is the important variable in the recognition of HF words, then high probability semantic associates would be expected to be as confusable as high probability acoustic associates of HF words. In other words, high semantic similarity may be seen to be only one component of high association.

This second possibility presents a picture of HF words being processed along several dimensions: semantic, acoustic, and perhaps other types, while LF words are processed primarily acoustically, being deficient in semantic and other types of associations. The demonstration by this set of experiments that acoustic similarity is a major factor in recognition memory for LF words is compatible with this view.

One final point might be added to this formulation. It predicts that HF words should encounter less interference from LF words because of the low probability of association of these words to the test word. The fact that more errors occurred with HF words paired with semantically-similar LF distractors than with those paired with acoustically-similar LF distractors in Experiment III may then result from: (1) a failure to equate probability of association for semantic and acoustic LF distractors; (2) a relative potency of semantic as compared to acoustic association in interfering with recognition of HF words; or (3) a combination of these two factors.

Despite these highly speculative possibilities, the data of Experiment III allows only the following clear conclusions: in the first place, acoustic similarity of distractor and test word is the major source of errors with LF words in this experiment. Secondly, semantic similarity of distractor and test word also contributes to error scores for HF words. It is possible that the importance of semantic similarity is secondary to or is related to the similar distractor frequency variable which was the source of the majority of HF errors in Experiment III. However, it is also possible that semantic similarity is the important variable in recognition memory for HF words, and that this importance is masked by the order effect. Thus, the distractor-type hypothesis remains an attractive explanation of the LF superiority effect in recognition memory.

## GENERAL DISCUSSION

Experiments I, II & III demonstrate that more errors are made with HF words in the recognition memory paradigm when the words are paired with semantically-similar distractors than when they are paired with acoustically-similar distractors. They further demonstrate that the reverse of this effect occurs with the LF words: significantly more errors are made when the LF words are paired with acoustically-similar distractors than when they are paired with semantically-similar distractors. It was suggested that these demonstrations have important implications for the LF superiority effect in recognition memory reported previously in the literature (Underwood & Freund, 1970; Shepard, 1967). Specifically, the pairing of HF and LF distractors with HF and LF words does not allow maximal interference with LF words, since HF and LF distractors would not tend to be acoustically-similar to the test words. As well, semantic interference of the type which occurred in the present three experiments may have occurred as a concomitant of the pairing of HF words with other HF words. This situation would yield a LF superiority effect.

Experiment III tested this notion specifically by pairing semantic and acoustic distractors, half of which were HF and half of which were LF, with HF and LF test words. The data indicated that acoustic similarity as manipulated here was indeed an important source of errors for LF words in recognition memory.

This factor, then, can no longer be overlooked, since it undoubtedly contributes to the LF superiority effect reported in the literature. A complicating factor in this experiment was that an order effect occurred in the HF word data, such that it cannot be stated with certainty that semantic interference is the major source of errors in recognition memory for HF words. All three experiments show that semantic similarity is an important variable, but Experiment III suggests that high distractor frequency is also implicated. Two possibilities for explaining the HF data of Experiment III have been described, including a reiteration of the Underwood & Freund explanation for the effect. Despite this speculation about the major source of HF errors in recognition memory, it remains a distinct possibility that semantic similarity would be seen to be the major source of errors if the order effect was not present. Even if this is not the case, it is certainly true that LF superiority is due in part to a lack of acoustic interference with LF words.

## SUMMARY

In the present paper, three hypotheses which attempt to explain superior performance with LF words in recognition memory were described. These included an interference hypothesis, a hypothesis based on a dual-process theory of recall and recognition, and a distractor-type hypothesis based on the notion that different features of HF and LF words are encoded into memory.

The distractor-type hypothesis proposed that semantic features are important in remembering HF words, while acoustic features are important in remembering LF words. The results of Experiments I, II & III provided strong support for this hypothesis by showing that more errors are made in recognizing HF words when they are paired with semantically-similar distractors than when they are paired with acoustically-similar distractors. Further, more errors of recognition were made with LF words when they were paired with acoustically-similar distractors than when they were paired with semantically-similar distractors.

The hypothesis further proposed that LF superiority effects reported in studies which pair HF and LF words with HF and LF distractors are due to: (1) lack of interference with LF words, since HF and LF distractors would not tend to be acoustically-similar to the test word; and (2) semantic interference with the HF words by pairing them with other HF words.

Experiment III provided strong support for (1) by showing that acoustic similarity but not distractor frequency had a significant effect in recognition memory for LF words. The HF data was less clear-cut, since a complex order effect occurred. It appeared that high distractor frequency was a more important variable than semantic similarity as a source of errors of recognition of the HF words. It was argued that although distractor frequency may be more important than, or related to the semantic similarity variable, the data does not rule out the possibility that semantic similarity of test word and distractor is a major variable which operates to enhance LF superiority.

The main finding of this set of experiments was that acoustic similarity is a potent variable in recognition memory. It was the major source of LF errors in all three experiments. Lack of acoustic interference undoubtedly contributes to superior performance with LF words, just as semantic, associative, or distractor frequency variables may contribute to inferior performance with HF words in recognition memory.

