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Letter Frequency and Versatility Retrieval Constraints on Thinking of a Word

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LETTER FREQUENCY AND VERSATILITY

RETRIEVAL CONSTRAINTS

ON THINKING OF A WORD

by

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VITA

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CHAPTER I

INTRODUCTION

Research on human memory processes has recently focused on short-term and long-term storage and retrieval. Most of the literature on human memory has consisted of studies on short-term processes. Interest in long-term memory (LTM) has grown over the last five years. This dissertation investigated LTM and more specifically, the retrieval of 6-letter words. Long-term memory in this study refers to semantic memory as opposed to memory for specific events. This distinction is similar to that made by Tulving (1972) in his definitions of semantic and episodic memory. Tulving views semantic memory as the memory necessary for the use of language, or one's mental dictionary. Episodic memory, in contrast, pertains to the storage of one's experiences.

Semantic memory research and memory research in general contains several areas of inquiry: stimulus selection, perceptual register, buffer systems, short-term store, long-term store, and retrieval processes. The present study concentrated on one aspect of one of these areas: the effect of category or pool size on LTM retrieval. The study of the effect of category size on LTM retrieval has been actively pursued (e.g., Freedman & Loftus, 1971; Landauer & Freedman, 1968). The equivocal data obtained from these studies (cf. Freedman et al., 1971; Loftus, Freedman, & Loftus, 1970) have obscured the delineation of the LTM-retrieval processes. This dissertation, through the use of the concept of letter versatility, attempted to provide a clearer description of the parameters of the category size-retrieval relationship.

CHAPTER II

REVIEW OF RELATED LITERATURE

Category Size and Semantic Retrieval

The category-size prardigm has been frequently used (e.g., Freedman et al., 1971) as an experimental tool for studying the semantic retrieval process. The utility of the category-size paradigm is based on relating retrieval latency to the magnitude of item scanning going on in LTM. If subjects' (Ss') memories are organized into categories or clusters, then success of retrieval of a particular item from a cluster should be dependent on the size of the cluster containing the item. Through this experimental procedure the processes and structures of semantic memory may be inferred.

Landauer et al. (1968) had Ss classify stimuli into members or nonmembers of categories. The categories presented varied in size (e.g., the category of seasons is smaller that the category of foods). The results of the speed of classification (i.e., the time required to state whether or not a stimulus belonged to a certain category) were equivocal. The authors concluded that recognition of category membership for large categories held in LTM depends to some extent on the size of the category. Landauer et al. did not go as far as suggesting that successive scanning of the category members had occurred. Successive scanning is the process of searching for an item through an array by selecting each member of the array, one at a time, until a solution is reached. Simultaneous scanning, in contrast, refers to searching for an item by processing more than one item at a time. The data also indicated that the less familiar a category is to S, the more likely he will use successive scanning in the retrieval process.

Briggs and Swanson (1969) determined the relationship between naming-response latency and memory-ensemble size. They used a paired-associate task with geometric shapes as stimuli and single letters and binary numbers as responses. Here, category size and retrieval was investigated in a short-term memory situation. A direct linear relationship between increasing latency of response and memory-ensemble size was found. With practice, Ss were able to increase the number of bits of information processed per second. The slope of the response latency-ensemble-size function did not change with practice. It was concluded that the selection of the proper memory ensemble was a separate process which preceded the matching processes and increased (speed of selection) with practice.

Interest in the category size-retrieval relationship has also extended into the exploration of how categories are stored (i.e., category hierarchies). Loftus et al. (1970) designed a study to test whether a S has to retrieve along a hierarchial path or can enter a category directly. The mean reaction time (RT) required for Ss to produce a member of a superordinate category (e.g., a city) did not differ significantly from RT's from subordinate categories (e.g., a U.S. city). The data suggest that the Ss, through some central processor, directly locate a category name. A strong correlation between category frequency, defined as the frequency of the most frequently given member of the category, and RT was found. There was a tendency for the S, once he had located the correct category, to produce the highest frequency word in that category.

Freedman et al. (1971) found a strong correlation between category size and word frequency of the dominant category response. This correlation affected the relationship between retrieval RT and category size. When frequency was not controlled category size did not significantly affect RT. A linear function between increasing category size and retrieval RT was found, however, when frequency and dominance (degree to which Ss associated an item to a category) were controlled. The strength of the data showing the category-size effect was slight. The authors concluded that the long-term memory retrieval process consists of two steps: 1.) entering the appropriate category, 2.) finding the appropriate cluster of items. Successive scanning of items, as opposed to simultaneous scanning, was more extensive with obscure categories.

Wilkins (1971) used the construct of conjoint frequency in successfully demonstrating the category size-RT effect. Conjoint frequency refers to the frequency in which instances are associated to categories. The frequency values were obtained in S-generated norms. As was expected, words of high conjoint frequency were categorized more quickly than words of low conjoint frequency and instances of small categories were categorized more quickly than instances of large categories.

Studies relating category size to categorization latency have shown some support for the finding of increasing response latencies with increasing category size. When the proper controls have been used (i.e., controlling frequency and dominance of the categorical responses) the functions have been more stable. Two stages in retrieval have been identified: the selection of the proper memory ensemble and the scanning of the ensemble for a match of an item to the task stimulus. The effects of category size on latency of retrieval, as mentioned, can be obscured when frequency and dominance of the category members are not controlled.

Letter Frequency and Versatility

Traditional research on semantic memory (e.g., Collins & Quillian, 1969) has used categories based on properties of objects as provided by the verbal descriptions of the objects. This dissertation, in contrast, used categories based on orthographic properties of words. Specifically, the categories were constructed from the pool of 6-letter words in the English language. The term pool membership rather than category membership was used in this study to distinguish this fundamental orthographic level of semantic category from the more conventional concept of semantic category already discussed. Pool membership in this study refers to all 6-letter English words containing a particular bigram (two letters appearing together) or a particular trigram (three letters appearing together). The size of the pools is measured by the bigram or trigram versatility (i.e., the number of different words containing the bigram or trigram). The constructs of letter (actually letter chunk in the present case) versatility and frequency form an attractive experimental paradigm for two reasons: 1.) they furnish a tool for examining the category (pool) size-retrieval function and 2.) have built-in controls for frequency and dominance by the nature of the construction of the pools.

Before the letter frequency and versatility paradigm is applied to the study of LTM retrieval, the constructs of letter frequency and letter versatility will be elaborated. Letter or letter-chunk frequency refers to the tabulated frequency of appearance of a letter or letter chunk in English text. There have been a couple of tabulated norms of letter frequency (e.g., Underwood & Schulz, 1960). The most extensive tables (Mayzner & Tresselt, 1965) contain single letter, bigram, up to pentagram (five-letter clusters) frequencies tabulated from 20,000 words of running text. Each letter up to pentagram was recorded for its occurrence. Reference was made to the length of the word and the position in the word in which the letter or letter chunk appeared. The norms provide a good approximation of the frequency of appearance of letter combinations in the written English language.

Experimental use of letter-frequency norms has been most frequent in anagram studies. For the last 20 years many psychologists have been interested in factors that affect the solution time of anagrams (i.e., time required to identify scrambled words). One of the most fundamental and perplexing variables in anagram studies has been letter frequency. It has been hypothesized (Dominowski, 1967) that as the total frequency of the bigrams comprising a solution word (e.g., the bigrams of the word "chair" are: ch, ha, ai, ir) is increased, solution time is decreased. Dominowski reasoned that as Ss rearranged the letters of an anagram they should tend to form letter combinations, such as bigrams, which are of high frequency. Words which contain high-frequency bigrams should have a higher probability of being generated than words of low bigram frequency (low BF). Mayzner and Tresselt (1959, 1966), Dominowski and Duncan (1964) and Dominowski (1967) have all reported significant effects of bigram frequency on anagram solution time. The data obtained in these studies have not shown consistent functions of bigram frequency and anagram solution time.

The inability to obtain a stable BF-solution-time function led to the development of the construct of bigram versatility (BV), as put forth in Topper, Macey, and Solso (1973). The idea of BV stemmed from a realization that when Ss test bigrams for a possible solution they would be expected to test a particular word only once. If successful they would have solved the problem, if unsuccessful, the word is removed from the pool of possible solutions and another word is selected. It is therefore more meaningful to use BV values, defined as the number of different words which contain a certain bigram, rather than BF, the total number of words a bigram appears in without respect to the number of different words. While BF and BV may be highly correlated (Solso, Topper, & Macey, 1973), there are many bigrams which may be high on one dimension and low on the other. This condition is seen when a bigram (e.g., "OF") is found in a small number of different words (low BV) of high frequency. It was predicted (Solso et al., 1973) that words with high-frequency and low-versatile bigrams would lead to faster solution times than words with bigrams of comparable frequency but higher versatility. Low-versatile bigrams contain fewer possible solution words, and therefore, fewer solutions to test. This theory has received experimental support from Solso et al. (1973).

Solso et al. (1973) also provided a test of the assumptions of the inter-structural associative paradox (ISAP) as developed by Solso (1974). The paradox can be summarized by two theorems:

> Theorem 1. Cue efficacy is inversely related to the number of responses it generates.
>
> Theorem 2. Cue efficacy is directly related to the probability that it will generate the encoded attribute of the to-be-remembered thing (p. 33).

Applied to the anagram solution process, the ISAP predicts that optimum cue efficiency occurs when there is a high probability the correct response is generated (high BF) and when a small number of possible responses (low BV) exist. The data (Solso, et al., 1973) were consistent with the ISAP predictions.

Thinking of a Word

The concept of letter versatility is well suited for experimentation on category size and LTM retrieval. The versatility count for any bigram or trigram is a measure of the size of the pool containing all the different words which have the bigram or trigram. Versatility levels obtained from sufficiently large samples of text serve an an index of the size of pools of words containing certain characteristics. The versatility levels should also indicate the relative size of the word pools in an adult S's LTM store of the English language.

The experimental task in the present study was to "think" of specific 6-letter words. This task, also called word redintegration, involves the retrieval of a response from a stimulus cue which itself is contained in the response. The task is similar to that used by Duncan (1966, 1970). Duncan (1966) required Ss to emit 5-letter words fitting initial- and final-positional letter cues. Duncan (1970) had Ss respond with 3-, 4-, or 5-letter words fitting single letter or bigram cues. Duncan found that the mean word frequency of the responses was above the pool's mean word frequency. Solution word frequency was lower and response latencies longer for bigram cues and longer (5-letter) solution words. Duncan accounted for the results with spew and sampling hypotheses. These hypotheses stated that reductions in the pools of acceptable words slowed response latency and reduced the probability of response. Reductions in the number of acceptable high-frequency words made it more difficult to come up with these words; thus more low-frequency words were emitted.

CHAPTER III

EXPERIMENT I

"FREE RESPONSE"

Experiment I was run to determine the relationship between pool size and semantic retrieval with a task where the S is free to respond with any member of the probed pool. The "free-response" experiment examined the parameters of the pool size-retrieval-latency function. The task of "thinking of a word" was employed with 6-letter words as responses and bigrams and trigrams serving as cues. Single-letter cues were not used since the pools of acceptable 6-letter word responses would be too large to control. Four-letter and 5-letter cues also were not used since their pools are generally too small to manipulate cue versatility and frequency.

Duncan (1966, 1970) found that the larger the pool from which to select a response, the more likelihood that a response can be retrieved from that pool. In Experiment I cue versatility served as a measure of pool size. It was hypothesized that in a "free response" retrieval task, such as in Experiment I, the success and speed of retrieval increases with increasing cue versatility.

Experiment I was also designed to test for the effects of cue frequency and frequency of the pool's dominant response (pool dominance) on retrieval latency. According to spew hypotheses (Underwood et al., 1960), high-frequency responses are emitted faster than lower-frequency responses. High-frequency cues contain higher-frequency pool members than lower-frequency cues and should therefore, facilitate the production of a response. Pool dominance was manipulated in response to the findings of two other studies. Wilkins (1971) reported shortened categorization latencies with categories having a response member of high conjoint frequency. Similarly, Freedman et al. (1971) stated that the speed of production of a category member was correlated with the dominance of the responses in the category. On the basis of these two studies and the dictates of the spew law, it is expected that high pool dominance contributes to the facilitation of semantic retrieval.

