EFFECTS OF STIMULUS MEANINGFULNESS (M) AND THORNDIKE-LORGE FREQUENCY IN PAIRED-ASSOCIATED LEARNING IN WHICH RESPONSES HAVE DIFFERENTIAL PROBABILITIES OF OCCURRENCE TO STIMULI

JAYLENE SUMMERS TILTON

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by

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B. S., Jackson College for Women of Tufts University, 1963
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A THESIS

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To
My Parents
and
Shaw David
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ABSTRACT

EFFECTS OF STIMULUS MEANINGFULNESS (m) AND THORNDIKE-LORGE FREQUENCY IN PAIRED-ASSOCIATE LEARNING IN WHICH RESPONSES HAVE DIFFERENTIAL PROBABILITIES OF OCCURRENCE TO STIMULI

by

JAYLENE SUMMERS TILTON
ABSTRACT

The differential effects of stimulus meaningfulness (m) and Thorndike-Lorge (T-L) frequency of stimuli were investigated in paired-associate learning (PAL). Two experiments were run. In Experiment I, m was a between-groups variable and T-L frequency was a within-groups variable. In Experiment II, T-L frequency was a between-groups variable and m was a within-groups variable. Half the subjects in both experiments learned responses designated as low-probability responses while half learned responses of high probability. Probability of response items was obtained by determining which responses occurred most frequently and which occurred infrequently or not at all to specific stimuli when Noble's (1952a) procedures were used to determine m value. The 140 subjects each learned a list separately in the usual paired-associate manner.

The obtained results led to the following conclusions. Hypothesis I, which was that in PAL, fewer errors will be made when the S-R associations consist of pairs in which each response has a high probability of occurrence to its stimulus, was borne out. Support for this was obtained in both Experiments I and II. The explanation forwarded for this finding was that with greater associative strength in the high-probability situation, the associative or hook-up stage was more rapid.
The results of the analyses of the within-groups data indicated support for Saltz's (1967) original findings by confirming his results for low-probability responses. That is, Hypotheses IIb and IIIb were confirmed in that under the low-probability condition, errors increased as T-L frequency of stimuli increased and \( m \) value of stimuli was held constant, and errors decreased as \( m \) value of stimuli increased and T-L frequency was held constant.

The results did not support Hypotheses IIa and IIIa, which were that under the high-probability condition, errors would decrease as T-L frequency of stimuli increased and \( m \) value was held constant, and errors would increase as \( m \) value of stimuli increased and T-L frequency was held constant. While the rates of error increase and decrease with changes in T-L and \( m \) were different at different levels of response probability, the directions of the effects under the high-probability condition were not as predicted. That is, even under the condition of high probability, errors increased as T-L frequency was increased with \( m \) held constant, and errors decreased as \( m \) was increased with T-L held constant. However, the effects under the high-probability condition were attenuated. It was held that Saltz's (1967) theorizing was sound, and that under the high-probability condition, two factors balanced each other to produce the attenuated effects. These factors are the nature of the interference of competing responses and the associative strength of the response to be learned.
Thus, under the high-probability as well as under the low-probability condition, the effects of $m$ and T-L frequency can be attributed to proactive interference manifested through response competition factors. It now seems apparent that $m$ and T-L frequency must be considered as separate factors operating differentially. While they are correlated variables, they effect PAL performance differently. The interference paradox of associative probability appears to be an oversimplification in that it equates meaningfulness and frequency and ignores their differential effects.
Influenced by the British Associationists and inspired by Fechner's attempt to measure higher mental processes scientifically, Hermann Ebbinghaus was the first psychologist to study systematically the effects of learning and memory. His classic work (Ebbinghaus, 1913), first published in 1885, laid the groundwork for the bulk of contemporary verbal learning theory and procedures. As Watson points out, "Ebbinghaus' research on learning and memory, as reported in his book of 1885, is perhaps the original impetus for more research in psychology than any single study" (Watson, 1963, p. 266).

In the United States, following Ebbinghaus' lead, functionalists such as Carr, Robinson, McGeech, Melton, and Underwood undertook the study of rote learning. Research in the area has since been active and two general patterns have been followed. In serial learning, the subject is shown a series of words or syllables one at a time and on successive showings must learn, as he sees each item, to call out or write down the one that is coming next before he sees it. Paired-associate learning, the second pattern that has also been used extensively, consists of learning several pairs of items. The pairs may appear in a different order on each trial, but subjects must learn
to anticipate the second member of each pair when the first one appears. Other procedures, too, have been developed and employed, such as the methods of modified free recall and "free" learning.

Typical research problems in rote learning have dealt with the effect of learning in parts or wholes, learning by massed or distributed practice, and transfer of training. For awhile, after the initial interest in verbal learning had been explored, the behavioristic approach dominated the attitudes of researchers. Animal psychology and simple processes were emphasized so that the mentalistic overtones of rote learning did not seem to fit into the research picture. However, another spurt occurred with the development of new issues, such as applying mathematical models to rote learning. One-trial learning was re-emphasized after Rock's (1957) research using paired-associate learning. Higher mental processes such as reasoning and problem solving, once banned by Behaviorists, are now more than respectable research areas. The influence of computers may be seen in the extension of information theory to psychology. Stimulation has come through the work being done in the study of linguistics. And in 1962, the Journal of Verbal Learning and Verbal Behavior was established. Thus, the field of verbal learning has grown to be an active and extensive area of research.

Throughout the history of the study of rote learning there has been an interest in the role of interference
effects. For example, McGeech (1932) wrote a caustic attack on the "law of disuse" theory. Such a theory proposes that forgetting occurs because of a lack of use of the learned material. McGeech's intention, as Melton (1961) has pointed out, was mainly to assert that there had been too much neglect of the tremendous amount of variance in learning that could be accounted for by interference factors. Today, interference theory is a major explanatory system for the effects of learning, transfer, and forgetting. Melton says, "...we are not yet in a position to treat all long-term forgetting as the product of interference factors alone, even though interference factors may well be by far the most important" (Melton, 1961, p. 190).

Postman takes an even stronger position stating, "(i)n­terference theory occupies an unchallenged position as the major significant analysis of the process of forgetting" (Postman, 1961, p. 152). In general, interference theory attributes errors in learning to the demonstrable adverse effect that learning has on the subject's ability to learn or retain other material.

The brunt of the earlier explanations of interference in learning has rested mainly upon the concept of retroactive inhibition (RI). This refers to the interference produced by new learning, interpolated between original learning and a measure of retention of the original learning. The magnitude of the retroactive inhibition effect is assessed against the performance of a control
group which has only the original learning and a measure of its retention, without any interfering learning task interpolated within the retention interval. Numerous laboratory studies have verified the reality of the phenomenon and explored the influence of several variables that govern its magnitude (Slamecka & Ceraso, 1960). In short, forgetting is explained by appealing to subsequent learning of other material.

There is also another source of interference in learning. This occurs when early learning can be shown to interfere with later learning. Such interference is called proactive inhibition (PI). Benton J. Underwood of Northwestern University was the first to emphasize the importance of PI in his classic 1957 paper. Following an extensive and detailed examination of the literature, he proposed that while traditionally forgetting was attributed to BI, it could more logically be attributed to the amount of prior practice subjects had had before learning the test list. For example, with heavily practiced subjects, retention of the last list learned was only 25 per cent or less, whereas with naive subjects, 75 per cent was retained. Thus, most forgetting could be attributed to PI rather than BI. (The importance of this finding is realized when it is seen that PI affected the shape of the curves of retention obtained by Ebbinghaus, who was a practiced subject). Underwood states:
It is my belief that we can narrow down the cause of forgetting to interference from previously learned habits, from habits being currently learned, and from habits we have yet to learn... It is my opinion that we should increase these studies for the simple reason that the proactive paradigm provides a more realistic one than does the retroactive paradigm (Underwood, 1957, p. 59).

Thus, the importance of extra-experimental learning was emphasized. One consequence of this new direction in verbal learning is a realization that experiments in verbal learning result in the modification of extra-experimental language behavior and the theories of verbal learning are about real-life language changes. As pointed out by Melton (1961), subjects are no longer viewed as entering the laboratory situation in a quasi-tabula rasa condition. Rather they are seen as bringing to the situation a complex system of linguistic patterns which can cause extra-experimental interference (EEI) or facilitation. If learning is inhibited in the experimental setting, interference is said to have occurred. On the other hand, if the proactive or retroactive effects aid learning, facilitation is said to have occurred.

Interference theory has several interpretations, advanced mainly as explanations of HI. One approach is the competition-of-response theory which was developed in the 1930's by McGeoch. It suggests that when learning is impaired, it is because one association, namely the remembered item, preempts the place of the correct item.
A second explanation for RI assumes that original list associations are unlearned during the learning of the interpolated laboratory list. Hence, recall of the first learned list is poorer after second list learning because the original associations have been unlearned, a process held to be similar to extinction in conditioning.

Research on response competition has lagged far behind that reported on unlearning. The term competition implies that more than one response is vying for expression at the time of stimulus presentation. Hence, while unlearning refers to the loss of response availability, response competition refers to a struggle between two or more available responses elicited by the same stimulus.