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## Appendix I

Summary of analysis of variance for the main effects of Experiment I

| SOURCE | SS | df | MS | F |
|---|---|---|---|---|
| Total | 1947.487 | 79 | | |
| Between Ss | 1327.237 | 19 | | |
| Groups (Order of Lists) | 132.612 | 1 | 132.612 | 1.998 |
| Error$_b$ | 1194.625 | 18 | 66.368 | |
| Within Ss | 620.250 | 1 | | |
| Test Word Frequency | 13.612 | 1 | 13.612 | .935 |
| Distractor Type | 1.012 | 1 | 1.012 | .199 |
| Order of Lists X TWF | 1.013 | 1 | 1.013 | .070 |
| Order of Lists X DT | .313 | 1 | .313 | .062 |
| TWF X DT | 171.023 | 1 | 171.023 | 44.537* |
| Order of Lists X TWF X DT | 10.602 | 1 | 10.602 | 2.761 |
| Error$_1$ | 262.125 | 18 | 14.563 | |
| Error$_2$ | 91.425 | 18 | 5.079 | |
| Error$_3$ | 69.125 | 18 | 3.840 | |

* $p < .001$

Ss = Subjects
TWF = Test Word Frequency
DT = Distractor Type

## Appendix II

Summary of analysis of variance for the main effects of Experiment II.

| SOURCE | SS | df | MS | F |
|---|---|---|---|---|
| Total | 1632.500 | 79 | | |
| Between <u>Ss</u> | 876.000 | 19 | | |
| Groups (Order of Lists) | 5.525 | 1 | 5.525 | .114 |
| $Error_b$ | 870.475 | 18 | 48.360 | |
| Within <u>Ss</u> | 756.500 | 60 | 2.125 | .130 |
| Test Word Frequency | 2.125 | 1 | 2.825 | .409 |
| Distractor Type | 2.825 | 1 | 17.100 | 1.050 |
| Order of Lists X TWF | 17.100 | 1 | 19.500 | .2.826 |
| Order of Lists X DT | 19.500 | 1 | 135.600 | 38.512* |
| TWF X DT | 135.600 | 1 | 98.525 | 27.982* |
| Order of Lists X TWF X DT | 98.525 | 1 | 16.293 | |
| $Error_1$ | 293.275 | 18 | 6.899 | |
| $Error_2$ | 124.175 | 18 | 3.521 | |
| $Error_3$ | 63.375 | 18 | | |

* $p < .001$

<u>Ss</u> = Subjects
TWF = Test Word Frequency
DT = Distractor Type

# Appendix III

Summary of analysis of variance for the main effects of Experiment III

| SOURCE | SS | df | MS | F |
|---|---|---|---|---|
| Total | 9807.75 | 63 | | |
| Between *Ss* | 3671.75 | 15 | | |
| Test Word Frequency | 870.25 | 1 | 870.25 | 4.35 |
| Errorb | 2801.50 | 14 | 200.11 | |
| Within *Ss* | 6136.00 | 48 | | |
| Distractor Type | 121.00 | 1 | 121.00 | 33.70* |
| DF | 784.00 | 1 | 784.00 | 7.61** |
| TWF X DT | 306.25 | 1 | 306.25 | 85.31* |
| TWF X DF | 2352.25 | 1 | 2352.25 | 22.83* |
| DT X DF | 16.00 | 1 | 16.00 | .22 |
| TWF X DT X DF | 25.00 | 1 | 25.00 | .34 |
| $Error_1$ | 50.25 | 14 | 3.59 | |
| $Error_2$ | 1442.75 | 14 | 103.05 | |
| $Error_3$ | 1038.50 | 14 | 74.18 | |

* $p < .001$

** $p < .025$

TWF = Test Word Frequency
*Ss* = Subjects
DT = Distractor Type
DF = Distractor Frequency

Appendix IV

Summary of analysis of variance of the HF data of Experiment III

| SOURCE | SS | df | MS | F |
|---|---|---|---|---|
| Total | 5289.500 | 31 | | |
| Between *Ss* | 786.000 | 7 | | |
| Order of Distractors | 668.250 | 3 | 222.750 | 2.761 |
| $Error_b$ | 786.000 | 4 | 80.688 | |
| Within *Ss* | 4503.500 | 24 | | |
| Distractor Type | 21.125 | 1 | 21.125 | 3.634 |
| DF | 2926.125 | 1 | 2926.125 | 51.391* |
| Order X DT | 185.125 | 3 | 61.710 | 10.616** |
| Order X DF | 533.625 | 3 | 177.875 | 3.124 |
| DT X DF | 40.500 | 1 | 40.500 | 3.503 |
| Order X DT X DF | 294.750 | 3 | 98.250 | 8.497*** |
| $Error_1$ | 23.250 | 4 | 5.813 | |
| $Error_2$ | 227.750 | 4 | 56.938 | |
| $Error_3$ | 46.250 | 4 | 11.563 | |

* $p < .005$
** $p < .025$
*** $p < .05$

*Ss* = Subjects
DT = Distractor Type
DF = Distractor Frequency
Order = Order of Distractors = Order of Distractor Types paired with test lists
HF = High frequency

Appendix V

Summary of analysis of variance of the LF data of Experiment III

| SOURCE | SS | df | MS | F |
|---|---|---|---|---|
| Total | 3648.000 | 31 | | |
| Between Ss | 2015.500 | 7 | | |
| Order of Distractors | 683.250 | 3 | 227.750 | .684 |
| $Error_b$ | 1332.250 | 4 | 333.063 | |
| Within Ss | 1632.500 | 24 | | |
| Distractor Type | 406.125 | 1 | 406.125 | 40.358* |
| DF | 210.125 | 1 | 210.125 | 1.913 |
| Order X DT | 140.125 | 3 | 46.708 | 4.642 |
| Order X DF | 242.125 | 3 | 80.708 | 2.205 |
| DT X DF | .500 | 1 | .500 | .018 |
| Order X DT X DF | 44.750 | 3 | 14.917 | .546 |
| $Error_1$ | 40.250 | 4 | 10.063 | |
| $Error_2$ | 439.250 | 4 | 109.813 | |
| $Error_3$ | 109.250 | 4 | 27.313 | |

* p .005

Ss = Subjects
DT = Distractor Type
DF = Distractor Frequency
Order = Order of Distractors = Order of Distractor Types paired with test lists
LF = Low frequency

# APPENDIX VI

Lists of high frequency and low frequency words used in Experiments I & II, and the semantically and acoustically-similar distractors with which they appeared in the recognition task.