The variable of cue size (bigrams vs. trigrams) tests the applicability of the versatility factor with different cues. The variable of cue size also determines the limiting conditions of the versatility effect in word redintegration. If cue versatility and frequency are the only factors of word redintegration, then bigram and trigram cues equated on these variables should produce equal success in retrieval.

An analysis of the word frequency of the responses given in Experiment I was performed to see if the normative frequency of emitted responses decreases as a function of decreasing pool size (Duncan, 1966, 1970). The comparison of mean pool and response normative frequencies also provides tests of the spew hypothesis. If reductions in pool size also reduce the number of available high-frequency responses, then lower-frequency responses should be emitted.

METHOD

Design

The design was a 2 x 3 x 2 x 2 factorial with repeated measurement in which there were two types of stimuli, an initial bigram or initial trigram of a to-be-thought-of 6-letter word. The initial bigram and trigram cues were varied over three levels of versatility, two levels of cue frequency, and two levels of pool dominance. There were two bigram and trigram cues used in each versatility x cue frequency x pool dominance combination, resulting in 48 cues. The 48 cues were divided into two lists such that each list of 24 cues contained one cue from each cell. Each of two groups of Ss received one of the two lists.

Subjects

The Ss were 40 undergraduates from introductory psychology courses at Loyola University who participated in the experiment as part of their course requirements. There were 20 Ss per group. The Ss were alternately assigned to each group on the basis of the order of their arrival to the experiment.

Materials

The source of the bigram and trigram versatility levels was Kucera and Francis (1967). A computer tape containing the complete 1,014,232 word corpus (50,406 different words) of the Kucera and Francis norms was obtained from the Department of Linguistics, Brown University. The Kucera and Francis norms are based on samples of published literature (e.g., newspapers, magazines, prose, etc.). All of the 6-character records were extracted from the computer tape. All of the 6-character records which contained hyphens, apostrophes, numbers, or abbreviations were deleted from the list. Computer programs were written to compile the total versatility and frequency of each bigram and trigram encountered in the resulting list of 5,651 6-letter words. The frequency totals comprise the sum of the frequencies of the words containing the particular bigram or trigram. The versatility totals represent the number of different 6-letter words which contained the bigram or trigram. The frequency and versatility totals were compiled for three positions of the bigram cue (12-34-56) and for the initial position (123) of the trigram cue. Tables 1 and 2 show the distribution of frequencies and versatilities for the bigrams and trigrams encountered in the corpus. Table 1, for example, indicates that 25 different bigrams found in the initial position of the 6-letter words had a total frequency of one and 14 different bigrams had a total frequency of two. There were 42 bigrams in the initial position with a total versatility count of one and 15 bigrams with a total versatility of two. The sum N for each position is equal to the number of different bigrams or trigrams encountered in the 6-letter corpus for that position.

The criteria for selecting representative bigram and trigram cues at three levels of versatility were: 1.) equally spaced intervals between versatility levels and 2.) sufficient members to enable the selection of cues at various levels of frequency within a level of versatility. All the cues used in Experiment I were initial cues (i.e., appeared in the first two or three positions in a 6-letter word). Tables 3 and 4 list the bigram and trigram cues and their mean values

Table 1

Frequency Distribution of Bigram Frequency (BF) and Versatility (BV) Totals (T) in 6-letter Words by Position

Initial Position (X X _ _ _ _)			Middle Position (_ _ X X _ _)			End Position (_ _ _ _ X X)		
T	BF	BV	T	BF	BV	T	BF	BV
	N	N		N	N		N	N
1	25	42	1	30	66	1	35	56
2	14	15	2	15	40	2	11	22
3	7	15	3	15	25	3	11	13
4	4	9	4	9	18	4	14	21
5	2	4	5	6	20	5	3	11
6	1	9	6	8	15	6	3	9
7	1	3	7	12	12	7	4	10
8	3	4	8	7	9	8	5	3
9	1	5	9	6	11	9	4	7
10	3	6	10	9	8	10	4	2
11-20	11	28	11-20	30	75	11-20	22	42
21-30	9	26	21-30	14	47	21-30	8	16
31-40	8	22	31-40	17	24	31-40	12	9
41-50	2	15	41-50	18	16	41-50	6	7
51-100	12	35	51-100	39	13	51-100	22	15
> 100	139	4	> 100	165	1	> 100	90	11

Note: For initial cues, Sum N = 242; for middle cues, Sum N = 400; for end cues, Sum N = 254. Bigram frequency and versatility totals calculated from Kucera and Francis (1967).

Table 2

Frequency Distribution of Trigram Frequency (TF) and Versatility (TV) Totals (T) in the Initial Position of 6-letter Words

	Initial Position (X X X _ _ _)	
T	TF	TV
	N	N
1	299	650
2	162	336
3	94	197
4	71	132
5	62	97
6	62	57
7	50	48
8	34	38
9	21	28
10	26	31
11-15	119	59
16-20	69	9
21-30	101	9
31-50	133	2
> 50	390	0

Note: Sum = 1693.

Table 3

Frequency (F), Versatility (V), and Pool Dominance (P)

Values of the Bigram Cues presented in Experiment I

V	P	High F cues	Low F cues	V values
V_{low}	High P	O P _ _ _ _	E R _ _ _ _	V_{low}
		E A _ _ _ _	E M _ _ _ _	μ = 7.00
	Low P	E S _ _ _ _	K N _ _ _ _	σ = 1.58
		O B _ _ _ _	E T _ _ _ _	
$V_{med.}$	High P	E N _ _ _ _	R I _ _ _ _	$V_{med.}$
		P U _ _ _ _	F E _ _ _ _	μ = 29.25
	Low P	E X _ _ _ _	D R _ _ _ _	σ = 2.59
		P L _ _ _ _	B L _ _ _ _	
V_{high}	High P	R A _ _ _ _	L A _ _ _ _	V_{high}
		M O _ _ _ _	S A _ _ _ _	μ = 48.12
	Low P	S P _ _ _ _	G A _ _ _ _	σ = 4.43
		P O _ _ _ _	B U _ _ _ _	

High F	Low F
μ = 22.69	μ = 8.46
σ = 5.19	σ = 2.28

High P	Low P
μ = 180.50	μ = 90.25
σ = 145.50	σ = 66.64

Table 4

Frequency (F), Versatility (V), and Pool Dominance (P)

Values of the Trigram Cues presented in Experiment I

V	P	High F cues	Low F cues	V values
V_{low}	High P	GOL___	ARI___	V_{low}
		RAR___	SKE___	μ = 2.00
	Low P	SCE___	TUN___	σ = 0.00
		LAD___	DED___	
$V_{med.}$	High P	GRO___	STU___	$V_{med.}$
		COM___	REV___	μ = 11.12
	Low P	PRO___	CLI___	σ = 0.93
		CLO___	STI___	
V_{high}	High P	STA___	THR___	V_{high}
		CAN___	PRI___	μ = 21.75
	Low P	PLA___	SHA___	σ = 5.02
		STR___	GRA___	

High F	Low F
μ = 28.36	μ = 8.44
σ = 9.30	σ = 2.80

High P	Low P
μ = 132.00	μ = 63.00
σ = 163.85	σ = 66.62

of versatility. The mean and standard deviation values for the low, medium, and high versatility levels (V_{low}, $V_{med.}$, and V_{high}) for all 48 cues in Experiment I were: 4.50, 2.74; 20.19, 9.27; and 34.94, 14.01, respectively. It should be noted that the versatility totals of each cue were adjusted from the raw totals calculated from the corpus so that the versatilities equal the total number of words which fit a cue after proper nouns, colloquialisms, and entries not listed in an English dictionary (Webster, 1960) were removed. Plurals were not removed from the pools.

A high-frequency (HF) bigram or trigram was classified as such if the mean frequency (cue frequency/cue versatility) of its pool members was above 15. The mean frequency of a cue's pool members was used as the cue frequency statistic in place of summed pool frequency totals to facilitate comparison of frequency values for cues of different levels of versatility. A bigram or trigram was classified as low frequency (LF) if its mean frequency was below 15. A frequency of 15 was chosen as the class limit since the complete 6-letter word corpus had a mean frequency of 14.68, $\sigma = 47.05$. The distribution of the corpus word frequencies was extremely skewed towards the low-frequency end. Over half of the words in the corpus had frequency values of only three or less. The use of the corpus mean-frequency value as a class limit allowed a more pronounced separation of cues on the basis of frequency. The μ's and σ's of the HF and LF bigram and trigram cues are listed in Tables 3 and 4. The frequency μ's and σ's for all the cues in Experiment I were for HF cues, $\mu = 25.52$, $\sigma = 8.04$; for LF cues, $\mu = 8.45$, $\sigma = 2.55$.

The variable of pool dominance refers to the word frequency of the highest-frequency member of a pool. The variable was manipulated by ranking the four cues, selected for each cue type x versatility x frequency cell, on the frequency of the dominant member of the pool. The cues with the two highest dominant responses were considered high pool dominant (HP) cues. The other two cues in the cell were called low pool dominant (LP). The mean and SD's of the HP and LP bigram and trigram cues are listed in Tables 3 and 4. The means and σ's for all the cues were: HP, $\mu = 156.25$, $\sigma = 156.83$; LP, $\mu = 76.62$, $\sigma = 68.01$.

The list of 48 stimuli was divided into two lists with each list containing a cue from each of the 24 conditions. The cues selected for each list were chosen randomly except for the few cases where trigram cues containing the same first two letters as another bigram cue were put in separate lists. Each cue was typed on an individual 3 x 5 inch card. On each card there were six typed dashes, each separated by a space. The bigram and trigram cues were typed in their appropriate first two or three spaces on the cards, indicating to S that he was to give to the experimenter (E) a 6-letter word beginning with the first two or three letters given to him.

Procedure

The E and S sat on opposite sides of a table with a partition between them. The instructions given to S explained that he would be given, one at a time, 3 x 5 inch cards with two (or three) letters followed by four (or three) empty spaces typed on them. He was informed that his task would be to think of a 6-letter word fitting the initial letters given to him. The S was instructed that proper nouns, abbreviations, or colloquialisms would not be allowed as acceptable responses. In order to avoid priming Ss toward a particular type response, no instructions were given as to the acceptability of plurals. If during the experiment, S asked if a plural was acceptable, he was told that it was. The S was told to respond as quickly as possible since he would be timed. The Ss were given one practice problem before the experiment began. The practice problem required S to give E a six-letter word fitting an initial trigram cue (N I C _ _ _). The practice problem was employed to familiarize S with the procedure for giving his responses to E (i.e., spelling the 6-letter word).

For each problem E gave S a card which was faced down, covering the stimulus. When E said "Go," S turned the card over and began working on the problem. The E manually started a stop watch when he said "Go," and stopped the watch when S had given him the last letter (finished spelling the word) of an acceptable 6-letter word. The time for solution was recorded to the nearest tenth of a second. The response was also recorded. If S gave an unacceptable response he was told to continue working. If at the end of 60 sec. an acceptable word had not been given, E removed the card and presented S a new one. Each of the two groups of 24 cards was arranged in a randomized order and presented to alternate Ss. The order of the cards was continually rotated one position for odd numbered Ss and presented in the reverse orders for the even numbered Ss.

RESULTS

Retrieval Latency

Each acceptable 6-letter word response was recorded along with its latency. Responses which were not in the pool (not in the Kucera & Francis norms), but were acceptable in all other respects, were allowed, and the word and time were recorded. Of the total of 960 cues presented to all Ss, 819 (85%) had acceptable responses given to them. Table 5 lists the mean number of responses in each of the experimental conditions. The 819 responses contain 105 (13%) acceptable words not in the experimental pool. As Table 5 indicates, there were increases in responses with increasing cue versatility and frequency.