The most widely held explanation for RI is the two-factor theory proposed by Helton and Irwin (1940) which attempts to combine both the competition-of-response and the unlearning theories. In this case, unlearning and recovery of the associations to the stimuli involved in the original learning is held to occur, as well as competition between original learning and interpolated learning. Unlearning, in most cases, has been attributed to processes that are assumed to be similar to those operating in conditioning paradigms, most specifically countereconditioning. It is felt that the unlearning of the first laboratory list, which is like experimental extinction, occurs when subjects learn a second list. With the passage of time these unlearned first list associations are thought to
recover spontaneously in strength and to be more readily recalled as the interval between interpolated list and recall of first list learning is lengthened. To date the support for this approach has been equivocal (Keppel, 1968). Other interpretations have been offered such as the one by Postman, Stark, and Henshel (1969) who maintain that a mechanism of response selection operates during interpolated learning. There is much controversy regarding the role of unlearning in RI, but since the present study is concerned with PI effects from earlier language habits there is no need to consider the issues here.

In PI, the situation is more complicated in that any effects of unlearning must be manifested in response competition. In RI, a subject learns List A, then List B, and is tested on List A. The effect of learning List B may be both to produce interfering responses and to unlearn List A, which may be more poorly recalled for both these reasons. However, in PI, where a subject learns List A, then List B, and is tested on List B, there can be no interference that results from the unlearning of the critical list (List B). What may well occur is the unlearning of List A during the learning of List B, with spontaneous recovery of the unlearned responses of List A accounting for some of the response competition that occurs in PI. However, to date there has been little support for the role of unlearning in laboratory studies of PI that follow the above paradigm (Slameoka & Ceraso, 1960; Keppel, 1968).
There is however, another possible source of PI that is of particular relevance for the present study. Extra-experimental associations stemming from a subject's linguistic habits may be unlearned during the acquisition of a laboratory list and, with the passage of time, spontaneously recover to produce PI at the recall of the laboratory list (Underwood & Postman, 1960). The present investigation assumes proactive interference effects of extra-experimental associations on original list learning, a phenomenon for which there is considerable experimental evidence (Postman, 1961, 1962, 1964; Slamecka, 1966).

The present study was an investigation of some of the specific competitive factors that may be causing PI in original list learning, rather than a study of unlearning. The stress was on the importance of the role of existing language habits. It has been recognized that in a verbal learning task, subjects bring to the laboratory certain associative tendencies to stimuli that will be encountered in the learning task. Slamecka says, "(i)f S must acquire new responses to items in the list, it is asserted that he must first break the older, preexperimental, associative bonds" (Slamecka, 1966, p. 822). Consistent with this viewpoint, it has also been stated that the greater conformity to language habits of a subject an experiment has, the greater the facilitation that should occur (Postman, 1962).
Some peripheral theories have been developed in an attempt to explain certain findings of interference research. For example, Slamecka (1966) has conducted investigations of pre-experimental associations. He obtained extralist and intralist pre-experimental associations to stimuli from subjects by having them give free associations to the stimuli. Some of these associations he included within the test list and differentiated among these from extra-experimental associations. In his Experiments I and II, he then instructed subjects to learn one or two competing lists. Subsequent recall of pre-experimental associations was not effected. In Experiment III latency measures were taken of free associations before and after competing list learning. No weakening of natural associations occurred. He concluded that the pre-experimental associations were inhibited but not unlearned during list acquisition. The hypothesis was suggested that strong associates are differentiated before they can be unlearned and weaker associates are unlearned more rapidly than they can become differentiated. Thus the subject brings proactive responses to a situation whether or not that situation presents a task divergent from the learned habits or consistent with it. It is to be expected that some of these responses will compete with or facilitate those required in the laboratory situation.

Current research by Ceraso (1967) offers some evidence which incorporates the concept of spontaneous re-
On the basis of his findings he has proposed that forgetting is best explained within the framework of a theory of search. Interference is simply a name for the general difficulty that is experienced when searching for an item embedded among other items in memory storage. Subjects forget because "crowding" occurs when more than one list is learned. That is, over time the two lists seem to merge and are indistinguishable from each other. As a result, retention of List II, which was learned after List I, is impaired.

Thus the mechanisms of interference effects have numerous interpretations and the resulting theories are still open for further revision and refinement.

Another important factor in verbal learning is the characteristic of stimuli called "meaningfulness." McGeech (1942), Underwood (1949), and Woodworth & Schlosberg (1954) all emphasize this factor as a relevant variable in verbal learning. There are various operations used for calibrating the association values of verbal units, which Underwood & Schulz (1960a) equate with meaningfulness. The point of departure for the analysis of meaningfulness in Underwood & Schulz's book, *Meaningfulness and Verbal Learning* (1960a), is Glaze's study (1928). He presented a long series of nonsense syllables (2,019) to subjects and asked them to indicate whether or not each syllable suggested an association to them. These syllables were then ordered along a scale defined by the percentage of subjects...
who had had an association.

Hull (1933) also attempted to get measures of association value. He used 320 syllables, divided into 20 lists of 16 syllables each, many of which had appeared in Glaze's list. Each of the 20 subjects was presented each list three times at a rate of two seconds per syllable. In addition to serial learning of the lists, subjects were required to report any associations the syllables might have, but not to try to think of associations. Thus, within a short period of time the subject was asked to do several things, making Hull's procedure questionable (Underwood & Schulz, 1960a).

Using another procedure to determine meaningfulness, Krueger (1934) spelled each syllable twice and subjects wrote the syllables as they were spelled. They also wrote the association aroused by the syllable if such a response occurred. Those syllables which aroused the greatest frequency of response were listed as having a 100 per cent association value. Values of the other syllables were based on the percentage frequency of the associations aroused by the 100 per cent syllables. A total of 2,183 syllables was used following 100 practice syllables. There were 586 subjects, each rating 1200 syllables.

Instead of working with consonant-vowel-consonant syllables, Witmer (1935) used syllables consisting of three consecutive consonants. Each of 4,535 syllables was presented on a memory drum for four seconds. Subjects
were instructed to spell the syllable and state what it meant for them, or say "yes" if it was meaningful but they were unable to state its meaning in the allotted time. The meaningfulness value was the percentage of the 25 subjects who reported an association. For several reasons, Noble (1952a) was dissatisfied with the above studies and other indices (Cason, 1926; Haagen, 1949) that had been developed. They either involved very short response intervals, free-association techniques, relative frequency measures, or their reliabilities were not reported. Therefore, Noble wished to determine the frequency distribution of continued associations given by subjects per unit time. (Continued associations are those which are successively elicited by the same stimulus, as distinguished from free or controlled associations). Noble selected 96 units for the final scaling of meaningfulness. These units consisted of about 20 per cent paralogs (e.g., gojey, neglan), 35 per cent words having a low-frequency-of-usage as indexed by the Thorndike-Lorge (1944) word count and 45 per cent having high-frequency values.

The method used by Noble to determine meaningfulness is sometimes referred to as the production method. The subjects were presented with a to-be-scaled disyllable and given 60 seconds to write all the different words elicited by the disyllable. The index of meaningfulness, referred to as m value, was the mean number of responses given to each disyllable during a 60 second period.
A positive relationship between $m$ value and learning has since been clearly demonstrated. For example, Noble (1952b) gave subjects disyllables of either low, medium or high $m$ value to learn in a standard serial anticipation method. Subjects who learned lists of low $m$ value required over twice as many trials to learn as did subjects who learned lists of high $m$ value. Similarly, Noble & McNeely (1957) found that in a paired-associate learning task, as $m$ value increased, errors decreased.

Another definition that is sometimes used for meaningfulness is the Thorndike-Lorge (T-L) 1944 word count done at Teachers College, Columbia University. These word counts were obtained from the literature of the English language. The relative frequency with which the 30,000 most frequent words occur in writing was tabulated to obtain a population index. Because it is an index of relative frequency of occurrence in the English language, it is also employed as an index of the frequency with which a subject has experienced the word. Each word in the table is listed according to how many times it occurs per million words.

Because both $m$ value and T-L frequency are positively related to learning, it has been reasonably assumed that these two variables are comparable measures. A positive relationship between learning and T-L frequency has been demonstrated (Bousfield & Cohen, 1955). For example, Cofer & Shevitz (1952) used four high-frequency
words and four low-frequency words in a study of the relationship of frequency to association value. The high-frequency words had an occurrence of 100 times per million or more, and the low, one time per million. Two adjectives and two nouns were used at each frequency level. Each word was presented for 10 minutes and subjects were asked to write down all the words they could associate to each stimulus word. The high-frequency adjectives elicited an average of 50 associates, and the low ones, 42. The high-frequency nouns elicited an average of 61 associates and the low-frequency ones, 44. Similarly, Lepley (1950) had subjects rate words for frequency of use. Next he asked them to give as many different synonyms as possible to each stimulus. A direct relationship was found between the frequency ratings and the number of synonyms produced. Such a result might be expected from the fact that it is known that high-frequency words in the T-L lists have more dictionary meanings than do low-frequency words (Thorndike, 1948; Zipf, 1945).

Thus, two different operational definitions for the meaningfulness of words have been used in the past few years. Again, these are the Thorndike-Lorge (1944) measure of the frequency of words in the English language, and Noble's (1952a) $m$, the number of associations elicited by a verbal unit in a 60 second interval. Since $m$ value and T-L frequency have been demonstrated to be moderately correlated, some writers (Underwood & Schulz, 1960a) suggest
that these two indices may not only be related variables but may also reflect the same underlying process.