---

## HIGH FREQUENCY TEST WORDS

| WORD | SEMANTIC DISTRACTOR | ACOUSTIC DISTRACTOR |
|---|---|---|
| WHOLE | ENTIRE | HOLE |
| GROUND | SOIL | HOUND |
| VARIOUS | DIFFERENT | FERROUS |
| SILENCE | STILLNESS | VIOLENCE |
| SKIN | FLEECE | SPIN |
| BALL | GLOBE | HALL |
| ABOUT | AROUND | ABOUND |
| BELIEVE | SUPPOSE | RELIEVE |
| ACTION | DEED | FACTION |
| SUBJECT | CITIZEN | OBJECT |
| ACROSS | OVER | CROSS |
| COMMON | FAMILIAR | SUMMON |
| INCREASE | MULTIPLY | MISTREAT |
| CENTURY | HUNDRED | USURY |
| SINCE | AGO | RINSE |
| LETTER | MESSAGE | FETTER |
| PRESIDENT | CHAIRMAN | RESIDENT |
| WONDERFUL | MARVELLOUS | WORKABLE |
| BLOW | PANT | FLOW |
| BROTHER | KINSMAN | MOTHER |
| REALIZE | ACCOMPLISH | SERIALIZE |
| LONDON | ROME | LYNDEN |
| ABOVE | OVERHEAD | REBUFF |
| CHILD | INFANT | MILD |
| WINDOW | PANE | WINNOW |
| CHECK | INSPECT | WRECK |
| COMING | HAPPENING | HUMMING |
| ACT | SCENE | FACT |
| SUGAR | SWEET | MUGGER |

APPENDIX VI (CONTINUED)

| WORD | SEMANTIC DISTRACTOR | ACOUSTIC DISTRACTOR |
|---|---|---|
| ROUND | PLUMP | MOUND |
| EXPERIENCE | ACTIVITY | CLEARANCE |
| DIRECTION | TREND | INFLECTION |
| PAPER | NEWS | CAPER |
| TWENTY | SCORE | SEVENTY |
| ACCEPT | RECEIVE | INTERCEPT |
| LAST | FINAL | FAST |
| NATIONAL | COUNTRY | RATIONAL |
| FORGET | NEGLECT | CORSET |
| BATTLE | WAR | CATTLE |
| BEHIND | BACK | UNLINED |
| BABY | YOUNG | MAYBE |
| CONDITION | STATE | EDITION |
| UNDERSTAND | COMPREHEND | SUPERMAN |
| BEAUTIFUL | PRETTY | DUTIFUL |
| VILLAGE | TOWN | PILLAGE |
| MYSELF | ME | THYSELF |
| LIGHT | LUMINOUS | FIGHT |
| ACCORDING | CORRESPONDING | RECORDING |
| THOUSAND | GRAND | TOWNSMAN |
| UNION | MERGER | ONION |
| CAPTAIN | OFFICER | CAPTION |
| SOCIETY | ASSOCIATION | SOBRIETY |
| INDUSTRY | INGENUITY | DENTISTRY |
| EFFORT | ATTEMPT | EFFECT |
| SECOND | MOMENT | BECKON |
| CENTER | HUB | MENTOR |
| ASK | QUESTION | MASK |
| GROUP | CLASS | CROP |
| FORMER | FOREGOING | FIRMER |
| NEW | FRESH | FEW |
| TOMORROW | TODAY | TIMOROUS |
| SIGH | MOURN | HIGH |
| BORN | BIRTH | MORN |
| CONSIDER | DELIBERATE | CONSOLIDATE |
| PARIS | PAREE | FERRIS |
| FURTHER | FORWARD | FEATHER |
| KITCHEN | COOKING | LICHEN |
| HALF | SEMI | ELF |
| OLD | WORN | ILL |
| DARK | NIGHT | DANK |

APPENDIX VI (CONTINUED)

| WORD | SEMANTIC DISTRACTOR | ACOUSTIC DISTRACTOR |
|---|---|---|
| IRON | BRAND | EARN |
| BUSINESS | AFFAIR | DIZZINESS |
| CIRCLE | SPHERE | PURPLE |
| SHARE | PIECE | SCARE |
| NEVER | NOT | NETHER |
| HERSELF | ALONE | PERCEPT |
| BLACK | GLOOM | FLACK |
| BESIDE | ALONG | SEASIDE |
| SALT | PEPPER | MALT |
| FLOWER | BLOOM | BOWER |
| DEGREE | EXTENT | PEDIGREE |
| HISTORY | CHRONOLOGY | MYSTERY |
| BUILDING | STRUCTURE | WILLING |
| DECLARE | STATE | DEPLORE |
| REGARD | LOOK | RETARD |
| FELLOW | GUY | YELLOW |
| NICE | GOOD | MICE |
| PEOPLE | CROWD | STEEPLE |
| SETTLE | INHABIT | NETTLE |
| ABLE | FIT | TABLE |
| MONTH | WEEK | TENTH |
| DURING | THROUGHOUT | CURING |
| GATHER | COLLECT | RATHER |
| CHURCH | TEMPLE | LURCH |
| COMPANY | VISITORS | SYMPHONY |
| SUPPORT | UPHOLD | RAPPORT |
| QUICKLY | RAPID | FICKLE |
| PRESENT | GIFT | CRESCENT |
| NONE | ONE | WON |
| ROSE | RED | HOSE |