Table 5 also shows the mean latency of response in each condition. An analysis of variance with repeated measures (Table 6) yielded an $F(2, 76) = 81.52$, $p < .001$ for versatility. The mean latencies for increasing versatility level were 28.15, 16.25, and 13.63 sec., respectively. The means for high and low cue frequency were 15.87 and 22.82 sec., respectively, $F(1, 38) = 62.03$, $p < .001$. There was a significant interaction of frequency and versatility, $F(2, 76) = 9.91$, $p < .001$. As Figure 1 shows, the effect of low cue frequency was particularly detrimental to retrieval with cues of low versatility. Simple-effect analyses were performed on the frequency variable. The effect of frequency at low versatility was highly significant, $F(1, 38) = 72.98$, $p < .001$. The effect of cue frequency in the middle- and high-versatility conditions was diminished, F's$(1, 38) = 6.43$ and 6.57, respectively, p's $< .025$. Simple-effect analyses on versatility revealed that the versatility effect was significant at both levels of frequency,

Table 5

Number of Responses and Mean Response Latency*

(in sec.) in Experiment I

			Bigram Cues		Trigram Cues	
			High F	Low F	High F	Low F
V_{low}	High P	No. responses	32	24	34	18
		Mean latency	25.60	34.28	17.08	39.03
	Low P	No. responses	29	21	35	28
		Mean latency	28.16	38.91	15.65	26.49
$V_{med.}$	High P	No. responses	37	36	39	35
		Mean latency	14.23	17.31	10.17	20.33
	Low P	No. responses	39	35	34	36
		Mean latency	13.30	19.57	19.56	15.56
V_{high}	High P	No. responses	39	40	40	35
		Mean latency	13.54	16.09	10.27	16.18
	Low P	No. responses	39	37	39	38
		Mean latency	12.77	15.76	10.12	14.33

Note: F = cue frequency; V = cue versatility; P = pool dominance. Total $\underline{N}$ = 40; $\underline{M}$ latency (all trials) = 19.34, $\underline{N}$ = 960.

*All mean response latencies were computed on latencies for all trials (i.e., $\underline{N}$ per cell = 40, no-response trial latency = 60).

Table 6

Analysis of Variance Summary Table for Experiment I

Source	SS	df	MS	F
Between Subjects (S)				
Groups (G)	447.22	1	447.22	0.33
S(G)	51921.53	38	1366.36	
Within Subjects (S)				
Versatility (V)	38302.54	2	19151.27	81.52***
Frequency (F)	11595.83	1	11595.83	62.03***
VF	4477.60	2	2238.80	9.91***
Pool Dominance (P)	25.94	1	25.94	0.12
VP	430.02	2	215.01	1.02
FP	753.55	1	753.55	3.33
VFP	263.56	2	131.78	0.67
Cue Size (C)	2012.74	1	2012.74	8.80**
VC	2380.83	2	1190.41	4.51*
FC	360.65	1	360.65	1.61
VFC	684.24	2	342.12	1.32
PC	586.83	1	586.83	3.75
VPC	1709.10	2	854.55	3.38
FPC	1782.70	1	1782.70	3.99
VFPC	614.62	2	307.31	1.07
VS(G)	17854.61	76	234.93	
FS(G)	7103.93	38	186.94	
VFS(G)	17170.13	76	225.92	
PS(G)	7987.77	38	210.20	
VPS(G)	15986.11	76	210.34	
FPS(G)	8591.39	38	226.09	
VFPS(G)	14857.96	76	195.50	
CS(G)	8687.79	38	228.63	
VCS(G)	20054.79	76	263.88	
FCS(G)	8508.59	38	223.91	
VFCS(G)	19745.14	76	259.80	
PCS(G)	5942.09	38	156.37	
VPCS(G)	19186.62	76	252.46	
FPCS(G)	16991.05	38	447.13	
VFPCS(G)	21764.07	76	286.37	
VG	5764.60	2	2882.30	12.27***
FG	9464.98	1	9464.98	50.63***
VFG	6135.40	2	3067.70	13.58***
PG	0.83	1	0.83	0.004
VPG	117.63	2	58.81	0.28
FPG	5521.33	1	5521.33	24.42***
VFPG	3072.50	2	1536.25	7.86***

Table 6 cont'd

Analysis of Variance Summary Table for Experiment I

Source	SS	df	MS	F
CG	2224.19	1	2224.19	9.73**
VCG	2444.03	2	1222.01	4.63*
FCG	21.27	1	21.27	0.10
VFCG	461.85	2	230.92	0.89
PCG	558.64	1	558.64	3.57
VPCG	758.74	2	379.37	1.50
FPCG	1388.31	1	1388.31	3.10
VFPCG	19.54	2	9.77	0.03

Note: $^{*}p < .05$

$^{**}p < .005$

$^{***}p < .001$

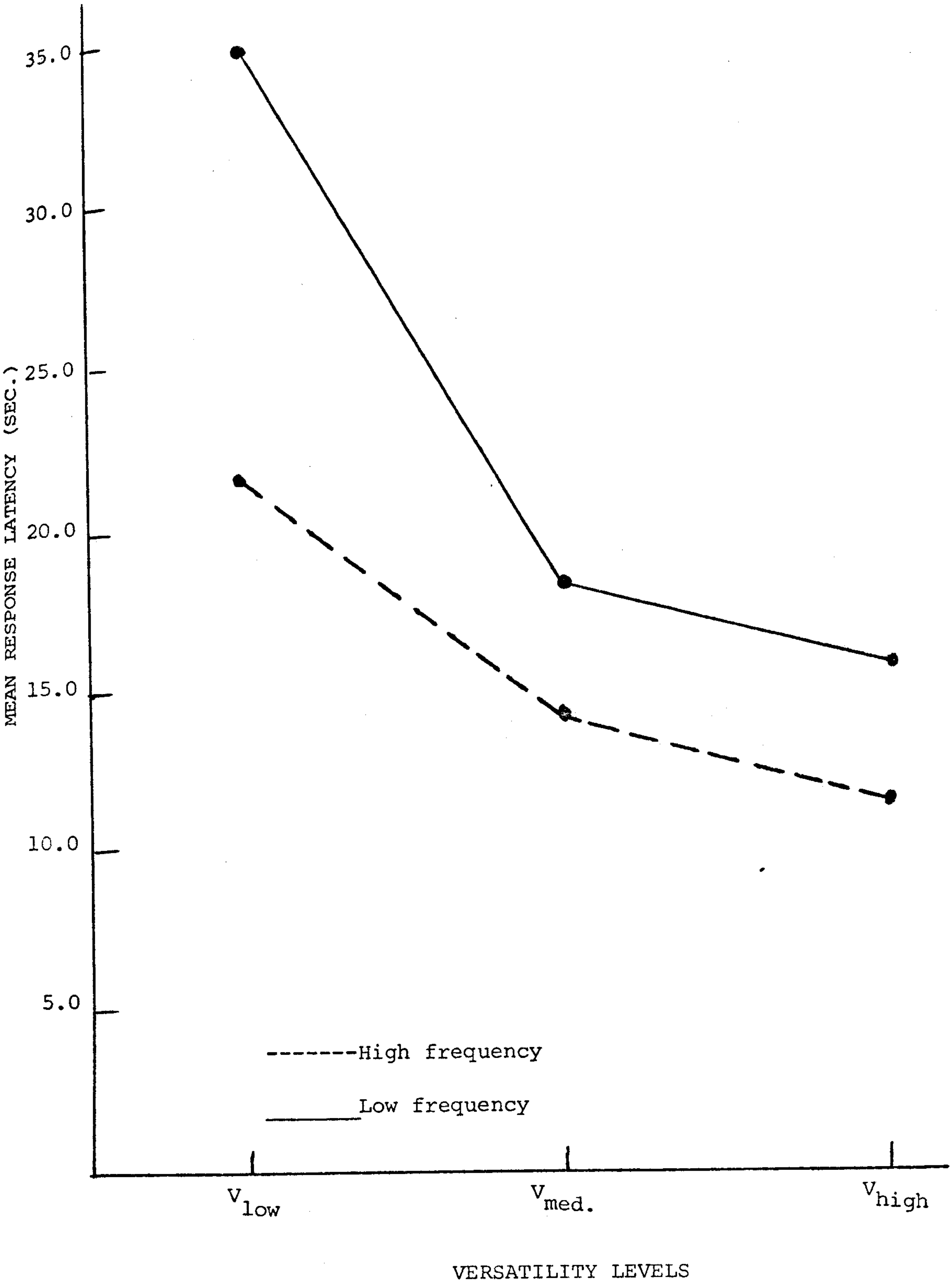

Figure 1. Mean response latency as a function of cue versatility and frequency.

$F(2, 76) = 18.09$, $p < .001$ at high cue frequency and $F(2, 76) = 72.97$, $p < .001$ at low cue frequency. A test on the difference in linear trend for versatility across frequency levels was significant, $F(1, 76) = 14.80$, $p < .001$. The variation due to differences in linear trends in simple effects of versatility accounted for 75% of the total variation of the versatility x frequency interaction.

While the overall difference in groups was not significant, Table 6 shows that there were significant interactions involving the experimental groups. These interactions suggest that the two lists varied in difficulty within certain conditions.

The overall experimental value of α used for each of the 31 F-tests in Experiment I was equal to 0.05/31 = 0.0016 (Kirk, 1968). The variables of pool dominance and cue size (bigram vs. trigram) did not produce significant effects on retrieval latency, F's$(1, 38) = 0.12$ and 8.80, respectively, p's $> .001$. High pool dominance was associated with only slightly faster retrieval than in the low pool-dominance condition. The cue-size variable approached significance at the overall experimental α. Trigram cues had lower mean solution times (17.90 sec.) than bigram cues (20.79 sec.). This result is surprising since trigram cues had lower mean versatilities (smaller pools) than bigram cues. Apparently, factors other than cue versatility or frequency were responsible for faster latencies with trigram cues.

Response Frequency

The normative word frequencies of the responses given by the Ss in Experiment I were analyzed to determine patterns of response frequencies across the experimental conditions. The frequencies of the responses were taken from the Kucera and Francis norms. The frequencies of the 105 responses (68 different words) not listed in Kucera and Francis were estimated in the following manner. The words not listed in the corpus were arbitrarily assigned a frequency value equal to the number of times they were given as responses. Since higher-frequency words have been found (Duncan, 1966, 1970, 1973) to be emitted more frequently than lower-frequency words, the procedure was adopted to give those words that were emitted more than once a higher estimated frequency value than the value assigned to the words emitted only once. The estimated frequencies were incorporated into the calculation of the means of the responses and pools.

The mean normative frequency of all the 819 responses given in the experiment was 32.77, $SD = 62.27$, which was significantly higher than the pool's mean normative frequency, $\mu = 16.30$, $\sigma = 42.44$, $z(818) = 11.11$, $p < .001$. Figure 2 shows the mean frequency of the responses and the pool members as a function of versatility level. At all three versatility levels the mean frequencies of the Ss' responses were significantly higher than their pool's mean frequency, for low versatility, $z(220) = 5.45$, $p < .001$, for medium versatility, $z(290) = 6.69$, $p < .001$, and for high versatility, $z(306) = 9.52$, $p < .001$. The frequencies of the responses in the middle- and high-versatility conditions departed from their pool's mean frequency more than the responses did in the low-versatility condition, z's(510) = 3.15, $p < .001$ and (526) = 5.52, $p < .001$, respectively. The mean frequency of the V_{high} responses was significantly higher than its pool's mean frequency than was the mean frequency of the $V_{med.}$ responses from its pool's mean frequency, $z(596) = 1.86$, $p < .05$.