For example, in a recent study by Postman (1962), frequency of occurrence and $m$ value were considered to be comparable measures. Subjects learned lists in which the stimulus terms were of low, medium, or high frequency of usage according to the Thorndike-Lorge word count. Postman found a nonmonotonic relationship. Stimuli of intermediate frequency resulted in faster learning than stimuli of higher frequency. Postman reasoned that his results were due to two opposing relationships which he later (Postman, 1964) denoted as the interference paradox of associative probability, a term first used by Underwood and Schulz (1960a, p. 46). Associative probability refers to the number of associates which are evoked by a verbal unit, hence it is analogous to Noble's definition of $m$. It is held that in a rote-learning experiment which consists of words in a subject's language, pre-experimental associations elicited by items in the list can serve as sources of both facilitation and interference. To the extent that the prescribed associations conform to the learner's language habits, unit-sequence facilitation will result. As the new associations diverge from prior language habits, unit-sequence interference will develop. Both facilitation and interference may be expected to increase with the meaningfulness of the items in the list. The larger the number of different associations which an item acquires through
linguistic usage, the more readily it can be linked with other items, either directly or through short mediational chains. At the same time, however, the amount of interference during acquisition and retention may be expected to increase with the number of pre-experimental associations which can compete with the prescribed connection. It is assumed that interference increases with meaningfulness at a faster rate than facilitation (Postman, 1964). This interpretation was used to account for the nonmonotonic relationship that was obtained, and no differentiation was made between \( m \) value and T-L frequency.

The interference paradox of associative probability is related to a larger effort by Underwood and Postman (1960) to utilize interference factors as an explanation of learning phenomena. The focus has been upon interference produced by previously acquired linguistic habits which are unlearned during acquisition and assumed to recover over a retention interval to compete with the conflicting prescribed associations at recall. Throughout this research, meaningfulness has been equated with word frequency as in the above mentioned study. The Underwood-Postman theory attempts to account for differences in learning and retention of verbal materials in terms of two sources of interference, labelled letter-sequence interference and unit-sequence interference, both of which are assumed to be a function of meaningfulness. The two-factor theory was first presented by Underwood at the 1961 Gould House Conference on verbal learning and verbal be-
havior. The basic principle underlying the theory is that learning and retention of a list of verbal materials must be superimposed upon the strong linguistic habits (EEI) which a subject brings with him to the laboratory setting and which he will experience during the learning and retention intervals.

While both RI and PI are assumed to be important, it is the PI component which is of greater importance, since it is assumed that there will be more conflicting verbal habits from EEI during acquisition of new verbal material (PI) than following the retention interval (RI).

It is assumed that a direct application of the two-factor theory can be made to pre-experimental S-R habits which would intrude during acquisition, eventually be unlearned, and then recover over the retention interval to interfere with the recall of verbal material. The two sources of EEI have been identified as letter-sequence interference and unit-sequence interference. Letter-sequence interference refers to interference stemming from stronger letter-letter associations than those learned in the experimental situation. For example, the association Q-U is presumed to be stronger than the pair Q-C because of greater past experience with the former sequence. Thus, to learn the response C it is necessary to impose this over the established habit of the response U which presumably is done through the mechanisms of competition and unlearning. Unit-sequence refers to interference from verbal items
which are responded to as entire units, such as words. Interference is expected to operate in a similar manner with units and letters. In general, it was assumed that there is a U-shaped relationship between EEI and meaningfulness. Thus, it was expected that as meaningfulness increases from low to high, the amount of EEI gradually decreases for letter sequences and then increases for unit sequences. Based on the data reviewed by Keppel (1968) the following conclusions may be drawn regarding this theory. For letter-sequence interference, meaningfulness does not seem to influence the rate of forgetting. Secondly, the data on unit-sequence interference also seem to indicate that meaningfulness does not influence the rate of forgetting. Thus there is an evident failure of the Underwood-Postman formulation to explain the role of EEI in verbal learning. However, it is again noted that the studies involve data which index meaningfulness by word frequency. A major difficulty with the Underwood-Postman theory may lie in conceptualizing meaningfulness as a function of word frequency.

Some researchers have been investigating m value and T-L frequency as separate factors in paired-associate learning situations (Saltz, 1967; Saltz & Modigliani, 1967). Saltz maintains that in paired-associate learning, m value and T-L frequency of response are related to learning through the operation of two mechanisms, response differentiation and resistance to interference from competing
associations. The new association to be learned is conceptualized as competing with previous associations. In addition, it has been shown that increased practice on an item, per se (without necessarily attaching the item to any other item), increases response differentiation or availability (Saltz, 1961; Underwood & Schulz, 1960a). Thus it was predicted and found that with response words of high \( m \) value, increasing T-L frequency produces greater response differentiation and results in faster learning (Saltz & Modigliani, 1967).

In another study in which three separate experiments were run, Saltz (1967) focused on the stimulus side of paired-associate learning. For stimuli, he selected 100 nouns from the Thorndike-Lorge (1944) tables. The five categories chosen were in frequency of occurrence per 4.5 million words: 1-4, 30-40, 100-200, 399-750, and 1,000-2,000. There were approximately 20 words per category. The \( m \) value of the stimuli was determined using Noble's (1952a) procedures, using 87 Ss. In Experiment I and II, three basic lists were used. All the stimuli had \( m \) values between 6.0-6.9, 7.0-7.9, or 8.0-8.9 and T-L frequency was held constant by taking two words from each T-L category. There were ten items in each list. Experiment III employed four different lists in which the stimuli varied from 30-40, 100-200, 399-750, and 1,000-2000 in T-L frequency. The \( m \) value was held constant by taking three items of 6.0-6.9 and 8.0-8.9 and four items of 7.0-7.9. Responses were high-
frequency nouns. Lists were presented in standard paired-associate manner for 15 trials or 1 errorless trial, whichever was briefer. The results of Experiments I and II, in which T-L frequency was a within-S variable and of Experiment III, in which T-L was a between-S variable, indicated that as T-L frequency increased, errors increased. In Experiment II (where $m$ was a between-S variable) and III (where $m$ was a within-S variable), as $m$ increased errors decreased monotonically. In Experiment I (where $m$ was a between-S variable) the results were nonsignificant with regard to $m$ value; however, the trend was for errors to decrease.

Considering all three experiments as a whole the results indicated that when T-L frequency was increased and $m$ value held constant a decrement in performance occurred as measured by mean errors per item. And when stimulus $m$ value was increased and T-L held constant performance improved.

In addition, in both Experiments I and II, the $m \times$ T-L interaction was significant, which Saltz tentatively suggested might reflect the tendency of high $m$ material to be relatively insensitive to variations in T-L frequency. Saltz interpreted his results within the framework of interference theory. He emphasized the importance of REI in proactive terms, stating:

...(1) if two stimuli evoke the same number of associates (i.e., have equal $m$ values) but one of these stimuli had occurred more frequently than the other, the S-R systems involving this
more frequent stimulus will be more resistant to interference from the new responses to be acquired than the systems involving the low frequency stimuli...Similarly, if T-L frequency is held constant, the strength of individual S-R systems would be greater if the stimulus has been associated with relatively few responses (low m) than if it has been associated with many responses (high m). Thus low m might result in greater negative transfer than high m in acquisition of a new response to the stimulus (Saltz, 1967, p.477).

The results indicate the discrepancies involved in considering m value and T-L frequency as comparable measures using an explanation of proactive effects in terms of strength of existing competing S-R associations.

The present study was an attempt to test Saltz's interpretation by investigating the effects of m value and T-L frequency on the rate of learning a different type of list than that used by Saltz. A comparison was made of the rate of learning lists in which the responses were associations frequently found in the S-R systems of the subjects and similar lists in which the responses were weakly associated in the subjects' S-R systems to the stimuli with which they were paired. The latter was the type of list used by Saltz.

Saltz used a proactive interference explanation to account for the differential effects of m value and T-L frequency on learning. If his explanation is correct, then some interesting results should be obtained if responses of the pairs to be learned are from the subject's own S-R system. That is, proactive facilitation should operate as T-L frequency of stimuli is increased and m value held
constant. In addition, when T-L frequency is held constant, lower \( m \) value should result in facilitation, since the fewer associations should each be stronger. The few associations made to low \( m \) stimuli should be stronger because the average frequency per association is lower for the high \( m \) words than for the low \( m \) words. The hypotheses presented below follow from the above rationale:

Hypothesis I: In a paired-associate learning task, fewer errors will be made when the S-R associations consist of pairs in which each response has a high probability of occurrence to its stimulus than when each response has a low probability of occurrence to its stimulus.

Hypothesis IIa: In a paired-associate learning task involving S-R pairs in which each response has a high probability of occurrence to its stimulus, errors will decrease as T-L frequency of stimuli increases and \( m \) value of stimuli is held constant.

Hypothesis IIb: In a paired-associate learning task involving S-R pairs in which each response has a low probability of occurrence to its stimulus, errors will increase as T-L frequency of stimuli increases and \( m \) value of stimuli is held constant.

Hypothesis IIIa: In a paired-associate learning task involving S-R pairs in which each response has a high probability of occurrence to its stimulus, errors will increase as \( m \) value of stimuli increases and T-L frequency of stimuli is held constant.
Hypothesis IIIb: In a paired-associate learning task involving S-R pairs in which each response has a low probability of occurrence to its stimulus, errors will decrease as m value of stimuli increases and T-L frequency is held constant.

Hypotheses IIa, IIb, and IIIa, IIIb follow from Saltz's interference theory interpretation of the differential effects of stimulus m and T-L frequency on rate of learning. That is, with regard to hypotheses IIa, if two stimuli evoke the same number of associates (i.e., have equal m values) but one of these stimuli has occurred more frequently than the other, the subjects' S-R system involving the more frequent stimulus will be more resistant to interference from new responses to be acquired in standard paired-associate learning than the system involving the low-frequency stimulus. However, if each response to be learned has a high probability of occurrence to its stimulus in the subjects' S-R systems, then the pairs to be learned that consist of high-frequency stimuli should be more easily learned than those involving low-frequency stimuli, for, if the associations have occurred more frequently, they should be stronger than those of S-R systems involving low-frequency stimuli. This is consistent with Saltz's theorizing although the predicted results for this particular list are opposite from those obtained by Saltz. The difference is that here the stronger associations resulting from higher T-L frequency should aid in learning
responses that have a high probability of occurrence in subjects' S-R systems; in Saltz's study, these stronger associations produced greater interference with new responses not in the subjects' S-R systems. Consistent with Saltz's theorizing, hypothesis IIb makes the assumption that in a learning task in which each response to be learned has a low probability of occurrence to its stimulus, high-frequency stimuli will involve stronger associations from subjects' S-R systems that will produce greater interference effects and lead to more errors.