LOW FREQUENCY TEST WORDS

| WORD | SEMANTIC DISTRACTOR | ACOUSTIC DISTRACTOR |
|---|---|---|
| FRISKY | ACTIVE | RISKY |
| ACME | PEAK | ACNE |
| NEBULOUS | VAGUE | OBLIVIOUS |
| PRECURSOR | FORERUNNER | USURPER |
| DECADENCE | DETERIORATION | CONCORDANCE |

APPENDIX VI (CONTINUED)

| WORD | SEMANTIC DISTRACTOR | ACOUSTIC DISTRACTOR |
|---|---|---|
| BELFRY | CUPOLA | PANTRY |
| MUMPS | VIRUS | PUMPS |
| IMPURE | UNCLEAN | INJURE |
| DIGRESSION | BACKTRACK | DIGESTION |
| GROUCH | COMPLAIN | CROUCH |
| ABASE | DEMEAN | ABATE |
| FABRICATION | MANUFACTURED | LUBRICATION |
| SONATA | CONCERTO | CANTATA |
| CYCLIST | JOCKEY | ENLIST |
| WRONGDOING | MISDEED | UNDOING |
| ADEPT | EXPERT | ADDICT |
| ACCREDIT | AUTHORIZE | ACCOUNTANT |
| FENNEL | HEATH | KENNEL |
| PARSNIP | HORSERADISH | PARSLEY |
| DOMINOES | CHECKERS | DOMINION |
| BAROQUE | ARTISTIC | BOUTIQUE |
| BARBED | HORNED | BARKED |
| GUSTO | ZEST | PRESTO |
| SHAG | MAT | CRAG |
| INSECURE | UNCERTAIN | INTEGER |
| TRANSLATOR | PARAPHRASE | TRANSMITTER |
| LIMBO | PURGATORY | JUMBO |
| WHEEZE | WHISTLE | SNEEZE |
| RECTORY | MANSE | REFECTORY |
| SOLILOQUY | MONOLOGUE | SOLOPSISM |
| MOUSTACHE | WHISKERS | PASTICHE |
| MANLIKE | HUMAN | FANLIKE |
| STANCE | POSTURE | STAUNCH |
| LAUD | PRAISE | LOUD |
| VENTRICLE | AURICLE | VENTRILOQUY |
| BALEFUL | FOREBODING | SALEABLE |
| SCAB | SORE | SWAB |
| BANNOCK | CORNBREAD | HAMMOCK |
| TIMBER | GIRDER | LIMBER |
| ROCKIES | ANDES | JOCKIES |
| CREDIT | VERIFY | AUDIT |
| LICE | FLEAS | MICE |
| PHOENIX | PEGASUS | SPHINX |
| SWIVEL | PIVOT | SHOVEL |
| ABET | INCITE | ABATE |
| BARONET | NOBLEMAN | BASSINET |
| YAM | POTATO | HAM |

APPENDIX VI (CONTINUED)

| WORD | SEMANTIC DISTRACTORS | ACOUSTIC DISTRACTORS |
|---|---|---|
| TENET | DOCTRINE | TENEMENT |
| OBOE | FLUTE | HOBO |
| CREDENCE | BELIEF | IMPEDENCE |
| COMA | TORPOR | SOMA |
| STUBBY | SQUAT | CHUBBY |
| VIRILE | MASCULINE | TYROL |
| RELEGATE | CONSIGN | DELEGATE |
| PRAETOR | CONSUL | GRADER |
| CAD | OAF | CAT |
| MANGO | PEPPER | MANGLE |
| ADOLESCENCE | PUBERTY | EXCRESCENCE |
| PORPOISE | DOLPHIN | TORTOISE |
| FRITTER | DWINDLE | FLITTER |
| RECLUSE | HERMIT | RECKLESS |
| PROGRESSION | SEQUENCE | PERMISSION |
| SINE | TANGENT | SYNE |
| CAPON | GELDING | CANON |
| BRAWN | MUSCLE | PRAWN |
| NOODLE | MACARONI | NOZZLE |
| REVERIE | DAYDREAM | REFEREE |
| PRONG | FORK | WRONG |
| MAUVE | VIOLET | MAIZE |
| KAYO | MONEY | KALE |
| COLLOQUIAL | CONVERSATIONAL | COLLOQUIUM |
| REVERSAL | INVERSION | REHEARSAL |
| CLIQUE | FRATERNITY | CLICK |
| CHROME | METAL | CRONY |
| SCAVENGER | JUNKMAN | RAVAGER |
| FENDER | BUMPER | FONDER |
| CARNAGE | BLOODSHED | CARTHAGE |
| FACET | ASPECT | FAUCET |
| PUNK | GANGSTER | PINK |
| COGNAC | BRANDY | COMPACT |
| BULLDOG | BOXER | BULLFROG |
| SKIMP | MEAGER | SHRIMP |
| PURVEY | SUPPLY | SURVEY |
| BEFIT | PROPER | REFIT |
| NEWT | SALAMANDER | LEWD |
| BANNISTER | RAILING | CANNISTER |
| REEK | FUME | REEF |
| TRUSTFUL | CONFIDING | TRUCKFUL |