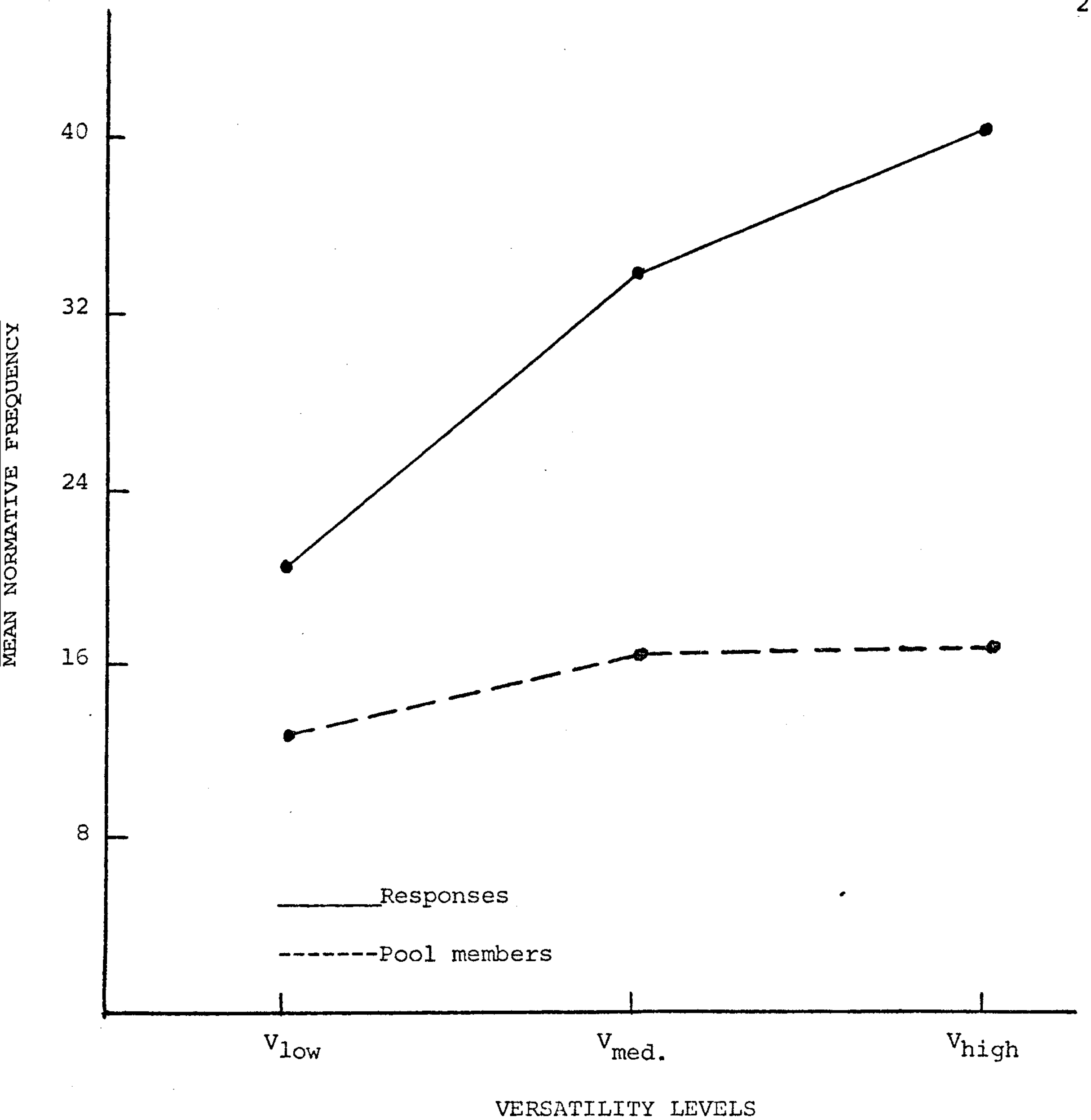

Figure 2. Mean normative frequency of responses and pool members as a function of cue versatility.

The product-moment correlation between versatility of cue and frequency of response was significant, $r = .11$, $t(817) = 3.29$, $p < .001$.

The mean frequency of the responses in the high cue-frequency condition was significantly higher than its pool's mean frequency than was the mean frequency of the low cue-frequency responses from its pool's mean frequency, $z(817) = 7.43$, $p < .001$. While the variable of pool dominance did not affect solution times, it did affect the mean frequency of the responses. The deviation of the mean frequency of the responses from the pool's mean frequency was significantly higher with high pool-dominance cues than with low pool-dominance cues, $z(817) = 4.23$, $p < .001$. Figure 3 shows the frequency of Ss' responses as a function of pool dominance and cue frequency. Both cue frequency and pool dominance were correlated with response frequency, r's = .42 and .32; t's(817) = 13.11 and 9.57, p's < .001, respectively.

Response frequencies from bigram and trigram cues were significantly elevated from their pool means, for bigrams, $z(407) = 9.97$, $p < .001$, and for the trigram cues, $z(410) = 4.77$, $p < .001$. The mean frequency of the responses from the bigram cues was significantly higher than its pool's mean frequency than was the mean frequency of the trigram-cue responses from its pool's mean frequency, $z(817) = 2.36$, $p < .01$. The point-biserial coefficient of correlation between increasing cue size and response frequency was negative and significant, $r_{pb} = -.56$, $t(817) = 19.50$, $p < .001$.

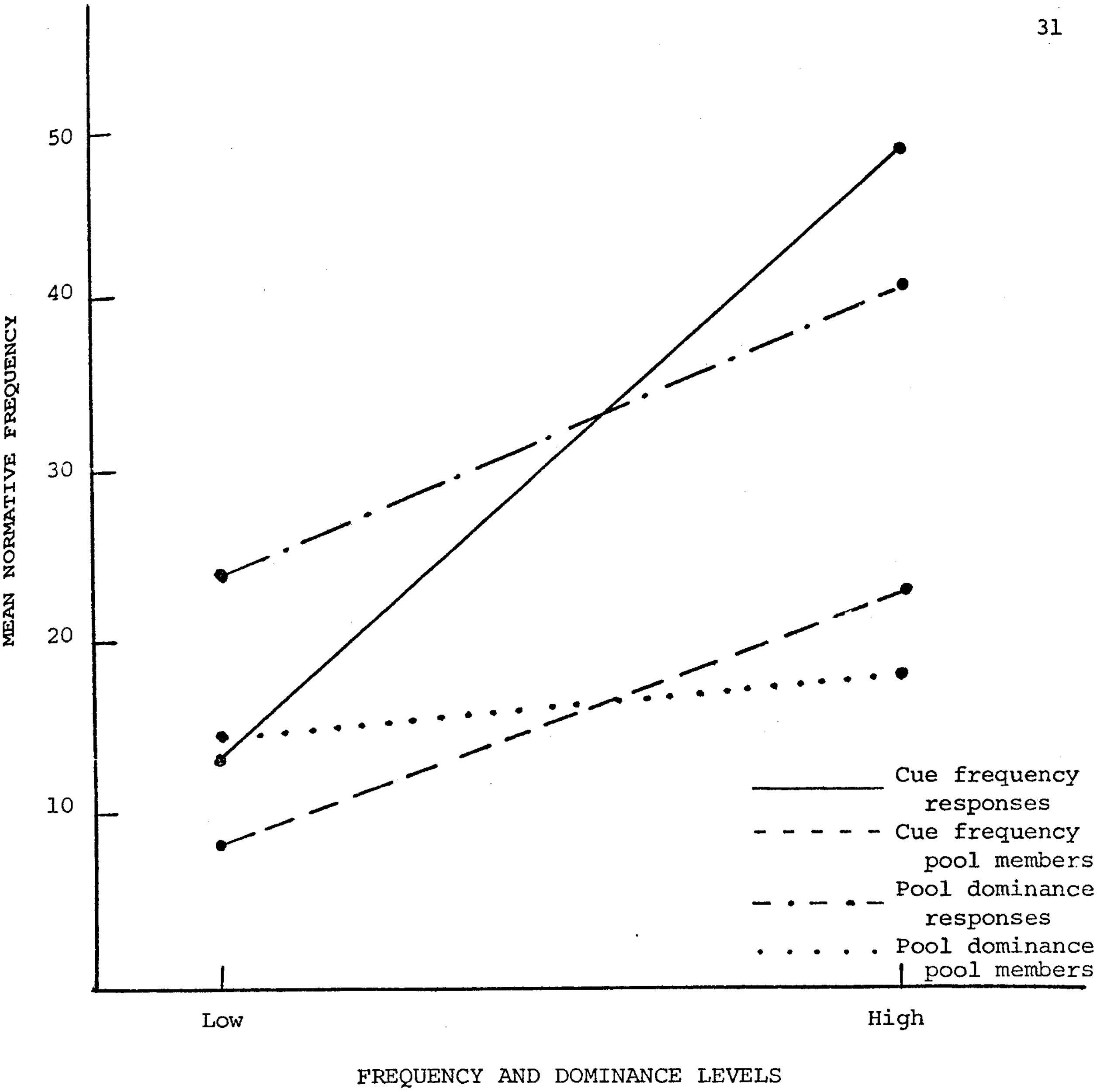

Figure 3. Mean normative frequency of responses and pool members as a function of cue frequency and pool dominance.

CHAPTER IV

EXPERIMENT II

"TARGET RESPONSE"

Experiment II had Ss retrieve specific words, given trigram cues of varying versatility. According to the ISAP (Solso, 1974), retrieval of an item depends on the probability the cue elicits the target response, and is a function of the number of items in the target pool. It was hypothesized that success in target-word retrieval is associated with cues of low versatility and high target-word frequency. Target words were divided into high- and low-frequency conditions. Spew laws predict that high-frequency target words should be emitted earlier than low-frequency target words. Cue frequency was not expected to influence retrieval here as in Experiment I. The emission of the target response is more directly governed by its own frequency than the mean frequency of its cue's pool.

METHOD

Design

The design was a 3 x 2 x 2 factorial with repeated measurement in which initial trigram cues represented three levels of versatility and two levels of frequency. The Ss, given an initial trigram, had to "think" of a predetermined 6-letter target word which varied at two levels of word frequency. There were a total of 24 trigram cues, two for each versatility x frequency x target-word frequency combination.

Subjects

The Ss were 20 additional undergraduates from introductory psychology courses at Loyola University who participated in the experiment as part of their course requirements. All Ss received the same 24 initial trigram cues.

Materials

It was anticipated that the nature of the task in Experiment II would make it extremely difficult for Ss to think of target words from initial bigram cues. In this experiment, instead, only initial trigram cues were utilized. The 24 trigram cues used in Experiment I served as cues in the present experiment.

From the two trigram cues in each condition in Experiment I, one cue was randomly selected for a high frequency target-word condition (HT) and the other cue was put into the low frequency target-word condition (LT). The target words in the high- and low-frequency conditions were selected in a random manner. For the selection of the high-frequency target words, all the words of frequency over 15 in each of the 12 pools selected to be in the high frequency target-word condition were numbered. From a table of randon numbers, a high-frequency word in each pool was selected as the target word for that cue. The only exception to this procedure was for one of the cues in the low-versatility condition, where there was no word of frequency of at least 15 in its pool. In this case the highest-frequency word in the pool was selected as the target word. In the low-frequency target condition all the words of frequency 2-14 in the appropriate pools were numbered. From a table of random numbers, a low-frequency word from each pool was selected as the target word from that pool. Words under a frequency of two were excluded from being target words since these words might have been too difficult to retrieve. Table 7 lists all the target words in Experiment II. The μ and σ of the frequencies of the high-frequency target words were 37.92 and 37.90, respectively. The low-frequency target words had a mean frequency of 6.00, $\sigma = 2.64$. The cue versatility and frequency values were given in Table 4.

The variable of pool dominance was not examined. Any effects of pool dominance should be equally distributed among the other variables due to the method of selection of the target words.

It was possible that Ss could "solve" these problems by adding a letter to the trigram cue and go down the alphabet in search of a potential word. As a check on this potential bias, an analysis of the fourth letters in each of the target words revealed that the words were well distributed around the alphabet with respect to the fourth letter.

Each initial trigram cue was typed on an individual 3 x 5 inch card. On each card were six typed dashes, each separated by a space. The trigram cues were typed in their appropriate first three spaces on the cards.

Procedure

The procedure followed in Experiment II was similar to that followed in Experiment I. The instructions given S explained that he would be given, one at a time, 3 x 5 index cards with three letters followed by three empty spaces typed on them. Subjects were informed

Table 7

Target Words used in Experiment II

		High T		Low T	
		Target Word	Frequency	Target Word	Frequency
V_{low}	High F	R A R E L Y	41	G O L F E R	3
		L A D I E S	28	S C E N I C	9
	Low F	S K E T C H	16	A R I S E N	4
		T U N N E L	10	D E D U C E	3
$V_{med.}$	High F	G R O W T H	155	C O M P E L	4
		C L O V E R	16	P R O V E N	11
	Low F	S T U D I O	31	R E V O L T	8
		C L I E N T	15	S T I C K Y	9
V_{high}	High F	S T A R E D	60	C A N D I D	3
		P L A N E T	21	S T R I V E	7
	Low F	P R I S O N	42	T H R I L L	5
		G R A N T S	20	S H A D E D	6
		μ = 37.92		μ = 6.00	
		σ = 37.90		σ = 2.64	

Note: T = target-word frequency; F = cue frequency; V = cue versatility.

that their task would be to give E 6-letter words fitting the cues given to them until E tells them they have said the target word. A practice problem was not employed. Subjects were told to give E 6-letter words as quickly as possible, as they would be timed. Target words did not include proper nouns, abbreviations, or colloquialisms. If S gave a response that was not a target word he was told to, "Continue." When a target word was given (spelling not required) S was told, "Correct," and the time for solution was recorded to the nearest tenth of a second. If at the end of 60 sec. a target word had not been given, E removed the card and presented S a new one. The 24 cards were arranged in a random order. The order was continually rotated one position for odd numbered Ss and presented in the reverse orders for the even numbered Ss.