Similarly, with regard to hypothesis IIIa, if T-L frequency of stimuli is held constant, the strength of individual S-R systems should be weaker if the stimulus has been associated with many responses (high m). Thus, in standard paired-associate learning, low m might result in greater negative transfer than high m in acquisition of a new response to the stimulus, since salient competing associations from subjects' S-R systems will be stronger. However, in using response items which have a high probability of occurrence to particular stimulus items in subjects' S-R systems, it is assumed that the response is, in terms of probability, a salient part of each subject's own S-R system. Following Saltz's reasoning, with low m, relatively few responses have been attached to the stimulus and the high probability responses to be learned should therefore be easier to learn than in the case of high m, because the salient association, assumed to be part of the
subject's S-R system, should be stronger.

The reasoning underlying hypothesis IIIb is again consistent with that of Saltz, i.e., when the responses to be learned have a low probability of occurrence in subjects' S-R systems, high stimulus m should produce less interference when T-L frequency is held constant, and result in fewer errors.

Hypothesis I also follows from the reasoning of Saltz:

The point of view taken here holds that in the acquisition of any verbal connection, the major problem is not the formation of the individual association. It is the differentiation of the given association from all other associations. This is obvious in paired-associates learning. Any single pair can usually be learned in one trial. Difficulty in learning is a consequence of learning many pairs in a single list. Reinforcement of a given pair can be conceptualized as strengthening the boundary strength between this pair and other pairs, thus producing differentiation (Saltz, 1961, p. 161).

Thus it can be argued that an S-R pair in which the response has a high frequency of occurrence to the stimulus is more easily differentiated from other responses, as compared to pairs in which the response has a low frequency of occurrence to its stimulus. Because the stimulus and response are strongly associated with each other, they are more resistant to interference from competing responses and therefore more readily differentiated from other pairs.
CHAPTER II

METHOD

Materials

Stimulus words that were used by Saltz (1967) were employed in this investigation. The m value of these stimulus words were independently obtained from 100 subjects (Ss) using Noble's (1952a) procedures and instructions, with some minimal changes. The specific instructions that were given in order to obtain m values are presented in Appendix 1.

Five categories based on T-L count, each containing approximately 20 words were used. In frequency of occurrence per 4.5 million words these categories were: 1-4, 20-40, 100-200, 399-750, and 1,000-2,000. The 100 words and their obtained m values are presented below in Table 1. The same 100 words and their obtained m values as determined by Saltz are presented below in Table 2. While Saltz's values were obtained in a manner similar to that used in this study, it is readily seen by inspection that the obtained m values in the two tables are not identical. However, in terms of low, intermediate, and high m values, they are comparable. From the 100 words in Table 1, seven lists each containing 10 stimuli were constructed according to the criteria described on page 29.

Two experiments were run. In Experiment I, three different basic lists were used. In one list, all the
TABLE 1

Mean $m$ Values for 100 Words Classified by Thorndike-Lorge Frequency

<table>
<thead>
<tr>
<th>Thorndike-Lorge L Frequencies</th>
<th>1-4</th>
<th>30-40</th>
<th>100-200</th>
<th>399-750</th>
<th>1,000-2000</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>m</td>
<td>m</td>
<td>m</td>
<td>m</td>
<td>m</td>
</tr>
<tr>
<td>Bison</td>
<td>9.68</td>
<td>8.70</td>
<td>9.04</td>
<td>10.70</td>
<td>11.61</td>
</tr>
<tr>
<td>Padlock</td>
<td>8.70</td>
<td>9.49</td>
<td>11.62</td>
<td>10.49</td>
<td>10.47</td>
</tr>
<tr>
<td>Zodiac</td>
<td>8.52</td>
<td>9.18</td>
<td>10.79</td>
<td>10.69</td>
<td>11.00</td>
</tr>
<tr>
<td>Dowry</td>
<td>8.41</td>
<td>9.65</td>
<td>11.06</td>
<td>10.11</td>
<td>11.17</td>
</tr>
<tr>
<td>Graphite</td>
<td>7.45</td>
<td>8.99</td>
<td>10.05</td>
<td>10.08</td>
<td>10.26</td>
</tr>
<tr>
<td>Yeoman</td>
<td>7.20</td>
<td>9.74</td>
<td>9.87</td>
<td>9.68</td>
<td>10.61</td>
</tr>
<tr>
<td>Concave</td>
<td>7.61</td>
<td>8.31</td>
<td>9.04</td>
<td>10.43</td>
<td>10.41</td>
</tr>
<tr>
<td>Kinsman</td>
<td>7.21</td>
<td>8.77</td>
<td>9.12</td>
<td>8.42</td>
<td>10.26</td>
</tr>
<tr>
<td>Ion</td>
<td>8.11</td>
<td>8.91</td>
<td>9.04</td>
<td>9.25</td>
<td>9.55</td>
</tr>
<tr>
<td>Questient</td>
<td>6.45</td>
<td>8.48</td>
<td>9.65</td>
<td>8.41</td>
<td>9.23</td>
</tr>
<tr>
<td>Farthing</td>
<td>6.10</td>
<td>8.30</td>
<td>9.81</td>
<td>9.96</td>
<td>9.96</td>
</tr>
<tr>
<td>Schism</td>
<td>5.76</td>
<td>8.85</td>
<td>8.97</td>
<td>8.31</td>
<td>9.54</td>
</tr>
<tr>
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<td>7.94</td>
<td>7.96</td>
<td>7.96</td>
<td>8.56</td>
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<td>7.84</td>
<td>7.04</td>
<td>7.24</td>
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<td>Burgher</td>
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<td>7.95</td>
<td>7.52</td>
<td>7.12</td>
<td>8.62</td>
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<td>Baitment</td>
<td>3.63</td>
<td>7.70</td>
<td>7.25</td>
<td>8.01</td>
<td>7.46</td>
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<td>Legume</td>
<td>5.90</td>
<td>7.15</td>
<td>7.97</td>
<td>8.17</td>
<td>7.01</td>
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<td>Malad</td>
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<td>7.74</td>
<td>8.88</td>
<td>7.22</td>
</tr>
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<td>Mean m</td>
<td>6.49</td>
<td>8.38</td>
<td>8.92</td>
<td>9.02</td>
<td>9.48</td>
</tr>
<tr>
<td>Thorndike-Lorge L Frequencies</td>
<td>1-4</td>
<td>3-40</td>
<td>100-200</td>
<td>399-750</td>
<td>1,000-2000</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>-----</td>
<td>------</td>
<td>---------</td>
<td>--------</td>
<td>------------</td>
</tr>
<tr>
<td>Toga</td>
<td>8.55</td>
<td>8.83</td>
<td>9.02</td>
<td>8.95</td>
<td>9.16</td>
</tr>
<tr>
<td>Bison</td>
<td>8.40</td>
<td>8.97</td>
<td>9.09</td>
<td>8.74</td>
<td>9.15</td>
</tr>
<tr>
<td>Padlock</td>
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<td>8.97</td>
<td>9.02</td>
<td>8.67</td>
<td>9.02</td>
</tr>
<tr>
<td>Zodiac</td>
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<td>7.53</td>
<td>8.28</td>
<td>8.36</td>
<td>8.90</td>
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<td>Dewry</td>
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<td>8.13</td>
<td>8.19</td>
<td>8.89</td>
</tr>
<tr>
<td>Graphite</td>
<td>6.79</td>
<td>7.38</td>
<td>8.00</td>
<td>8.03</td>
<td>8.87</td>
</tr>
<tr>
<td>Yeoman</td>
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<td>7.96</td>
<td>8.03</td>
<td>8.68</td>
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<tr>
<td>Conceal</td>
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<td>7.09</td>
<td>7.88</td>
<td>7.64</td>
<td>8.39</td>
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<tr>
<td>Kinism</td>
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<td>7.02</td>
<td>7.48</td>
<td>7.55</td>
<td>8.18</td>
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<tr>
<td>Ion</td>
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<td>6.97</td>
<td>7.30</td>
<td>7.52</td>
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<td>Quotent</td>
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<td>7.30</td>
<td>7.47</td>
<td>7.98</td>
</tr>
<tr>
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<td>7.82</td>
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<td>6.77</td>
<td>7.67</td>
</tr>
<tr>
<td>Egress</td>
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<td>6.68</td>
<td>6.83</td>
<td>6.71</td>
<td>7.14</td>
</tr>
<tr>
<td>Offshoot</td>
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<td>6.08</td>
<td>6.89</td>
<td>6.63</td>
<td>6.42</td>
</tr>
<tr>
<td>Burgah</td>
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<td>6.38</td>
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</tr>
<tr>
<td>Baintment</td>
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<td>6.29</td>
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<tr>
<td>Legume</td>
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<td>5.69</td>
<td>5.97</td>
</tr>
<tr>
<td>Hyssop</td>
<td>3.51</td>
<td>5.34</td>
<td>5.99</td>
<td>5.69</td>
<td>5.69</td>
</tr>
</tbody>
</table>

Mean m 5.91 6.99 7.25 7.41 7.71

1. Originally there were to be 20 words from each category. Due to a clerical error, Category 100-200, contains 21 words and Category 399-750, contains 19 words.
stimuli had $\text{m}$ values between 7.0-7.9, in a second list the stimuli had $\text{m}$ values between 8.0-8.9, and in the third lists the stimuli had $\text{m}$ values between 9.0-9.9. (Saltz used $\text{m}$ values between 6.0-6.9, 7.0-7.9, and 8.0-8.9). In each of the three lists, two stimuli came from each of the five T-L frequency categories. Thus, $\text{m}$ was a between-list variable, with the 10 stimuli in a list from a single level of $\text{m}$ value, and T-L frequency was a within-list variable with two stimuli from each of the five T-L categories.