APPENDIX VI (CONTINUED)

| WORD | SEMANTIC DISTRACTOR | ACOUSTIC DISTRACTOR |
| --- | --- | --- |
| SAINTLY | HOLY | FAINTLY |
| GRAVEN | CARVED | CRAVEN |
| GRIME | SOOT | GRIPE |
| PAUNCH | POTBELLY | HAUNCH |
| SERENADE | MELODY | RENEGADE |
| STARLING | BLACKBIRD | STARVING |
| CORRELATE | CORRESPOND | SPORULATE |
| TEDIUM | BOREDOM | MEDIUM |
| CURSORY | SUPERFICIAL | BURSARY |
| BISON | BUFFALO | BYGONE |
| LYE | ACID | LIE |
| CROCUS | SAFFRON | FOCUS |

## APPENDIX VII

List of eight sets of 100 words and the distractors with which they were paired in Experiment III.

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SET I: High-frequency words paired with high-frequency semantically-similar distractors

| WORD | DISTRACTOR | WORD | DISTRACTOR |
|---|---|---|---|
| ABLE | FIT | ACT | SCENE |
| AFTERNOON | EVENING | AMERICAN | INDIAN |
| BEGIN | START | BOAT | SHIP |
| BOTH | EACH | BROTHER | SISTER |
| BUSINESS | PLEASURE | CENTURY | HUNDRED |
| DOLLAR | QUARTER | DREAM | SLEEP |
| FIGURE | NUMBER | EXERCISE | PRACTICE |
| ALWAYS | FOREVER | ALMOST | NEARLY |
| AMONG | BETWEEN | ASK | QUESTION |
| BECOME | DEVELOP | INTEREST | CONCERN |
| LETTER | MESSAGE | MOTHER | FATHER |
| NEED | WANT | RIVER | STREAM |
| ENGLAND | FRANCE | KILL | MURDER |
| NEWSPAPER | MAGAZINE | NORTH | SOUTH |
| EXPERIENCE | ACTIVITY | FAVOUR | HELP |
| HEIGHT | LENGTH | LESS | MORE |
| MOVE | STILL | STRENGTH | POWER |
| STORM | RAIN | RAISE | LOWER |
| PERHAPS | MAYBE | STAND | LIE |
| LIP | MOUTH | SUGGEST | INDICATE |
| PLANT | SEED | THING | STUFF |
| SPIRIT | COURAGE | CONDITION | POSITION |
| CONTROL | COMMAND | COMPLETE | TOTAL |
| CITIZEN | SUBJECT | SECOND | MOMENT |
| TOMORROW | TODAY | LOOK | REGARD |
| QUICKLY | RAPID | THOUSAND | GRAND |
| COLLECT | GATHER | TEMPLE | CHURCH |
| OFFICER | CAPTAIN | OVER | ACROSS |
| OLD | WORN | BACK | BEHIND |
| CHILD | BABY | CLASS | GROUP |
| NIGHT | DARK | FORWARD | FURTHER |
| MONTH | WEEK | STREET | AVENUE |

APPENDIX VII (CONTINUED)

| WORD | DISTRACTOR | WORD | DISTRACTOR |
|---|---|---|---|
| COMMON | FAMILIAR | TWENTY | SCORE |
| EFFORT | ATTEMPT | SUPPOSE | BELIEVE |
| SOCIETY | ASSOCIATION | VILLAGE | TOWN |
| COMPANY | VISIT | PRESENT | GIFT |
| LAST | FINAL | ACTION | DEED |
| PRODUCE | DIRECT | PURPOSE | REASON |
| FEW | MANY | CRY | LAUGH |
| DAY | LIGHT | WORTH | VALUE |
| WORLD | EARTH | WORK | LABOR |
| WISE | JUST | WHILE | DURING |
| WARM | COOL | VARIOUS | SEVERAL |
| UNCLE | AUNT | TURN | WHEEL |
| TRIP | TRAVEL | TOUCH | FEEL |
| TOGETHER | APART | TABLE | CHAIR |
| TALK | SPEAK | SWEET | SUGAR |
| SUCCESS | GLORY | STRAIGHT | NARROW |
| SQUARE | CIRCLE | SOUND | NOISE |
| CERTAIN | SURE | RUSH | HURRY |

SET II: High-frequency words paired with low-frequency semantically-similar distractors

| WORD | DISTRACTOR | WORD | DISTRACTOR |
|---|---|---|---|
| BEAUTIFUL | RAVISHING | DANGER | RISKY |
| DIFFERENT | VARIABLE | DIRECTION | ORIENTATION |
| DISTANCE | MILEAGE | ENEMY | RIVAL |
| CUP | MUG | AGAINST | VERSUS |
| METHOD | TECHNIQUE | TASTE | NIBBLE |
| SPACE | EXPANSE | QUEEN | EMPRESS |
| MARCH | STRUT | PICTURE | DRAWING |
| CONSIDER | PONDER | PRAISE | LAUD |
| WHISTLE | WHEEZE | UNDERSTAND | COMPREHEND |
| SUPPORT | UPHOLD | INDUSTRY | INGENUITY |
| MENTION | CITE | SURPRISE | AMBUSH |
| CHECK | INSPECT | STAND | POSTURE |
| CENTRE | HUB | BARE | NUDE |
| STATION | DEPOT | COLONY | HABITATION |
| BAD | EVIL | DECEMBER | CALENDAR |
| STORY | YARN | PARTY | FACTION |