RESULTS

Of the 480 stimuli presented, only 108 (22%) target words were given. The mean latencies of response for the target words that were emitted were: for V_{low} cues $M = 14.52$ sec. ($N = 58$), for $V_{med.}$ cues $M = 18.76$ sec. ($N = 31$), and for V_{high} cues $M = 20.13$ sec. ($N = 19$). There was an average of 5.4 out of a possible 24 solutions per S. Table 8 shows the number of target words retrieved in each of the experimental conditions. Due to the extreme skewness of the response latencies, an analysis of the data from Experiment II was performed using the frequencies of "successes" and "misses" in emitting the target word. A chi-square partition (Winer, 1971) revealed a significant factor of versatility, $\chi^2(2) = 28.60$, $p < .001$. Figure 4 is a plot of the number of target words retrieved as a function of versatility level.

Table 8

Number of Target Words given as Responses in Experiment II

		High T	Low T
V_{low}	High F	17	7
	Low F	21	13
$V_{med.}$	High F	13	6
	Low F	2	10
V_{high}	High F	6	8
	Low F	4	1

Note: T = target-word frequency; F = cue frequency;

V = cue versatility.

Total possible target responses per cell = 40.

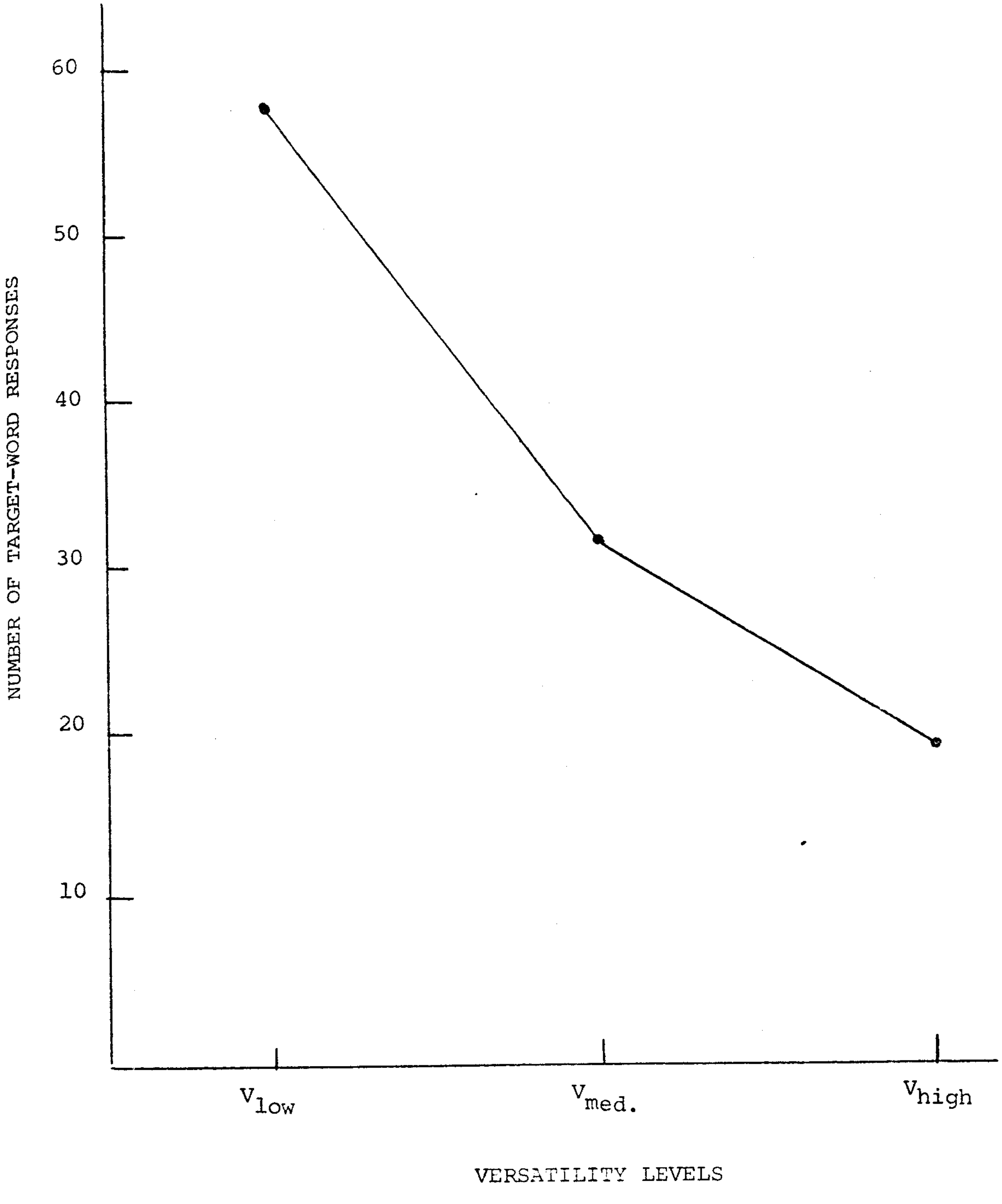

Figure 4. Number of target-word responses as a function of cue versatility.

The graph shows that the number of successful retrievals increased with decreasing versatility. Table 9 lists the χ^2 values for all the variables and their interactions. The overall experimental value of α used for each of the seven chi-square tests was equal to 0.05/7 = 0.007. Only the versatility variable was significant at the overall .05 level.

The interaction of versatility and target-word frequency approached significance. Figure 5 displays the form of the interaction between versatility and target-word frequency. The effect of target-word frequency appears to have an effect on solution only in the low-versatility level. This may have been due to a "floor effect." There were very few solutions in the middle- and high-versatility levels (cf. Table 8). This possible "floor effect" may have prevented the target-word frequency variable from reaching significance.

Table 9

Partition of Chi Square for Experiment II

Source	Chi Square	df
RV	28.60***	2
RT	3.45	1
RF	0.30	1
RVT	8.23**	2
RVF	7.95**	2
RTF	2.27	1
RVTF	6.84*	2

Note: R = target word given-not given; V = cue versatility; T = target-word frequency; F = cue frequency.

*$p < .05$

**$p < .025$

***$p < .001$

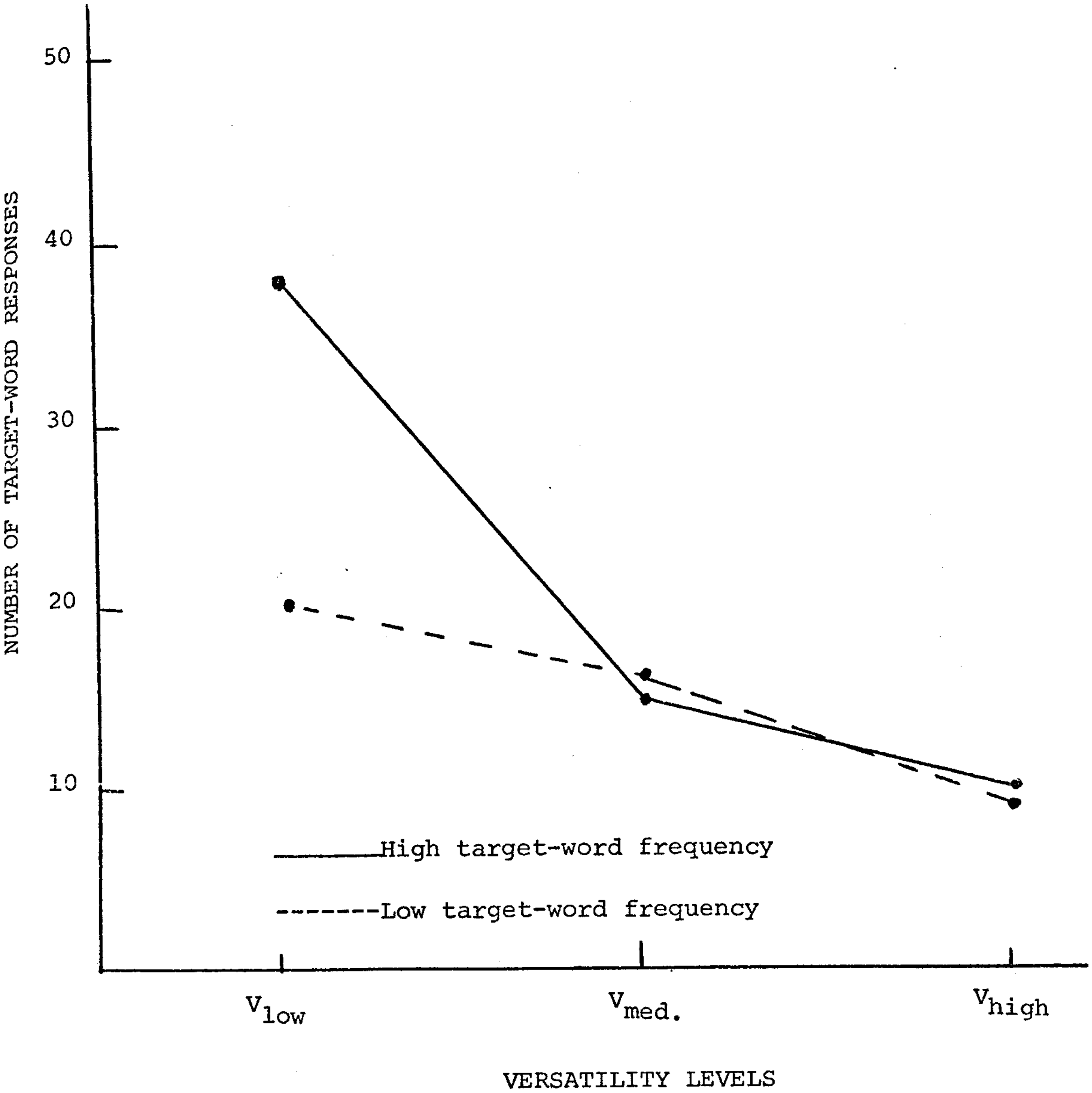

Figure 5. Number of target-word responses as a function of cue versatility and target frequency.

CHAPTER V

EXPERIMENT III

Experiment III replicated part of Experiment I and also tested whether the effects of cue versatility and cue frequency on word redintegration are similar for cues appearing in different positions in the words. In addition to initial-positional bigram cues, middle-positional (third and fourth letters) and final-positional (fifth and sixth letters) bigram cues were presented to Ss in a "thinking" of a 6-letter word task. Horowitz, White, and Atwood (1968) found that initial and final cues aided recall of words more than middle cues. Horowitz et al. suggested that different retrieval processes operated with different positional cues. If cue versatility and frequency completely govern retrieval latency, then cue position should not affect the retrieval of words from cues equated on frequency and versatility. Experiment I, however, showed that other factors, such as cue size, may affect retrieval. Potential differences in the potency of positional cues may be attributed to cuing biases, such as pronounciation cues, associated with initial cues. The greater immunity of middle- and final-positional cues to pronounciation biases allows one to study word redintegration with more control over cuing biases.

The effects of different positional cues on response frequency were also examined. Possible differences in spewing tendencies among the positional cues were discussed.

METHOD

Design

The design was a 3 x 2 x 2 factorial with repeated measurement in which bigram cues appeared at three different positions of a to-be-thought-of 6-letter word. The bigram cues also varied at two levels of versatility and frequency. There were two bigram cues in each position x versatility x frequency combination, resulting in 24 bigram stimuli.

Subjects

The Ss were 20 additional undergraduates from introductory psychology courses at Loyola University who participated in the experiment as part of their course requirements. All Ss received the same 24 bigram cues.

Materials

The eight bigram cues in the initial position ($P_{init.}$) were taken from the cues in the first experiment. One cue from each of the bigram versatility x frequency x pool dominance cells in Experiment I was randomly selected to be used in Experiment III. Pool dominance was not examined here. Any effects of pool dominance should be equally distributed among the other variables.

The bigram cues in the middle and final positions ($P_{mid.}$ & P_{final}) were selected to approximate the versatility and frequency levels of the $P_{init.}$ cues. Table 10 lists all of the cues used in Experiment III. For all the cues the μ and σ values of increasing versatilities were: V_{low}, $\mu = 8.58$, $\sigma = 1.38$; V_{high}, $\mu = 31.33$, $\sigma = 3.77$. The μ and σ values of the high-frequency cues (HF) were: $\mu = 23.76$, $\sigma = 5.63$.