Experiment II employed four different basic lists. The stimuli for each list were from the same T-L frequency category, the four categories involved being 30-40, 100-200, 399-750, and 1,000-2,000. Within each of these lists, three stimuli had $\text{m}$ values of 7.0-7.9, four had $\text{m}$ values of 8.0-8.9, and three had $\text{m}$ values of 9.0-9.9. Here, T-L frequency was a between-list variable, and $\text{m}$ value a within-list variable. The seven basic lists are presented below in Tables 3 and 4. Half of the Ss learned responses designated as low-probability responses while half learned responses of high probability. Probability of response items was obtained by determining which responses occurred most frequently, as compared with responses that occurred infrequently or not at all to stimuli, when Noble's (1952a) procedures were used to determine $\text{m}$ value. A count was made to determine which responses occurred the largest percentage of time to each of the stimulus items to be used in the lists. An
Table 3
The Three Basic Lists for Experiment I for the High Probability Group

<table>
<thead>
<tr>
<th>CONCAVE -GLASS</th>
<th>ZODIAC -ASTROLOGY</th>
<th>TOGA -DRESS</th>
</tr>
</thead>
<tbody>
<tr>
<td>KINSMAN -FRIEND</td>
<td>PADLOCK -COMBINATION</td>
<td>BISON -EXTINCT</td>
</tr>
<tr>
<td>CHAOS -TURMOIL</td>
<td>SEEDLING -YOUNG</td>
<td>ARMOR -METAL</td>
</tr>
<tr>
<td>MALICE -HURT</td>
<td>FILTER -CHARCOAL</td>
<td>GROCER -STORE</td>
</tr>
<tr>
<td>CLIENT -PATIENT</td>
<td>WISDOM -AGE</td>
<td>TOWEL -WIPE</td>
</tr>
<tr>
<td>FUNCTION -PURPOSE</td>
<td>PORTER -HOTEL</td>
<td>MEASURE -WEIGHT</td>
</tr>
<tr>
<td>DOZEN -DIRTY</td>
<td>STATION -RAILROAD</td>
<td>LABOR -PAIN</td>
</tr>
<tr>
<td>AFFAIR -SEX</td>
<td>QUARTER -DOLLAR</td>
<td>MACHINE -AUTOMATIC</td>
</tr>
<tr>
<td>MATTER -ATOM</td>
<td>ORDER -COMMAND</td>
<td>HUSBAND -MARRIAGE</td>
</tr>
<tr>
<td>PROMISE -SECRET</td>
<td>PROBLEM -TROUBLE</td>
<td>OFFICE -DESK</td>
</tr>
</tbody>
</table>
Table 4

The Four Basic Lists for Experiment II
for the High-Probability Group

| GROCER     | STORE | TOWEL | WIPE  |
| LAUNDER    | WASHER| MEASURE| RULER |
| ARMOR      | METAL | POISON | MURDER |
| FILTER     | CHARCOAL | PORTER | HOTEL |
| SEEDLING   | YOUNG | WISDOM | AGE  |
| LIVER      | BACON | RACKET | BALL |
| RECESS     | BREAK | EVIL   | SIN  |
| SHILLING   | POUND | FUNCTION | PURPOSE |
| CHAOS      | TURMOIL | GLORY | FLAG |
| MALICE     | HURT | RESPONSE | REACTION |
| LABOR      | PAIN | HUSBAND | MARRIAGE |
| MACHINE    | AUTOMATIC | OFFICE | DESK |
| KNOWLEDGE  | SMART | STORY | TALE |
| STATION    | RAILROAD | ORDER | COMMAND |
| QUARTER    | DOLLAR | PROBLEM | TROUBLE |
| ISSUE      | GIVE | QUESTION | TEST |
| DISTANCE   | TRAVEL | JOURNAL | DIARY |
| AFFAIR     | SEX | REPLY | LETTER |
| DOZEN      | DIRTY | PROMISE | SECRET |
| MISTAKE    | CORRECT | MATTER | ATOM |
item which occurred with a high frequency (22-52% of the
time) and which did not occur as a response to another
stimulus item in the list was used as the response member
of the pair for the H-group.

In the L-group, a set of high-frequency words from
the Thorndike-Lorge word list was chosen to function as re-
sponses. Thus, pairs that consisted of stimuli and
responses which were weakly associated with each other were
established. Table 5 below presents the list of responses
that were used. The responses were paired with the stimuli
in the same order that they are presented in Tables 3, 4 and
5. For example, the first word in each list in Table 3 was
paired with the first word in Table 5 so that the stimulus
CONCAVE was paired with the response COUNTRY, and the
stimulus ZODIAC was also paired with COUNTRY for a differ-
ent group of Ss. Thus, L-group lists represent a replica-
tion of Saltz's experiments, and H-group lists were an
extension of his research.

Subjects

Introductory psychology students at the University
of New Hampshire served as Ss. There were 90 females and 50
males, making a total of 140 Ss in the two experiments. In
Experiment I, 41 females and 19 males were run, for a total
of 60 Ss. In Experiment II, 49 females and 31 males were
run, making a total of 80 Ss. No attempt was made to con-
trol for sex differences. Ss were randomly assigned to the
different conditions of the experiments prior to being run.
Table 5

The Ten Responses Used for the Low Probability Group

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>COUNTRY</td>
</tr>
<tr>
<td>2.</td>
<td>FLOOD</td>
</tr>
<tr>
<td>3.</td>
<td>PREVAIL</td>
</tr>
<tr>
<td>4.</td>
<td>TRICK</td>
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<td>5.</td>
<td>DINNER</td>
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<td>6.</td>
<td>GRAMMAR</td>
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<td>7.</td>
<td>RETURN</td>
</tr>
<tr>
<td>8.</td>
<td>SOLID</td>
</tr>
<tr>
<td>9.</td>
<td>MEMORY</td>
</tr>
<tr>
<td>10.</td>
<td>WAGON</td>
</tr>
</tbody>
</table>
Procedure

The general procedure was the same for the two experiments. All Ss were first presented a paired associate practice learning task to learn to a criterion of two successive errorless trials or for 15 trials, whichever was briefer. The instructions that were given to Ss are presented in Appendix 2. The practice list stimuli consisted of five paralogs taken from Noble's list (1952a) and the responses were five-digit numbers. This list was presented in five different orders randomly chosen so that no pairs appeared more than once in adjacent positions. The practice list is presented in Table 14 in Appendix 3. Its function was to acquaint the S with the general procedure of PAL, thus making Ss more homogeneous on this variable on the experimental task.

On the main task, Ss were instructed that they were to learn a list consisting of pairs of words which were to be presented in different orders. The specific instructions are presented in Appendix 2. The lists were presented in the usual paired-associate manner. Half the Ss learned lists which consisted of pairs in which each response had a high probability of occurrence to its stimulus (H-group). The other half of the Ss learned lists which consisted of pairs in which each response had a low probability of occurrence to its stimulus (L-group).

Lists were presented on a Glorick memory drum with a
one-and-a-half second anticipation period in which the stimulus alone was presented, followed by a two-second period in which the stimulus and response were presented simultaneously. The drum took one-and-a-half seconds to advance to the next stimulus item. The intertrial interval was five seconds. The lists were printed in elite type in capitals on tapes of 80 lb. fotolith paper. Each list was presented in five different orders. The orders were chosen randomly, with the restriction that pairs not appear in adjacent positions more than once. The same orders were used for all lists and the starting order was the same for all lists.

Each S learned the experimental list to two errorless trials or 20 presentations, whichever was briefer. Upon completion of the study, Ss were thanked for their cooperation and asked not to discuss the experiment with their classmates.

In summary, in Experiment I, m value of the stimuli was manipulated between lists, while T-L frequency of stimuli was held constant across lists but was manipulated within lists. Half the Ss (H-group) learned lists consisting of pairs of words in which each response had a high probability of occurrence to its stimulus. The other half of the Ss (L-group) learned lists consisting of the same set of stimuli but different responses, each of which had a low probability of occurrence to its stimulus.

In Experiment II, T-L frequency was manipulated between lists while m value of the stimuli was held constant
across lists but was manipulated within lists. Two groups (H and L groups) were again differentiated as above.
CHAPTER III

RESULTS

Each of the two experiments was analyzed separately as a repeated measurements design. In Experiment I, \( m \) value was a between-groups variable and T-L frequency was a within-groups variable. In Experiment II, \( m \) value was a within-groups variable and T-L frequency was a between-groups variable. In addition, trend analyses were carried out on the data. In both experiments, the dependent variable was the mean number of errors per item made by each S in learning his list to criterion.

The major results will be presented first by interpreting the trends indicated by the curves of Figure 1 and Figure 2, pp. 38 and 39. Statistical support for these inferences will then be presented.

The most obvious result of the study was that response probability produced an effect. As both Figure 1 and Figure 2 indicate, under the condition of high response probability there were consistently fewer errors made than under the condition of low response probability.