## APPENDIX VII (CONTINUED)

| WORD | DISTRACTOR | WORD | DISTRACTOR |
|---|---|---|---|
| PAIR | DUAL | APPLY | SOLICIT |
| KNIGHT | VASSAL | FLASH | STREAK |
| JOURNEY | CARAVAN | GAVE | AWARD |
| CAUSE | EVOKE | CHARACTER | TEMPERAMENT |
| ROOM | LODGING | CLOUD | SMOG |
| COLOR | TINT | CORNER | NOOK |
| COTTON | FLEECE | DIVIDE | SUBTRACT |
| DOUBT | MISTRUST | EDGE | BRINK |
| ESCAPE | EVADE | FAMILY | PARENTS |
| FAMOUS | ILLUSTRIOUS | FIELD | HEATH |
| FIGHT | BICKER | FOREIGN | ALIEN |
| FRESH | MINT | KNOWLEDGE | INTELLECT |
| MARK | TAG | MEASURE | ASSESS |
| MODERN | CONTEMPORARY | NATIVE | INBORN |
| NECESSARY | INDISPENSABLE | OBTAIN | RETRIEVE |
| PASSAGE | CORRIDOR | PERIOD | COMMA |
| PREPARE | CONCOCT | PRICE | PENALTY |
| PROBLEM | IMPEDIMENT | PROVE | VERIGY |
| REAL | SUBSTANTIAL | REALIZE | VISUALIZE |
| REMEMBER | RECOLLECT | REMOVE | EXTERMINATE |
| REPLY | RETORT | RICH | AFFLUENT |
| ROSE | POPPY | ROUND | PLUMP |
| SAME | IDENTICAL | SEEK | QUEST |
| SHOUT | CLAMOUR | SILENCE | STILLNESS |
| SOFT | MUSH | SOLDIER | VETERAN |
| SPECIAL | DISTINCTIVE | SPEECH | ORATION |
| STONE | BOULDER | STUDY | PERUSE |
| TEACHER | TUTOR | THIN | SKINNY |
| USUALLY | CUSTOMARY | VIEW | VISTA |
| VOTE | BALLOT | WATCH | FIXATE |
| WHITE | IVORY | WIDE | YAWNING |
| WILD | WOOLY | WONDERFUL | STUPENDOUS |
| WONDER | MEDITATE | YELLOW | JAUNDICE |
| YOUNG | IMMATURE | DOZEN | GROSS |

SET III: High-frequency words paired with high-frequency acoustically-similar distractors

| WORD | DISTRACTOR | WORD | DISTRACTOR |
|---|---|---|---|
| ACCEPT | EXCEPT | AGO | AGE |
| ALONE | ALONG | BOX | BOY |
| CAME | CAMP | CASE | CARE |

APPENDIX VII (CONTINUED)

| WORD | DISTRACTOR | WORD | DISTRACTOR |
|---|---|---|---|
| FARMER | FORMER | FELLOW | FOLLOW |
| FINE | FIRE | HALL | HILL |
| HAND | HARD | HOLE | HOLD |
| ILL | ALL | KIND | KING |
| LAND | LAID | LEFT | LIFT |
| LOVE | LOSE | MILE | MILK |
| MUST | MOST | NATURAL | NATIONAL |
| NINE | NONE | NOSE | NOTE |
| PAID | PAIN | PIECE | PEACE |
| PLAIN | PLAN | POINT | PAINT |
| PRICE | PRINCE | READ | ROAD |
| WISE | WIFE | WHETHER | WEATHER |
| WEAR | WEAK | WASH | WISH |
| TIRE | TIME | TALL | TAIL |
| SUFFER | SUMMER | STICK | STOCK |
| SAIL | SOIL | SINGLE | SIMPLE |
| SICK | SINK | SHARE | SHAPE |
| SHAKE | SHADE | SEEK | SEED |
| SEASON | REASON | SAND | SEND |
| ROOF | ROOM | RISE | RIDE |
| QUIET | QUITE | PRESS | DRESS |
| LOAD | LORD | PROPER | PAPER |
| SAME | SAVE | SEE | SEA |
| SEEM | SEEN | SET | SIT |
| SHALL | SHELL | SON | SOON |
| SOUND | SOUTH | STEP | STOP |
| SUCH | MUCH | THAN | THEN |
| THERE | THEIR | THANK | THINK |
| THOUGH | THOUGHT | THREE | THROW |
| TOO | TWO | TOWN | DOWN |
| TREE | TRUE | UP | US |
| VERY | VARY | WALK | WALL |
| BORN | BURN | WANT | WENT |
| WERE | WHERE | WHILE | WHOLE |
| WHO | WHY | WOOD | WORD |
| WORLD | WOULD | BEAST | BEAT |
| BUY | BY | CLEAR | CLEAN |
| DEAD | DEAR | EAST | EAT |
| EVEN | EVER | FEED | FEET |
| FOOD | FOOT | FORM | FROM |
| GOOD | GOLD | HEAR | HEART |
| IF | IT | LIKE | LIVE |
| ORDER | OTHER | OUR | OUT |

# APPENDIX VII (CONTINUED)

| WORD | DISTRACTOR | WORD | DISTRACTOR |
|---|---|---|---|
| MASTER | MATTER | GUIDE | GUARD |
| GRAVE | GRACE | GAME | GATE |
| FIX | SIX | DARE | DATE |
| CROWN | CROWD | BETTER | BUTTER |

SET IV: High-frequency words paired with low-frequency, acoustically-similar distractors.