Table 10

Versatility (V) and Frequency (F) Values of Bigram Cues presented in Experiment III

	V_{low}		V_{high}	
	High F	Low F	High F	Low F
$P_{init.}$	O P	E R	E N	R I
(X X _ _ _ _)	E S	K N	P L	B L
$P_{mid.}$	F I	O C	A T	O R
(_ _ X X _ _)	K E	T L	M P	R A
P_{final}	A D	F Y	C H	R Y
(_ _ _ _ X X)	I L	H E	G E	S H

V_{low}	V_{high}
$\mu = 8.58$	$\mu = 31.33$
$\sigma = 1.38$	$\sigma = 3.77$

Low F	High F
$\mu = 7.15$	$\mu = 23.76$
$\sigma = 3.18$	$\sigma = 5.63$

Note: P = position of the cue in the to-be-thought-of 6-letter word.

For the low-frequency cues (LF), $\mu = 7.15$, $\sigma = 3.18$.

Procedure

The procedure followed in Experiment III was similar to that used in Experiment I. The instructions contained the additional information that Ss would receive bigram cues in either the first two positions, third and fourth positions, or fifth and sixth positions of a to-be-thought-of 6-letter word. A practice word was not employed.

RESULTS

Retrieval Latency

There were 317 acceptable responses (66%) to the 480 cues presented to all Ss. The 317 responses contained 53 (17%) words not in the experimental pool. Table 11 shows the distribution of responses and latencies in the different experimental conditions. It can be seen that there is an increase in the number of responses in going from low- to high-versatile cues. There were also more responses given to initial bigram cues than to cues in the other two positions.

An analysis of variance with repeated measures was performed on the retrieval-latency data from Experiment III (Table 12). The overall experimental value of α used for each of the 15 F-tests was equal to 0.05/15 = 0.003. The analysis revealed three significant sources of variation at the experimental α level. Mean retrieval latency decreased from 38.34 sec. to 25.82 sec. with increasing versatility, $F(1, 19) = 46.88$, $p < .001$. Table 12 indicates that cue frequency and versatility interacted. The nature of the interaction, however, was different from that found in Experiment I. Figure 6

Table 11

Number of Responses and Mean Response Latency*

(in sec.) in Experiment III

		V_{low}		V_{high}	
		High F	Low F	High F	Low F
$P_{init.}$	No. responses	33	29	37	37
(X X _ _ _ _)	Mean latency	22.28	26.43	13.88	18.42
$P_{mid.}$	No. responses	21	22	29	25
(_ _ X X _ _)	Mean latency	44.58	37.15	28.52	39.00
P_{final}	No. responses	10	14	34	26
(_ _ _ _ X X)	Mean latency	52.60	46.99	22.67	32.44

Note: P = position of the cue in the to-be-thought-of 6-letter word; V = cue versatility; F = cue frequency.

Total *N* (responses) = 317; total possible responses per cell = 40; *M* latency (all trials) = 32.08, *N* = 480.

*All mean response latencies were computed on latencies for all trials (i.e., *N* per cell = 40, no-response trial latency = 60).

Table 12

Analysis of Variance Summary Table for Experiment III

Source	SS	df	MS	
Within Subjects (S)				
Versatility (V)	18802.47	1	18802.47	46.88**
Cue Position (P)	33722.98	2	16861.49	38.95**
PV	5699.75	2	2849.87	6.18*
Frequency (F)	843.21	1	843.21	3.29
VF	3781.04	1	3781.04	17.71**
PF	180.01	2	90.00	0.31
PVF	1793.61	2	896.81	2.33
S	19524.84	19	1027.62	2.98*
SV	7620.48	19	401.08	1.16
SP	16450.93	38	432.92	1.26
SF	4872.75	19	256.46	0.74
SVF	4055.39	19	213.44	0.62
SPV	17513.87	38	460.89	1.34
SPF	10930.18	38	287.64	0.83
SPVF	14596.48	38	384.12	1.11
Replications (SPVF)	82727.19	240	344.70	

Note: $*p < .005$

$**p < .001$

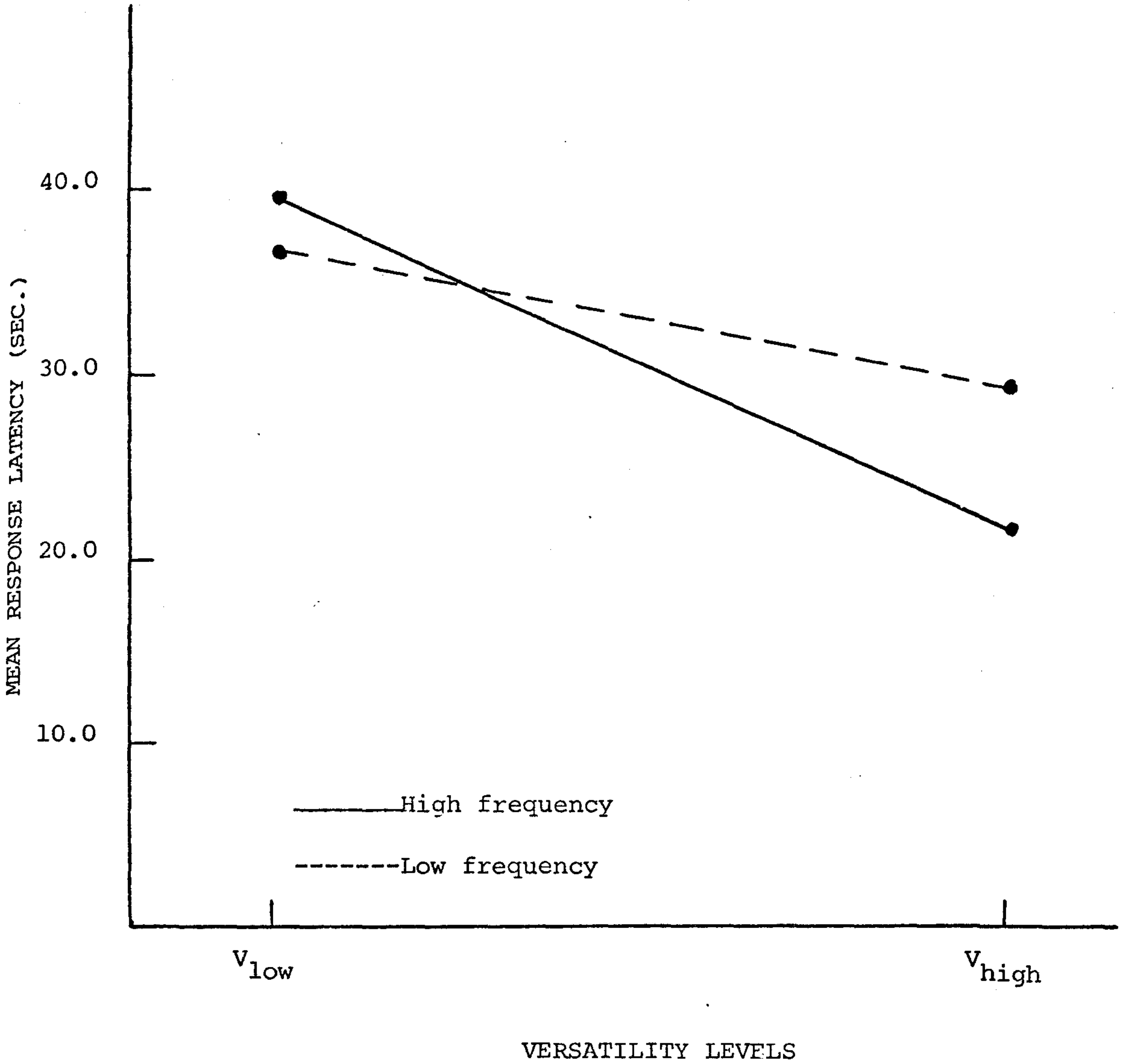

Figure 6. Mean response latency as a function of cue versatility and frequency.

shows that the effect of cue frequency was minimal in the V_{low} condition. This relationship is opposite to that seen in Experiment I, where the cue frequency effect was maximal in the V_{low} condition. The failure to obtain a frequency effect in Experiment I may have been an artifact of a "floor effect" in the V_{low} condition. Inspection of Table 11 reveals that there were relatively few solutions in the V_{low} condition for middle- and especially final-positional cues. A simple effects analysis revealed that the versatility variable was significant at both levels of frequency, at high frequency, $F(1, 19) = 49.18$, $p < .001$; at low frequency, $F(1, 19) = 7.13$, $p < .025$. The simple effect of frequency at high versatility was significant, $F(1, 38) = 15.98$, $p < .001$, at low versatility, $F(1, 38) = 2.05$, $p > .05$.

The position of the bigram cue was a significant source of variance. The means for the initial, middle, and final cues were 20.25, 37.31, and 38.68 sec., respectively, $F(2, 38) = 38.95$, $p < .001$. The initial cues had significantly faster times than the middle and final cues, F's$(1, 38) = 53.79$ and 62.71, p's $< .001$. The middle- and final-positional cues did not differ significantly in affecting retrieval, $F < 1$. The lack of overall differences between middle- and final-positional cues is misleading. The interaction of the positional and versatility variables, while not significant beyond the overall experimental .05 level, indicated an interesting pattern of response latencies in going from low to high versatility. Tests on simple-effects of versatility showed that the versatility effect was highly significant for final-positional cues, $F(1, 38) = 49.34$, $p < .001$. For initial- and middle-positional cues the versatility effect was less pronounced, F's(1, 38) = 6.71, $p < .02$, and 5.04, $p < .05$, respectively. Figure 7 is a plot of mean response time as a function of versatility and position. The plot shows a reversal in relative speed of retrieval for the middle and final cues between the two versatility levels. While the middle-positional cues were associated with faster response times in the low-versatility condition, final-positional cues had faster times in the high-versatility condition. The initial cues showed the fastest times in both versatility conditions.

Response Frequency

The procedure for analyzing the normative word frequencies of the responses in Experiment III was identical to that used in Experiment I. Of the 317 responses, 264 were in the Kucera and Francis word corpus and were assigned frequency values equal to their norm value. The 53 responses (48 words) not listed in the corpus were assigned a frequency value equal to the number of times the particular word was emitted. The total pool of words in Experiment III had a mean normative frequency of 14.86, $\sigma = 44.38$, which was significantly lower than the mean normative frequency of the 317 responses, $M = 38.50$, $SD = 81.48$, $z(316) = 9.48$, $p < .001$.