Inspection of the curves of Figure 1 reveals that as \( m \) value increases and T-L frequency is held constant, errors decrease under conditions of both high and low response probability (P). In addition, under the condition of low P,
Fig. 1. Mean number of errors per item per subject as a function of μ value and response probability.
Fig. 2. Mean number of errors per item per subject as a function of T-L frequency and response probability.
errors decrease more rapidly than is the case under the condition of high P.

Inspection of the curves of Figure 2 reveals that as T-L frequency increases and m value is held constant, errors increase under both high and low P. In addition, it may be seen that under the condition of low P, errors increase more rapidly than is the case under the condition of high P.

In Experiment I, a 2 x 3 x 5 factorial repeated measures design was used, with two levels of P; three levels of m value; and five levels of T-L frequency, which was the repeated measurement.

The main analysis yielded significant $F$'s ($p<.01$) for the effects of P, T-L and the P x T-L interaction. Table 6, p. 41, presents a summary of the analysis of variance for Experiment I.

The significant $F$ for P indicates that P produced an effect. Thus, varying response probability level from low to high decreased errors. High response probability resulted in superior learning, compared with low response probability.

The significant $F$ for T-L indicates that the performance was not the same at all levels of T-L frequency. However, the significant $F$ for the P x T-L interaction shows that the effect of T-L was not independent of the level of P.

With relation to the hypotheses of the study, the
Table 6

Analysis of Variance of the Mean Errors Per Item for Experiment I

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>MS</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Between</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( m ) value (( m ))</td>
<td>2</td>
<td>11.42</td>
<td>.61</td>
</tr>
<tr>
<td>Response probability level (( P ))</td>
<td>1</td>
<td>875.52</td>
<td>46.67**</td>
</tr>
<tr>
<td>( m \times P )</td>
<td>2</td>
<td>2.98</td>
<td>.16</td>
</tr>
<tr>
<td>Error (( b ))</td>
<td>54</td>
<td>18.76</td>
<td></td>
</tr>
<tr>
<td><strong>Within</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thorndike-Lorge Frequency (T-L)</td>
<td>4</td>
<td>53.89</td>
<td>15.05**</td>
</tr>
<tr>
<td>( m \times T-L )</td>
<td>8</td>
<td>10.39</td>
<td>2.90**</td>
</tr>
<tr>
<td>( P \times T-L )</td>
<td>4</td>
<td>25.42</td>
<td>7.10**</td>
</tr>
<tr>
<td>( m \times P \times T-L )</td>
<td>8</td>
<td>4.25</td>
<td>1.19</td>
</tr>
<tr>
<td>Error (( w ))</td>
<td>216</td>
<td>3.58</td>
<td></td>
</tr>
</tbody>
</table>

**P<.01**
following conclusions may be drawn. Hypothesis I, which was that performance would be superior when P level was high, was supported. The findings that T-L produced an effect, and also that it was not independent of P level, are consistent with Hypotheses IIa and IIb which stated that in PAL involving S-R pairs in which each response has high P, errors will decrease as T-L frequency of stimuli increases and m value is held constant, whereas with low P, errors will increase. However, such an analysis of the data is not sufficient by itself to support the specific predictions which were made, and the results of further analyses that were carried out are presented below.

In Experiment II, a $2 \times 4 \times 3$ factorial repeated measures design was used, with two levels of P; four levels of T-L; and three levels of m value, which was the repeated measurement.

The main analysis, summarized in Table 7, p. 43, yielded significant $F$s ($p < .01$) for the effects of P, m and the $m \times P$ interaction.

The significant $F$ for P, as in Experiment I, indicates that varying response probability level from low to high resulted in fewer errors. Again, high P resulted in superior learning, compared with low response probability.

The significant $F$ for m indicates that performance was not the same at all levels of m value, and the significant $F$ for the $m \times P$ interaction shows that the effect of m value was not independent of P level.
### Table 7

#### Analysis of Variance of the Mean Errors Per Item for Experiment II

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>MS</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Between</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thorndike-Lorge Frequency (T-L)</td>
<td>3</td>
<td>59.19</td>
<td>2.71</td>
</tr>
<tr>
<td>Response probability level (P)</td>
<td>1</td>
<td>1550.47</td>
<td>70.96**</td>
</tr>
<tr>
<td>T-L x P</td>
<td>3</td>
<td>20.32</td>
<td>.93</td>
</tr>
<tr>
<td>Error (b)</td>
<td>72</td>
<td>21.85</td>
<td></td>
</tr>
<tr>
<td><strong>Within</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>m value (m)</td>
<td>2</td>
<td>81.82</td>
<td>38.78**</td>
</tr>
<tr>
<td>m x T-L</td>
<td>6</td>
<td>23.07</td>
<td>10.93**</td>
</tr>
<tr>
<td>m x P</td>
<td>2</td>
<td>39.37</td>
<td>18.66**</td>
</tr>
<tr>
<td>m x T-L x P</td>
<td>6</td>
<td>7.02</td>
<td>3.33*</td>
</tr>
<tr>
<td>Error (w)</td>
<td>144</td>
<td>2.11</td>
<td></td>
</tr>
</tbody>
</table>

**p < .01

*p < .05
With regard to the hypotheses of the study, the following conclusions may be drawn from this analysis of the results of Experiment II. Hypothesis I was again supported, as in Experiment I, since performance was superior when P level was high.

The findings that \( m \) produced an effect, and that the effect of the \( m \times P \) interaction was significant are consistent with Hypotheses IIIa and IIIb, which state that in PAL involving S-R pairs in which each response has high P, errors will increase as \( m \) value of stimuli increases and T-L is held constant, whereas with low P, errors will decrease.

Since the above analyses did not permit full evaluation of the predictions made in Hypotheses II and III, in which opposite trends were predicted with increases in \( m \) and T-L frequency under conditions of high as contrasted with low P, trend analyses were carried out on the data.

The trend analyses were done in two parts. In the first, \( L \) (slope) scores were analyzed to determine trends in the within-groups data. As shown in Table 8, p.45, in Experiment I both the \( F \) for the mean and the \( F \) for \( P \) were significant (\( p<.01 \) and \( p<.05 \), respectively). In addition, analyses of the \( L \) scores carried out separately at each of the two levels of \( P \) yielded significant \( F \)s (\( p<.01 \)) for the mean. (See Tables 10 and 11, p.46).

From these analyses, it may be concluded that the best fit straight line through the different levels of T-L
### Table 8

Trend Analysis Using Slope (L) Scores for the T-L x P Interaction in Experiment I (Within data)

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>MS</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>1</td>
<td>1904.07</td>
<td>40.43*</td>
</tr>
<tr>
<td>P</td>
<td>1</td>
<td>960.60</td>
<td>20.39*</td>
</tr>
<tr>
<td>Error</td>
<td>58</td>
<td>47.10</td>
<td></td>
</tr>
</tbody>
</table>

**p<.01
*p<.05

### Table 9

Trend Analysis Using Slope (L) Scores for the m x P Interaction in Experiment II (Within data)

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>MS</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>1</td>
<td>321.12</td>
<td>39.35**</td>
</tr>
<tr>
<td>P</td>
<td>1</td>
<td>154.01</td>
<td>18.87**</td>
</tr>
<tr>
<td>Error</td>
<td>78</td>
<td>8.16</td>
<td></td>
</tr>
</tbody>
</table>

**p<.01
Table 10

Trend Analysis Using Slope (L) Scores for T-L at High P in Experiment I (Within data)

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>MS</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>1</td>
<td>80.03</td>
<td>10.42**</td>
</tr>
<tr>
<td>m</td>
<td>2</td>
<td>3.11</td>
<td></td>
</tr>
<tr>
<td>Error</td>
<td>27</td>
<td>7.68</td>
<td></td>
</tr>
</tbody>
</table>

**p<.01

Table 11

Trend Analysis Using Slope (L) Scores for T-L at low P in Experiment I (Within data)

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>MS</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>1</td>
<td>2784.03</td>
<td>31.30**</td>
</tr>
<tr>
<td>m</td>
<td>2</td>
<td>58.66</td>
<td></td>
</tr>
<tr>
<td>Error</td>
<td>27</td>
<td>88.93</td>
<td></td>
</tr>
</tbody>
</table>

**p<.01
averaged across the levels of P is not horizontal, i.e., that the slope of this line is not zero. Further, the analysis shown in Table 9 indicates that the curve through different levels of T-L under low P ascends more rapidly than the analogous curve under high P. However, the significant Fs obtained in the analyses shown in Tables 10 and 11 indicate that at both levels of P errors increase as T-L frequency increases. (The data analyzed here are the within-groups data presented in Figure 2).

As shown in Table 9, p. 45, in Experiment II, the Fs for the mean and P are both significant ($p < .01$). In addition, analysis of the L scores carried out separately at each of the two levels of P yielded significant Fs ($p < .01$) for the mean. (See Tables 12 and 13, p. 48).

From these analyses, it may be concluded that the best fit straight line through the different levels of $m$ averaged across the levels of P is not horizontal, i.e., that the slope of this line is not zero. Further, the analysis shown in Table 9 indicates that the curve through different levels of $m$ under low P decreases more rapidly than the analogous curve under high P. However, the significant Fs obtained in the analyses shown in Tables 12 and 13 indicate that at both levels of P errors decrease as $m$ value increases. (The data analyzed here are the within-groups data presented in Figure 1.)