| WORD | DISTRACTOR | WORD | DISTRACTOR |
|---|---|---|---|
| HOPE | HOOP | BRANCH | BRUNCH |
| BOOK | BOOR | CHIEF | CHEF |
| CLASS | CRASS | DAILY | DALLY |
| DEPARTMENT | DEPORTMENT | GLASS | GLOSS |
| GREEN | GREED | HOME | HONE |
| HORSE | HORDE | IRON | ICON |
| KNOCK | KNACK | LEAST | LEASH |
| LIFE | LICE | LINE | LINT |
| LONDON | LINDEN | MAKE | MACE |
| MATERIAL | MATERNAL | MEET | MEED |
| MIDDLE | MUDDLE | MORNING | MOANING |
| NAME | NAPE | OBJECT | ABJECT |
| PAST | PEST | PICK | PUCK |
| POPULATION | COPULATION | POSSIBLE | PASSABLE |
| PROMISE | PREMISE | PUBLIC | PUBIC |
| PULL | PALL | QUITE | QUIRE |
| RACE | RAPE | REACH | ROACH |
| REFUSE | REFUTE | WRONG | WRANG |
| WHOSE | WHORE | WAVE | WOVE |
| VALLEY | VOLLEY | TRUTH | TROTH |
| SUDDEN | SADDEN | STATE | STAVE |
| STAR | SPAR | SPOT | SPAT |
| SPOKE | SPIKE | SMILE | STILE |
| SKIN | SHIN | SIZE | SINE |
| SELL | SILL | SALT | SILT |
| SAD | SOD | RUSH | RASH |
| RULE | RUSE | PURE | PORE |
| NOON | NOOK | SINCE | SINGE |
| SMALL | SPALL | SUMMER | SIMMER |
| UNDER | UDDER | ABOUT | ABORT |
| BIRD | BARD | BANK | BUNK |
| DEATH | DEARTH | DECIDE | DERIDE |

APPENDIX VII (CONTINUED)

| WORD | DISTRACTOR | WORD | DISTRACTOR |
|---|---|---|---|
| DANCE | DUNCE | FACE | FANE |
| FORTH | FIRTH | FRIEND | FRIED |
| GLAD | GRAD | GOLD | GUILD |
| GONE | GONG | HANG | HANK |
| HURT | HART | HUMAN | HYMEN |
| JOB | JAB | KEEP | KELP |
| MARY | MARX | MINE | MIRE |
| MOON | MOOT | NEVER | NEWER |
| NICE | NILE | OPEN | OWEN |
| ADDITION | EDITION | PART | PERT |
| PLEASANT | PHEASANT | POOR | POOH |
| REGARD | RETARD | REPEAT | REPEAL |
| ROLL | RILL | SEAT | SATE |
| SERVE | SWERVE | SMOKE | SMOCK |
| SNOW | STOW | PILE | PIKE |
| SOLDIER | SOLDER | STORE | STORK |
| TAKEN | TOKEN | TRUST | TRYST |
| TYPE | TAPE | VOICE | VOILE |

SET V: Low-frequency words paired with high-frequency semantically-similar distractors. This set is identical to set II above, except that the distractor served as the word, and the word served as the distractor with this set.

SET VI: Low-frequency words paired with low-frequency semantically-similar distractors

| WORD | DISTRACTOR | WORD | DISTRACTOR |
|---|---|---|---|
| NEBULOUS | OBLIVIOUS | DETERIORATION | DEPRECIATION |
| NOOODLE | MACARONI | PIVOT | SWIVEL |
| SUPERFICIAL | CURSORY | FRATERNITY | CLIQUE |
| SOOT | GRIME | BANISTER | RAILING |
| SOLAR | STELLAR | EXPLODE | DESTRUCT |
| CORE | PITH | CONVERGE | FOCAL |

APPENDIX VII (CONTINUED)

| WORD | DISTRACTOR | WORD | DISTRACTOR |
|---|---|---|---|
| ZODIAC | HOROSCOPE | COSMOS | UNIVERSE |
| ADROIT | DEXTEROUS | ALIBI | PRETEXT |
| AMPUTATE | SEVER | ARDENT | ZEALOUS |
| BANDIT | OUTLAW | BICKER | SQUABBLE |
| BOYCOTT | SANCTION | CALICO | GINGHAM |
| CHAPLAIN | VICAR | COLLOQUIAL | VERNACULAR |
| CONSISTENCY | THICKNESS | CRESTFALLEN | DOWNCAST |
| DAVENPORT | CHESTERFIELD | DESPONDENCY | DESOLATION |
| DORMANT | LATENT | ELASTICITY | FLEXIBILITY |
| EVANESCENT | TRANSIENT | FASTIDIOUS | METICULOUS |
| FLORIN | DUCAT | GABLE | DORMER |
| GRAVEYARD | CEMETARY | HERON | EGRET |
| INFAMOUS | NOTORIOUS | IRRESISTABLE | COMPELLING |
| KERCHIEF | BANDANNA | LIMBO | PURGATORY |
| LEVIATHON | MAMMOTH | MELON' | SQUASH |
| HEATH | MOORLAND | NESTLE | CUDDLE |
| ORATORY | RHETORIC | PAGAN | INFIDEL |
| PLACID | SERENE | PLAUSIBLE | CREDIBLE |
| PREFECT | MONITOR | PROPHESY | PREDICTION |
| REBUFF | SNUB | REPROACH | SCOLD |
| RUDDER | KEEL | SEDATIVE | TRANQUILIZER |
| SHOAL | REEF | DRENCHED | SODDEN |
| ARENA | STADIUM | STUPOR | DAZE |
| SUPERSTITION | MYTH | SYNOPSIS | PRECIS |
| TEDIUM | BOREDOM | TIDBIT | MORSEL |
| PLASTER | MORTAR | TRANSLUCENT | OPAQUE |
| TRESPASS | POACH | VESIBULE | ANTEROOM |
| WENCH | SHREW | WITCHCRAFT | WIZARDRY |
| ZENITH | NADIR | SCHOLARLY | ERUDITE |
| REPULSIVE | REVOLTING | POTION | TONIC |
| RASCAL | NUISANCE | MONOLOGUE | SOLILOQUY |
| MASCULINE | FEMININE | MANIAC | FANATIC |
| JETTY | WHARF | ADLIB | IMPROMPTU |
| HERMIT | RECLUSE | GUILE | DECEPTION |
| GREGARIOUS | SOCIABLE | FIEND | DEMON |
| SLAUGHTER | CARNAGE | SLANDER | LIBEL |
| CASK | KEG | CHARY | WATCHFUL |
| ELEGANT | REFINED | LINT | FUZZ |
| SIMPER | SMIRK | SEDUCE | ENTICE |
| TRITE | BANAL | WAIF | ORPHAN |
| ADJACENT | CONTIGUOUS | ACME | APEX |
| ADDICTION | OBSESSION | CAUTION | DISCRETION |
| STIGMA | TAINT | TACTICS | STRATEGY |