Both low- and high-versatile cues produced mean response frequencies significantly above their pool's mean frequency, for low versatility, $z(128) = 3.67$, $p < .001$, for high versatility, $z(187) = 9.79$, $p < .001$. The mean frequency of the responses in the high-versatility condition was significantly higher than its pool mean than was the mean frequency of the responses in the low-versatility condition from its pool mean, $z(315) = 5.35$, $p < .001$. The correlation of

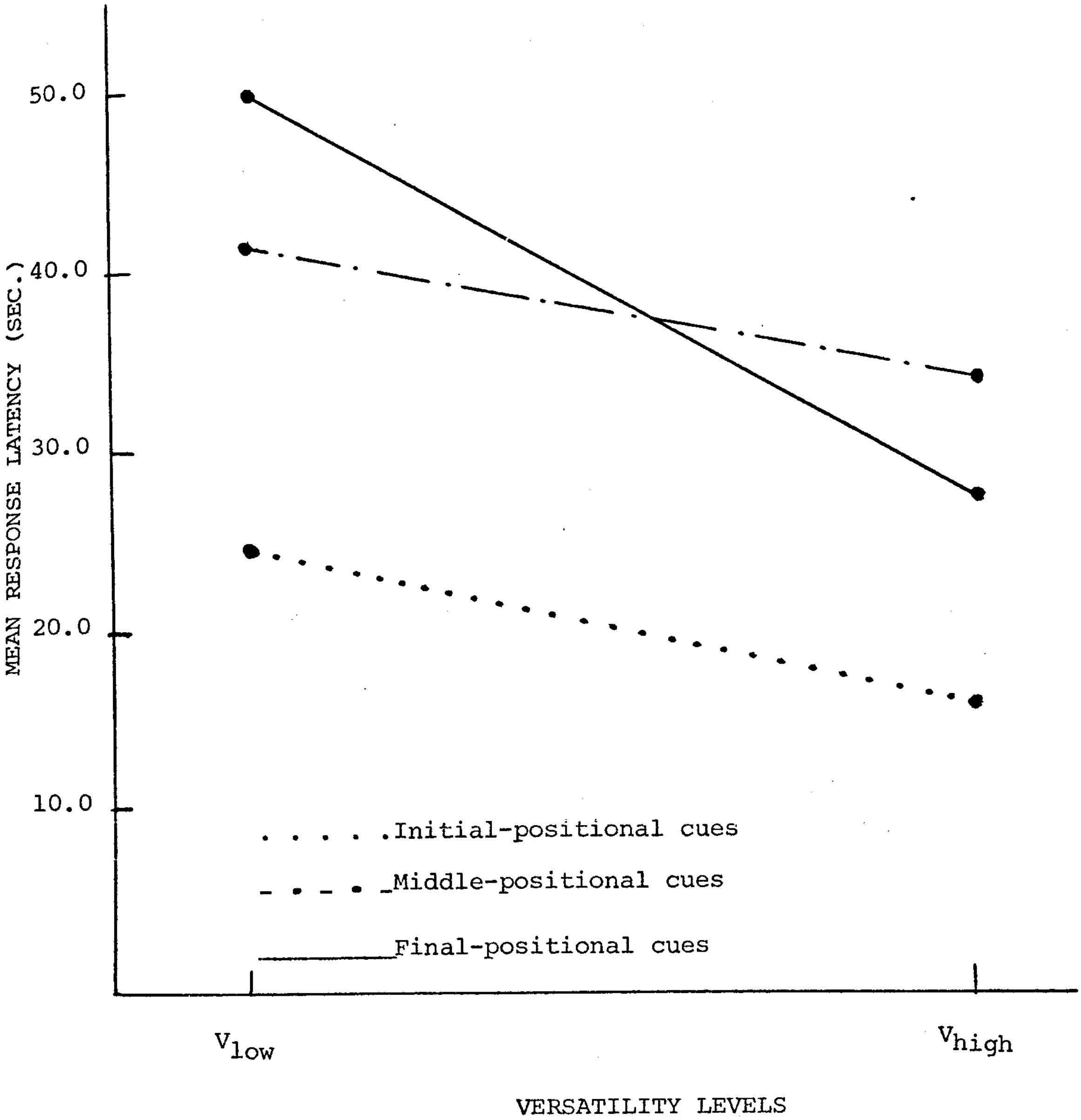

Figure 7. Mean response latency as a function of cue versatility and position.

versatility and response frequency was significant, $r = .10$, $t(315) = 1.83$, $p < .05$.

The mean frequency of the responses from the high-frequency cues was significantly higher than its pool's mean frequency than was the mean frequency of the responses from the low-frequency cues from its pool's mean frequency, $z(315) = 34.06$, $p < .001$. The correlation of cue frequency and response frequency was significant, $r = .32$, $t(315) = 6.04$, $p < .001$.

Figure 8 shows the mean response frequency as a function of positional cue. The plot reveals that the frequency of the responses from the middle-positional cues did not differ significantly from its pool's mean frequency, $z(96) = 0.75$, $p > .05$. The initial- and final-positional cue mean response frequencies were significantly above their pool's mean frequency, for initial cues, $z(135) = 6.26$, $p < .001$; for final cues, $z(83) = 12.22$, $p < .001$. The mean frequency of the responses from the final-positional cues was significantly higher than its pool mean than were the mean frequencies of the responses from the initial- and middle-positional cues from their pool's mean frequencies, z's(218 & 179) = 5.17 and 6.64, p's < .001. The mean frequency of the initial-cue responses was higher than its pool's mean frequency than was the mean frequency of the middle-cue responses from its pool's mean frequency, $z(231) = 2.72$, $p < .005$.

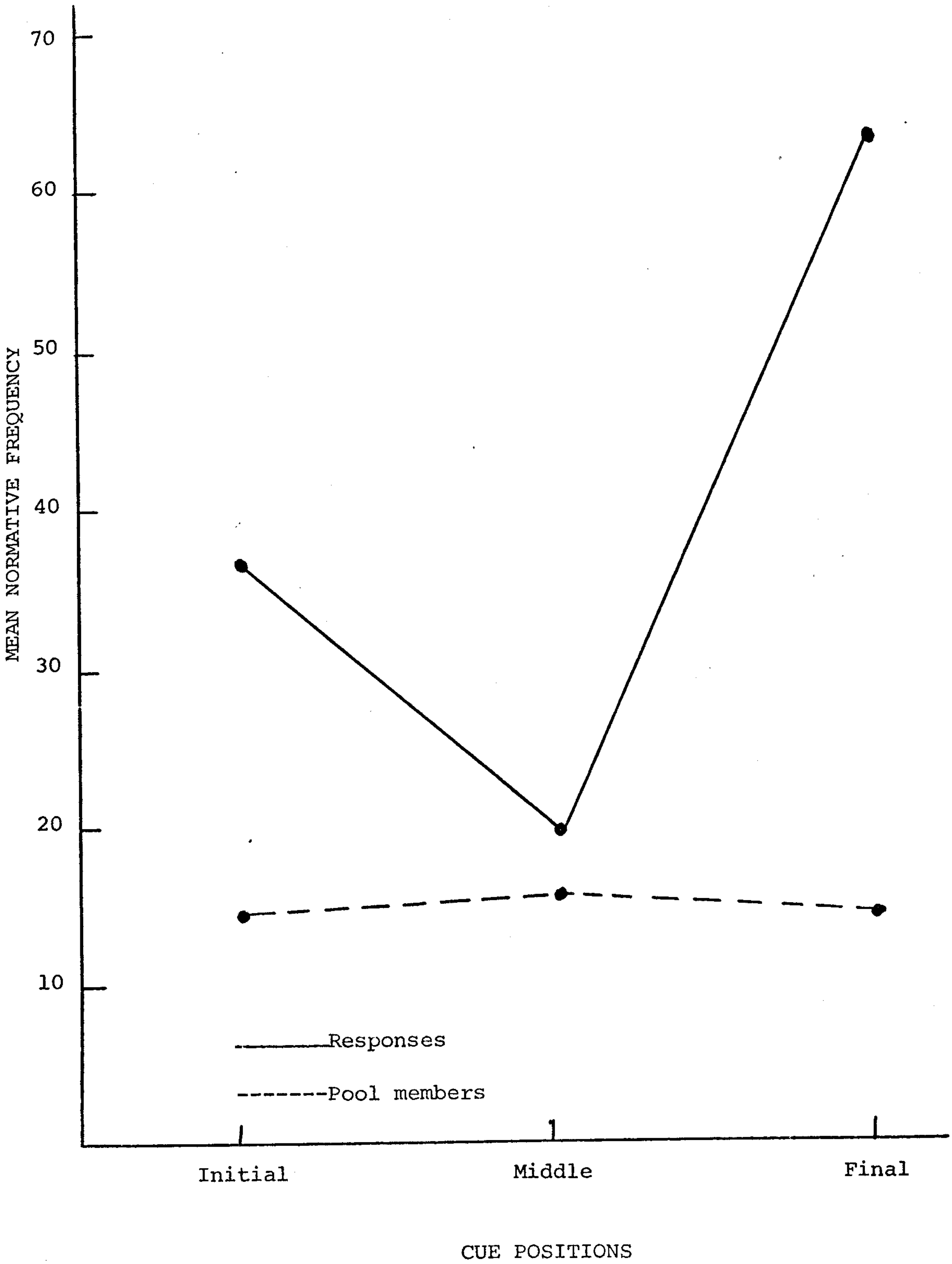

Figure 8. Mean normative frequency of responses and pool members as a function of cue position.

CHAPTER VI

DISCUSSION

Cue Versatility and Retrieval

Experiments I and II in this study have demonstrated that the relationship between category size and semantic retrieval depends, in first order, on the nature of the retrieval task. In Experiment I, where the retrieval task consisted of only requiring the S to produce an exemplar from a semantic pool, high cue versatility led to faster retrieval latencies. In contrast, Experiment II showed that when a specific member of a pool was to be retrieved, low cue versatility facilitated retrieval.

Solso (1974) used the analogy of finding a particular book in an unindexed library in describing the relation between cue efficacy and memory retrieval (the ISAP). In his hypothetical example, five libraries, containing 10, 100, 1,000, 10,000, and 100,000 books respectively, are to be searched to find the book Main Street by Sinclair Lewis. The books in the first library can be searched quickly, but the probability of finding the desired book is low. If the fifth library containing 100,000 books is searched, the probability is high that the book will be found, albeit after a lengthy search.

The use of the library analogy with a few additions can provide a useful model for comparing the retrieval processes involved in the first and second experiments in the present study. Consider the human long-term memory store to be like a library. In the library the books are not indexed nor ordered on the shelves. Each book can represent a 6-letter word in semantic memory. The number of books or words in the store varies from individual to individual. The maximum number of words in the store would equal the 5,651 6-letter words listed in the Kucera and Francis corpus plus a small number of words not contained in the word norms. However, it is expected that the average S's pool contains fewer words than this maximum, since many of the words are of low frequency and may have never been encountered by S.

In Experiment I S had to retrieve any word with certain initial two or three letters. The number of words fitting the initial cue varied, depending on the cue versatility. This task can be compared to the task of retrieving a book by a certain author in an unindexed library. It should be expected that the more books written by an author, the faster the retrieval of a book by that author. If there are two tasks, one of retrieving a book by Sinclair Lewis, and one of retrieving a book by William Shakespeare, the probability is higher that a book by Shakespeare will be found before a book by Lewis is found. This analogy held in Experiment I, where a 6-letter word with certain initial letters was retrieved faster, on the average, when many examples containing the specific initial letters existed.

To use the library analogy to cover Experiment II, one factor should be added. Even though the books in the library are unindexed and scattered throughout, allow each book to have a distinguishing marking (cue) to represent its having been written by a certain author.

This is not an unreasonable allowance when the experimental situation is studied. A S would not be expected to test each 6-letter word in his store for a match with the given cue. Rather, the S restricts his search to words fitting the cue. Let each book by Sinclair Lewis have a red marking on its cover and each work by William Shakespeare have a blue marking on its cover. Grant the additional proviso that every work by each author is bound separately and that there is only one copy of each work. What would be the expected relative latencies of two tasks, one specifying the retrieval of Main Street, by Sinclair Lewis, the other specifying the retrieval of The Merchant of Venice, by William Shakespeare? Given that both books are in the library, the book by Lewis should on the average be retrieved faster. The hypothetical S going through the library has fewer red book covers to check than blue book covers. Similarly, in Experiment II S has fewer words to check for cues of low versatility than for cues of high versatility. Experiment II demonstrated that success in retrieving target-words is greatest with low-versatile cues. The latency data on the "successes" in target-word retrieval displayed the expected order of retrieval latencies: $V_{low} < V_{med.} < V_{high}$.

The strong category-size-retrieval effect obtained in this study suggests a successive-scanning rather than simultaneous-scanning retrieval process. This finding stands in contrast to other semantic-retrieval studies (e.g., Freedman et al., 1971; Landauer et al., 1968; Loftus et al., 1970), where evidence of the significance of the pool-size variable has been scanty. These studies have favored simultaneous scanning over successive scanning processes.

It is believed that two factors are responsible for the disparity in past semantic studies and the present study. The first factor is the failure of past semantic-retrieval studies to take into account the differences in the type of response constraints in the experimental task. The differences in "free-response" and "target-response" tasks and their effect on the pool-size-retrieval function has been demonstrated in the present study. Freedman et al. (1971) allowed Ss to retrieve any word from overlapping categories. While the authors did have certain stimuli in which there was only one possible response, the majority of stimuli allowed more than one response. In this task, large category size should facilitate retrieval. A similar expectation exists in Loftus et al. (1970), where retrieval from subordinate and superordinate categories only restricted responses to the criterion of belonging to the particular categories. On the other hand, Landauer et al. (1968) had Ss classifying particular stimuli in terms of smaller and larger categories. Small pool size did help retrieval here. The differences in expectations in the pool-retrieval functions do not erase the weakness of the pool-size variables in these studies. It does, however, caution E to analyze the requirements of his experimental task before predicting the effect of pool size on retrieval.