In the second part, similar trend analyses of the linear components were carried out on the between-groups
### Table 12

**Trend Analysis Using Slope (L) Scores for m at High P in Experiment II (Within data)**

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>MS</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>1</td>
<td>15.18</td>
<td>7.48**</td>
</tr>
<tr>
<td>T-L</td>
<td>3</td>
<td>6.67</td>
<td>3.29*</td>
</tr>
<tr>
<td>Error</td>
<td>36</td>
<td>2.03</td>
<td></td>
</tr>
</tbody>
</table>

**P < .01

* P < .05

### Table 13

**Trend Analysis Using Slope (L) Scores for m at Low P in Experiment II (Within data)**

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>MS</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>1</td>
<td>459.96</td>
<td>45.77**</td>
</tr>
<tr>
<td>T-L</td>
<td>3</td>
<td>60.74</td>
<td>6.04**</td>
</tr>
<tr>
<td>Error</td>
<td>36</td>
<td>10.05</td>
<td></td>
</tr>
</tbody>
</table>

**P < .01

P < .01
data. These failed to yield any significant Fs.

With regard to the hypotheses, the trend analyses of the L scores lend no support to Hypotheses IIa or IIIa. That is, it was predicted that under the high P condition, errors would decrease as T-L frequency was increased and m was held constant, and that under the high P condition errors would increase as m was increased and T-L was held constant. Such results were not obtained. However, the trend analyses of the L scores do support Hypotheses IIb and IIIb. That is, with m value held constant, errors increased as T-L frequency was increased under the low P condition, and, under the low P condition, with T-L frequency held constant, errors decreased as m was increased. Thus, these findings support Saltz's (1967) findings (for low P) and bear out Hypotheses IIb and IIIb.

The analysis shown in Table 6 reveals that in Experiment I a significant F ($p<.01$) was obtained for the m x T-L interaction. In Table 7, it is seen that a significant F ($p<.01$) was obtained in Experiment II for the m x T-L interaction. Also, as Table 7 indicates, in Experiment II, a significant F ($p<.05$) resulted for the m x T-L x P interaction. The significant m x T-L interaction in both Experiments indicates that the effect of m is not the same at all levels of T-L, and vice versa. Thus, it may be concluded that m and T-L do not operate independently of each other.

The significant F for the m x T-L x P interaction
indicates that the two-way interactions are not independent of the levels of the third variable involved.

In summarization, the statistical analyses lead to the following conclusions. Hypothesis I was supported in both Experiment I and Experiment II. That is, in PAL, fewer errors will be made when the S-R associations consist of pairs in which each response has a high probability of occurrence to its stimulus.

The results of the analyses of the within data indicate support for Saltz's (1967) original findings by confirming his results for low probability responses. However, the results do not support Hypotheses IIa and IIIa, which follow from Saltz's theorizing. While the slopes of the curves for $m$ are different at different levels of $P$, as are the slopes of the curves for T-L frequency, the direction of these slopes is not as predicted. That is, even under conditions of high $P$, errors increased as T-L frequency was increased and $m$ was held constant, and errors decreased as $m$ was increased and T-L was held constant. However, the rates of increase and decrease, respectively, were higher under the low $P$ condition than under the high $P$ condition. Therefore, it is necessary to re-examine Saltz's interpretation of the manner in which $m$ value and T-L frequency operate. Such an examination follows in the Discussion section.
CHAPTER IV

DISCUSSION

The findings of the present investigation can be divided into four major parts: the effects of manipulating response probability level; the effects produced by manipulating m and T-L frequency as separate factors under low response probability; the effects produced by manipulating m value and T-L frequency as separate factors under high response probability; and interaction effects.

Before considering the meaning of these results, a recapitulation of the relevant theoretical positions will be presented. Postman (1962) has assumed that T-L frequency and m value are comparable measures. When stimulus items of low, medium, and high T-L frequency were found to produce a nonmonotonic function in PAL, he invoked the interference paradox of associative probability as an explanation. This explanation assumes that in a learning experiment involving stimuli from a subject's own repertoire or language, pre-experimental associations elicited by such stimuli can serve as sources of both facilitation and interference in learning new responses, and that the effect produced is a function of the number of associations (m value). To the extent that the prescribed associations conform to the subject's own repertoire, facilitation will occur. However, as new associations
depart from old associations, interference will also de-
velop. Both facilitation and interference may be expected
to increase as meaningfulness of the stimuli increases.
The larger the number of different associations a word has,
the more easily it can be linked with other items either
directly or through short mediational chains. Simultaneous-
ly, however, the amount of interference during acquisition
and recall may be expected to increase with an increasing
number of pre-experimental associations, which will compete
with the prescribed associations.

Saltz (1967), on the other hand, has maintained that
meaningfulness and familiarity, when operationally defined
as m value and T-L frequency, respectively, operate as
separate factors. Noble, too, considers familiarity to be
independent of meaningfulness stating..."(t)he meaningful is
always familiar, but the familiar is not always meaningful"
words may be found to have high T-L frequency. However,
there are words such as but which may have a high T-L fre-
quency rating but not be very meaningful and obtain low
association ratings \(m\).

In investigating the stimulus side of PAL, Saltz
(1967) invoked a proactive interference explanation for the
differential effects of m value and T-L frequency. He
assumed that with increasing T-L frequency (increasing
familiarity), greater proactive interference should occur
and lead to poorer learning when subjects are required to
learn new associations. This is because in learning new
associations it is necessary to overcome stronger old associations as T-L frequency increases. However, with increasing meaningfulness as measured by \( m \) value, decreased proactive interference should occur. At low \( m \), the associative strength is assumed to be greater for individual pairs on the average because there are fewer pairs, compared to the high \( m \) situation. For example, if a stimulus has two associations, the frequency of occurrence of association is divided between these two pairs. But with the same T-L frequency at high \( m \) it may be divided by as many as nine pairs. Hence, on the average, the associative strength of any one pair under high \( m \) is lower than under low \( m \) conditions. At low \( m \) it follows that the individual S-R pairs have stronger associations that are harder to break to learn new pairs than at high \( m \), where the individual pairs are weaker and easier to overcome to learn new pairs. This is consistent with Underwood’s (1945) finding that learning a new response to a stimulus was harder when a single response had been strongly associated with it than when several responses had been weakly associated with the stimulus.

Saltz’s results were consistent with this formulation, since they indicated that as \( m \) value was increased and T-L frequency held constant for stimuli, new learning improved. When T-L frequency was increased and \( m \) value held constant for stimuli, opposite results were obtained. For Saltz, then, the crucial factor in producing interference effects in new learning was not the number of previous asso-
ociations to a stimulus, but the associative strength of existing associations, which was assumed to increase as the number of associations decreased, with the frequency of occurrence of the stimulus held constant.

The present study tested Saltz's interpretations of the differential effects of m and T-L frequency by investigating PAL in which the responses were of high probability, i.e., part of a subject's own S-R system. It was hypothesized that, in learning pairs of high response probability, proactive facilitation should occur as T-L frequency of stimuli increased and m was held constant. This prediction was made because the pairs of high T-L frequency (and constant m) are stronger pairs on the average than those of lower T-L frequency. Since these pairs conform to subjects' language habits and consist of relatively strongly associated stimuli and responses to be learned, the more familiar the pairs are in terms of frequency, the more readily they should be reproduced.

Similarly, it was held that when T-L frequency was held constant, lower m should result in facilitation because the fewer associations (low m) would be, on the average, stronger as compared with the high m items. It was assumed that the response to be learned would be, in terms of probability, a salient part of each subject's own S-R system. Hence with low m, relatively few responses would have been attached to the stimulus and the high probability responses to be learned should, therefore, be easier to learn than in
the case of high $m$, because the associations, assumed to be part of the subject's S-R system, should be stronger on the average under low $m$. The hypotheses presented below follow from the above rationale:

Hypothesis I: In a paired-associate learning task, fewer errors will be made when the S-R associations consist of pairs in which each response has a high probability of occurrence to its stimulus than when each response has a low probability of occurrence to its stimulus.

Hypothesis IIa: In a paired-associate learning task involving S-R pairs in which each response has a high probability of occurrence to its stimulus, errors will decrease as T-L frequency of stimuli increases and $m$ value of stimuli is held constant.

Hypothesis IIb: In a paired-associate learning task involving S-R pairs in which each response has a low probability of occurrence to its stimulus, errors will increase as T-L frequency of stimuli increases and $m$ value of stimuli is held constant.

Hypothesis IIIa: In a paired-associate learning task involving S-R pairs in which each response has a high probability of occurrence to its stimulus, errors will increase as $m$ value of stimuli increases and T-L frequency of stimuli is held constant.

Hypothesis IIIb: In a paired-associate learning task involving S-R pairs in which each response has a low probability of occurrence to its stimulus, errors will
decrease as $m$ value of stimuli increases and T-L frequency is held constant.

Data in support of Hypotheses IIa, IIb, IIIa and IIIb would lend further support to Saltz's interference explanation of the differential effects of increased $m$ and T-L frequency on new (i.e., low-probability response) learning. It was evident that data in support of Hypotheses IIIa would cast doubt on the validity of the mediational interpretation of the role of increased $m$, since it would be difficult to explain why increased availability of mediating responses should lead to poorer learning.