APPENDIX VII (CONTINUED)

SET VII: Low-frequency words paired with high-frequency acoustically-similar distractors. This set is identical to set IV above, except that with this set, the distractor serves as the test word and the test word serves as the distractor.

SET VIII: Low-frequency words paired with low-frequency acoustically-similar distractors.

| WORD | DISTRACTOR | WORD | DISTRACTOR |
|---|---|---|---|
| VIPER | VISOR | AEON | AERIE |
| AFFERENT | EFFERENT | ALLITERATION | ALLOCATION |
| TOPPLE | TIPPLE | TONIC | TOXIC |
| ARIA | AURA | ASSET | ASSENT |
| ASTUTE | ACUTE | AUTOCRATIC | AUTOMATIC |
| AXIL | AXLE | AZORE | AZURE |
| BADGE | BUDGE | BALD | BALK |
| BANDY | BAWDY | BARBER | BARKER |
| BARONET | BAYONET | BEHEAD | BEHELD |
| BLISTER | BLUSTER | BRIBE | BRINE |
| BURGHER | BURGLAR | CARROT | CARAT |
| CLARIGY | CLASSIFY | CLAMP | CLUMP |
| CACKLE | COCKLE | COLLUSION | COLLISION |
| COMICAL | CONICAL | CONSCRIPTION | CONSECRATION |
| CONTEMPLATION | CONTAMINATION | CONTRITION | CONTORTION |
| COUCH | COUGH | DEDICATION | DEDUCTION |
| DESPERATION | DESTINATION | DISPOSE | DISPROVE |
| ENDORSEMENT | ENDOWMENT | SEVER | SEWER |
| SHACK | SHANK | SHUDDER | SHUTTER |
| SIMULATE | STIMULATE | SLASH | STASH |
| SKIRMISH | SKITTISH | SLOUCH | SLOUGH |
| SNUGGLE | SMUGGLE | SPINAL | SPIRAL |
| STARK | STORK | SQUINT | SQUIRT |
| STATIONARY | STATIONERY | TARTAR | TARTAN |
| THICKEN | THICKET | THRUSH | THRASH |
| TICKLE | TACKLE | TINGLE | TINKLE |
| TRANSITION | TRANSLATION | TREASURY | TREACHERY |

APPENDIX VII (CONTINUED)

| WORD | DISTRACTOR | WORD | DISTRACTOR |
|---|---|---|---|
| TOPIC | TROPIC | TUBER | TIBER |
| TUMOR | TUDOR | TURBID | TORPID |
| UNSUITED | UNSULLIED | VALOUR | VELOUR |
| WEIRD | WIELD | WICKER | WICKET |
| WRETCH | WRENCH | WHOLESOME | WHOLESALE |
| EVACUATION | EVAPORATION | EVENTFUL | EVENTUAL |
| EXASPERATE | EXAGGERATE | FLATTEN | FLAXEN |
| GOGGLE | GIGGLE | INDIGENT | INDIGNANT |
| ECCENTRIC | ECLECTIC | GRADATION | GRADUATION |
| HISTORIC | HISTRIONIC | IDIOM | IDIOT |
| IMPRUDENCE | IMPUDENCE | INCARNATION | INCANTATION |
| INFLATION | INFLECTION | KENNEL | KERNEL |
| LATERAL | LITERAL | LYNX | LYNCH |
| MIGRATE | MITIGATE | NOZZLE | NUZZLE |
| NOOSE | NORSE | OBSESSION | OBSTRUCTION |
| ORGANIST | ORGANISM | OVERLAID | OVERLAND |
| PACKET | PICKET | PALTRY | PANTRY |
| PERPETUATE | PERPETUATE | PLUNDER | PLUNGER |
| PROVINCIAL | PROVISIONAL | PULLET | PULLEY |
| QUAVER | QUAKER | RACIAL | RADIAL |
| RAMPANT | RAMPART | RAPTURE | RUPTURE |
| RAVISH | RADISH | RECEPTION | RECESSION |
| RESIDUE | RETINUE | SAVOUR | SAVIOUR |