The second factor accounting for the discrepancies in the data between traditional semantic-retrieval studies and the present study (or other word redintegration tasks) is the problem of trying to compare two fundamentally different retrieval tasks. Freedman et al. (1971) suggests this difference when comparing previous semantic-retrieval studies to "thinking-of-a-word" studies (e.g., Duncan, 1970). The retrieval times in semantic-retrieval studies range from milliseconds to 1-2 seconds. Typically, word-redintegration studies involve mean retrieval times of over five sec. and in excess of 30 sec. in the present study. The longer latencies suggest a higher level of retrieval and less automaticity in the retrieval process in word-redintegration tasks. In the present study different retrieval processes may have been involved if tetragrams or pentagrams had been used to elicit 6-letter words. Semantic retrieval studies involving higher-level retrieval (RT's over a few seconds) give evidence of a successive-scanning retrieval process. Successive scanning processes, in turn, are affected by pool size more than simultaneous processes would be.

Cue Frequency and Retrieval

While cue versatility controls pool size, cue frequency in the present study indicates the average availability of the pool members fitting a cue. According to the spew hypothesis (Underwood et al., 1960):

> ...the order of availability of verbal units is directly related to the frequency with which the units have been experienced. Other things being equal, therefore, the more frequently a verbal unit has been experienced, the more quickly will this become a response in a new associative connection (p. 86).

According to the spew hypothesis, cues of high frequency should lead to faster retrieval since their pool members will be emitted earlier than the members of low-frequency cues. In Experiment I high cue frequency was associated with faster retrieval times. This supports the finding of Freedman et al. (1971), where a linear relationship between the frequency of the pool members and retrieval RT was obtained.

The significant interaction of frequency and versatility in Experiment I indicated that at low-versatility levels (cf. Figure 1) cue frequency becomes an even more potent factor in retrieval. This finding is not surprising in as much as varying cue frequency at low-versatility levels affects each individual pool member more than at high-versatility levels. For example, if two cues have versatilities equal to five and differ in frequency by 30, then the mean frequency difference per pool item = 30/5 = 6. The same cue frequency difference of 30 for two cues of versatilities equal to 30 is equal to a mean pool member difference in frequency of 30/30 = 1. Thus, changes in cue frequency are more likely to be potent (affect retrieval latency) with cues of low versatility.

In Experiment III the overall effect of frequency was not significant. Inspection of the cell means (cf. Table 11) reveals that for initial cues, high-frequency cues had faster retrieval times than low-frequency cues. For middle- and final-positional cues, differences in retrieval latency were slight between high-frequency and low-frequency cues. The middle- and final-positional cues showed reversals under low versatility, whereby low-frequency cues had faster times than high-frequency cues. The only explanation for this finding is that the task was too difficult (only 42% solutions) for the variable to affect retrieval (i.e., a "floor effect").

In Experiment II cue frequency was not a significant variable and it was not expected to be. Instead, target-word frequency was expected to significantly affect retrieval. The critical frequency factor in Experiment II was the availability of the target response and not the other pool members. Actually, one may reason that retrieval should be faster when high-frequency target words are members of low-frequency pools. In this case there would be fewer other pool members interfering with the emission of the target response. There is some evidence for this theory (cf. Table 8). The overall variable of target frequency was not significant, although cues with high-frequency target words had more target-word retrievals. Again, the poor performance, especially in the middle- and high-versatility conditions, may have suppressed the variable.

Pool Dominance and Retrieval

The variable of pool dominance in Experiment I did not affect retrieval times. The idea for examining the variable came from semantic-retrieval studies (e.g., Wilkins, 1971) where the task involved retrieval of a specific item or information about a specific item in a category. Experiment I potentially involved all pool members, so it was not unexpected that a variable concerning only the highest-frequency member had no significant effect on retrieval.

An alternative procedure for employing the pool-dominance variable would have been to obtain S-generated responses to the stimuli. The bigram and trigram cues could have been pre-experimentally ranked on the variable of pool dominance (i.e., frequency with which the most frequently given response is elicited by each cue). The target words used in Experiment II could have also been ranked on their pre-experimental association to their cues.

An alternative to the pool-dominance variable in the present study would have been to study the effect of the number of high-frequency words in the pools on retrieval latency. The effects of this variable are discussed further under the section of response frequency.

Cue Size and Retrieval

The faster mean retrieval time for trigram cues (17.90 sec.) vs. bigram cues (20.79 sec.) in Experiment I approached significance. The faster trigram times are contrary to the theory of shorter retrieval latencies with highly-versatile cues in a "free-response" task. The low-, medium-, and high-versatility levels for the bigram cues were higher than the corresponding trigram versatilities. The data is also contrary to the finding (Duncan, 1970) that large cues (bigram cues) produce longer latencies than smaller cues (single-letter cues) in word redintegration.

Duncan (personal communication) has offered the hypothesis, that in the production of 6-letter words, trigram cues define the pool of responses to a greater degree than do bigram cues. In 6-letter word redintegration there are competing responses from 7-letter words (as well as possibly 5- and 8-letter words) beginning with the same initial cue. Trigram cues may reduce a number of these interfering responses.

Another bias in favor of the larger, trigram cues, is pronounciation effects. The extra-letter cue adds pronounciation cues as well as extra graphic cues. Simply speaking, trigram cues more closely resemble the 6-letter word responses, in all respects, than do the bigram cues.

Cue Position and Retrieval

Experiment III demonstrated that the relationship of cue versatility and "free-response" retrieval, found in Experiment I, holds for middle- and final-positional cues. The versatility effect, however, was diminished in the $P_{mid.}$ condition. While overall retrieval times for $P_{mid.}$ and P_{final} were similar, Figure 7 shows that reversals in the order of retrieval times occurred between the two versatility levels. At high versatility the order of retrieval latencies corresponded to that found by Horowitz et al. (1968) and Horowitz, Chilian, and Dunnigan (1969), $P_{init.} < P_{final} < P_{mid.}$. The Horowitz et al. (1968, 1969) studies are not directly comparable to the present study. Horowitz et al. used word fragments as cues to recall of previously presented words. The cues were not controlled for versatility, although they did find that cues (initial) eliciting many associates (high versatility) were negatively correlated to recall. This can be viewed as confirmation of the ISAP and the finding in Experiment II that large pool size hinders retrieval of target responses.

The question remains as to why different-positional cues equated on versatility and frequency still differ in their ability to aid retrieval? One suggestion, as a factor in the favoring of initial cues as retrieval aids, is the addition of pronounciation cues associated with initial cues. Initial cues when pronounced can evoke responses from their sound cues. As cited earlier, this can be a factor favoring trigram over bigram cues, due to the additional sound cues of the extra letter.

Pronounciation effects can be a potential bias in a word-retrieval experiment, such as the target-response experiment in the present study. Some trigrams, when pronounced as presented, sound like the beginning of their target word (e.g., tun→ tunnel). Other cues have different natural pronounciations from their target words (e.g., ari→ arisen). This potential bias can be minimized with more use of cues other than initial ones.

Middle and final cues are much more limited in their providing pronounciation cues. Middle- and final-word fragments serve more as graphic and nonvocal cues (Dolinsky, 1973). Dolinsky (1973) demonstrated the role of word fragments serving as syllables in aiding recall. Initial and final cues are less likely to disrupt syllabic patterns and thus, have greater redintegrative powers. Another factor favoring initial cues (Horowitz et al., 1968) is the fact that forward associations (initial-cue associations) are more salient than backward associations (middle- and final-cue associations).

Brown and McNeill (1966) demonstrated that the perceptual organization of a word rests on initial word fragments. Even kindergarten children (Marchbanks & Levin, 1965) apparently perceptually organize words around their initial letters. It would appear then that the closer the redintegrative cue matches the perceptual organization of the word, the more facilitative the cue is in eliciting the word.

Response Frequency

The analysis of the normative frequencies of the responses in Experiments I and III revealed that in all the experimental conditions the mean frequency of the emitted responses was higher than the corresponding means of the pool frequencies. The overall elevation in response frequency replicates the spew effect found in other word redintegration studies (e.g., Duncan, 1966, 1970, 1973). The only exception to this finding was in Experiment III, where the mean frequency of the responses from the $P_{mid.}$ cues was not significantly higher than its pool mean. The explanation for this lack of response-frequency elevation remains a question. The explanation of the increased elevation in the mean frequency of the P_{final} (cf. Fig. 8) responses is easier to formulate. An examination of the response protocols for the P_{final} cues showed that one very high-frequency response (CHURCH-frequency = 348) was emitted 12 times. The emission of this response can account for the overall elevation in the mean frequency of the P_{final} responses.

The progressive increase in elevation in response frequency with increasing cue versatility, found in Experiments I and III, confirms the findings of previous research (i.e., Duncan, 1970) which showed lower-frequency responses with smaller response pools. The responses from the trigram cues (smaller pools) were significantly lower in frequency than bigram-cue responses. As reported, the point-biserial correlation between increasing cue size (decreasing pool size) and response frequency was negative and significant. The failure to find differences in mean response frequencies between bigram and trigram cues beyond the .01 level may have been due to variations in the composition of the respective pools. If, for example, the trigram pool in Experiment I contained a few very high-frequency words, then the response frequencies may be elevated from a low percentage of the total number of the responses. Median-frequency response may have been a more appropriate measure in comparing response frequencies.

The correlation of increasing pool size and response frequency may be misinterpreted. To determine the relationship of pool dominance and frequency (as distinguished from pool size, per se) to response frequency, rank-order correlations were computed between these variables. All of the cues in Experiment I were ranked according to the mean frequency of the responses given to them. The cues were also ranked according to the frequency of the highest-frequency member in their pool (pool dominance). The correlation of pool dominance and response frequency was highly significant, $r = .81$, $t(46) = 9.47$, $p < .001$. The cues were then ranked according to the number of high-frequency members (frequency ≥ 15) in their pool. The rank-order correlation of this variable with response frequency was also significant, $r = .66$, $t(46) = 6.04$, $p < .001$.

As related earlier, the product-moment correlations of pool dominance and cue frequency with response frequency in Experiments I and III were also significant. These correlations were all higher than the correlations of versatility and response frequency. The correlational data imply that pool dominance and the number of high-frequency pool members contribute to determining the level of response frequency. Reductions in pool size usually have concomitant reductions in pool dominance and frequency. It is the reduction in the number of available high-frequency responses associated with reduced pool size that makes it difficult to think of high-frequency words with cues of low versatility.

SUMMARY

A task of "thinking" of a 6-letter word was employed to investigate the relationship of pool size and semantic retrieval. In Experiment I, Ss were free to respond with any 6-letter word which fit the initial bigram and trigram cues presented to them. The cues varied at three levels of versatility (the number of 6-letter words fitting the cue) and two levels of frequency (the mean frequency of the words fitting the cue). The versatility and frequency values were calculated from the Kucera and Francis (1967) word norms. The response latencies in Experiment I indicated that high cue versatility and frequency facilitated retrieval. Cue versatility and frequency interacted, as the frequency variable was more potent in the low-versatility condition. The variable of pool dominance, or the frequency of the dominant response fitting a cue, was not significant. The shorter latencies with the trigram cues versus the bigram cues were accounted for by the effects of pronounciation and pool delineation.

In Experiment II, Ss were required to emit pre-experimentally selected 6-letter target words. Trigram cues varied at three levels of versatility and two levels of frequency. The target words also varied at two levels of frequency. The task proved to be exceedingly difficult. Only the variable of cue versatility reached significance. Low-versatile cues produced the most target responses. The experiment confirmed the predictions of the inter-structural associative paradox,

whereby small pool size was beneficial to the retrieval of a specific response.

Experiment III replicated the findings of Experiment I using middle- and final-positional cues. Success in retrieval, however, was depressed with middle- and final-positional cues. The positional effect was interpreted in terms of vocal, syllabic, and perceptual factors.

The normative frequencies of the responses were examined in Experiments I and III. In all conditions, except with middle-positional cues, the mean response frequencies were significantly elevated above their pool means. The data supported the spew hypothesis. The higher response frequencies found with increasing pool size were discussed in connection with pool dominance and the number of available high-frequency responses, rather than pool size per se.

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The final copies have been examined by the director of the dissertation and the signature which appears below verifies the fact that any necessary changes have been incorporated and that the dissertation is now given final approval by the Committee with reference to content and form.

The dissertation is therefore accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

Aug 19, 1974
Date

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Director's Signature