Initially, pilot work was conducted in which subjects were asked to produce their own responses to stimuli in order to obtain high-probability responses. A week later they were asked to "learn" lists consisting of these pairs. This procedure had to be abandoned because it was found that performance was, in most cases, errorless. Subjects did not have to "learn" anything because these associations were too predominant. Even though subjects had to produce what was presumably one of many associations, there did not seem to be any interference effects. Thus, assuming the produced response to be one of the most dominant and highest in a hierarchy of responses, once verbalized, the items continued to be readily reproduced. It was decided, therefore, to abandon such a procedure for obtaining a set of highly associated responses to the stimuli.
Instead, in order to obtain high-probability responses, it was decided to use group norms based on the data obtained using Noble's (1952a) procedures. Associations to the stimuli were tabulated and the percentage of frequency of association was determined for each item. Because it was assumed that responses with a very high probability of occurrence would result in association so strong that little learning would be necessary, medium probability levels were employed. Such a decision was based not only on the results of the pilot work but also on related research. For example, Postman (1962) reported that when subjects produce their own responses to stimuli for PAL, there are relatively few errors in learning such pairs as compared to traditionally created pairs. In addition, intralist intrusions at recall rarely occurred. Abra (1966) reported comparable results in a similar experiment using the method of generated responses. It is apparent that in lists consisting of very strongly associated stimuli and responses there is good differentiation among pairs and learning is rapid.

Thus, although two sets of responses were employed and one was of higher probability than the other, it would technically be more precise to label these latter responses "medium probability", since in a 0-100% range the responses fall into the middle portion. The necessity for providing
subjects with an opportunity to make errors in order to detect the effects of increased m and T-L frequency led to the selection of this probability level.

Two experiments were run in the present investigation. In Experiment I, m value for stimuli was a between-groups variable and T-L frequency was a within-groups variable. In Experiment II this relationship was reversed. After a practice PAL task, subjects learned a list of 10 pairs of words to a criterion of two errorless trials or to 20 trials, whichever was briefer. The dependent variable was the mean number of errors made per item.

Response probability produced an effect in both Experiments I and II. Under the condition of high P, there were consistently fewer errors made than under low P in the two experiments. Thus, Hypothesis I was supported: performance was superior when response probability was high.

The trend analyses of the L scores which were done on the within-groups data support Hypotheses IIb and IIIb. That is, with m value held constant, errors increased as T-L frequency was increased under the low P condition. And, under the low P condition, with T-L frequency held constant, errors decreased as m value was increased. That is, with meaningfulness held constant, as familiarity of stimuli increased, performance became poorer, but with familiarity held constant, as meaningfulness of stimuli increased per-
formance improved. Hence, the relevant part of the present investigation yielded data that are consistent with those of Saltz (1967).

Hypotheses IIa and IIIa, which are relevant to the high P condition were not supported. In Experiment I, it was found that T-L produced an effect not independent of P level, and in Experiment II m produced an effect not independent of P level. However, trend analyses revealed that contrary to what was predicted, under conditions of high P, errors increased as T-L frequency increased and m was held constant. And, errors decreased as m was increased with T-L held constant. That is, similar effects of variations in m and T-L were obtained under high P and low P, although opposite predictions had been made for the former condition.

However, while Hypotheses IIa and IIIa were not borne out, trend analyses of the within-groups data demonstrated that the rates of increase and decrease in errors produced by increased T-L and m, respectively, were lower under the high P condition. That is, while increased m still led to fewer errors, and increased T-L to more errors, the effects were clearly attenuated when the responses to be learned were responses that had a high degree of probability of occurrence to their particular stimulus.

The significance of these major findings will now be discussed. It is not surprising that response probability produced an effect in both Experiments I and II. The acquisition of a paired-associate list can be divided into
two stages, according to Underwood and Schulz (1960a). These stages are the response-learning or response-recall stage, and the associative or hook-up stage. In the former stage, subjects must learn what the responses are and how to reproduce them. In the present experiment it was assumed that the responses to be learned were already part of the subjects' language repertoire and did not differ in this respect under the low versus high probability conditions. On the other hand, prior to actual presentation of the list to be learned, responses of high P had associative strength with their stimuli which was assumed to be higher than the comparable associative strength under the low P condition. Because an association was already established between the stimuli and responses under high P, at least some of the second-stage learning was completed. The following illustration may be given. Assume that a situation exists in which there is a stimulus toga which has an m of three; Roman, clothes and dress. Thus, in an subject's S-R system the following pairs are available; toga-Roman, toga-clothes and toga-dress. In the low P condition, the subject is required to learn toga-stone. It is assumed that in order to do this, he must overcome the interference caused by the habits that already exist in his language system, namely, toga-Roman, toga-clothes and toga-dress. In addition, he must build up associative strength between the stimulus and required response. In learning this pair (toga-stone) he
makes several errors due to interference from strong previous associations. Under the high P condition, he is required to learn toga-dress. While toga-dress is part of his S-R system and has considerable associative strength, the subject must still overcome interference from those pairs which are of higher probability, such as toga-Roman and toga-clothes. (Remember the high P condition consisted of responses of medium probability.) However, as compared with the low P condition, this is relatively easy to do because the response he must produce has considerable associative strength with the stimulus. Hence, fewer errors are made.

In the low P condition, the associative strength is minimal, whereas it is stronger in the high P condition. Thus, under high P interference still occurs, as it does under low P, so that some learning is necessary, but since the responses in high P are readily available the amount of competition is relatively small, leading to more rapid learning in high P. This remains consistent with Postman's (1962) finding that facilitation occurs as there is greater conformity to the subject's existing language habits. However, not only is there facilitation, as seen in the more rapid learning under high P, but there is also interference, as indicated by the errors made. As the results of the pilot work indicated, if responses of very high P were used to eliminate interference, so few errors would occur that differential effects between g and T-L frequency would be
Learning has been shown to be relatively rapid under similar conditions in which there is an established association between the stimuli and responses (Key, 1926; Underwood & Schulz, 1960b). Hence, support of Hypothesis I lends further confirmation to this interpretation.

As noted, support was obtained for Hypotheses IIb and IIIb which is essentially a confirmation of Saltz's earlier work. However, results opposite to those predicted were obtained for Hypotheses IIA and IIIa. In other words, under high P condition, m and T-L frequency operated in a similar manner as under the low P condition. The main difference was that the effects of increased m and T-L were not as great under high P as under the low P condition. The significance of this finding will now be explored.

To recapitulate briefly, the results of this investigation indicate that when a subject is given new associations to learn in a PAL task, increased stimulus m leads to faster learning and increased stimulus T-L frequency leads to slower learning. This relationship holds both for pairs with responses that have a low probability of occurrence to their appropriate stimulus and for pairs with responses that have a high probability of occurrence to their stimulus. However, in the case of pairs with high-probability responses, the effects of increased m and T-L frequency are attenuated. That is, while increased m still produces faster learning with high-probability responses,
the advantage of high \( m \) over low \( m \) is smaller than is the case with low-probability responses. Similarly, while increased T-L frequency leads to poorer learning with high-probability responses, the advantage of low T-L over high T-L is smaller than that obtained with low-probability responses.

Before turning to an interpretation of these results, a comment on the earlier pilot work is in order. It will be recalled that the original attempt was to have each subject produce the responses to be learned at a later time, thus providing a set of responses of maximum probability of occurrence to their stimuli for the high-probability condition. From the interference theory position taken by Saltz, predictions IIa and IIIa would be most firm for responses of very high probability from the subject's own S-R system. However, this approach had to be abandoned because learning was so rapid that no difference in the effects of the manipulated variables could be detected. The new approach, based upon group norms, necessitated a lower level of response probability for the "high" response probability condition, in order that errors could occur. But by reducing the level of response probability, the opportunity was again opened for interference from responses in the subject's own S-R system that had even higher levels of probability. Hence, both the high P and the low P conditions constituted new learning for the subjects in which interference from previously established habits could occur. Thus, while Hypotheses IIa and IIIa were theoretically sound, it may be
impossible to demonstrate the effects they predict, since increasing the probability level of the responses to a point where interference from more probable responses in the subject's S-R system does not occur may necessitate that the learning task be so easy that differences in the effects of \( m \) and T-L frequency cannot be detected. However, this remains an empirical question to be answered by future research, and an interpretation of the attenuated effects of increased \( m \) and T-L frequency under the high P condition obtained in the present study will now be offered.

Manipulation of \( m \) value and T-L frequency produced less difference in performance under high P than under low P. This can be accounted for by considering the manner in which two factors balance each other. The factors are the nature of the interference of competing responses and the associative strength of the responses to be learned. Under high P and low \( m \), with T-L frequency held constant, the subject must overcome interference from, for example, two other responses and learn a third. These three responses are on the average stronger associations than, for example, any of the six responses attached to the stimulus under high \( m \). At low \( m \), the subject must learn one response, overcoming the interference of stronger responses with a stronger response, as compared with the high \( m \) condition. Under high \( m \) there may be interference from more responses but the strength of these associations is weaker on the average. In addition, the response to be learned is weak-
er, as compared with the low $m$ condition. Hence the stronger interference under low $m$ is balanced by the stronger association of the response to be learned and the weaker interference under high $m$ is balanced by the weaker association of the response to be learned. The difference in performance is less across $m$ values under high $P$ than under low $P$, because in the low $P$ condition the response to be learned has minimal associative strength with the stimulus and must overcome interference of all the responses from the subject's S-R system, at both low and high $m$. These interfering responses are stronger on the average at low $m$, and hence cause more interference leading to a greater decrement in performance under the low $m$ condition.

A similar analysis may be made with regard to T-L frequency. Under high $P$, with low T-L and $m$ value held constant, the responses causing interference are, on the average, weaker than those under high T-L. The response to be learned is also weaker under low T-L than the comparable response under high T-L. The weaker response at low T-L has to overcome the weaker interference, and the stronger response at high T-L combats the stronger interference. The associative strength of the responses to be learned overcomes the interference in parallel fashion at both high and low T-L, under high $P$. Thus there is less difference in performance from low to high T-L frequency than under low $P$, where the response to be learned in either the low T-L or high T-L condition must overcome
interference of all the responses in the subject's S-R system and the response to be learned is of relatively low associative strength. On the average, the responses in the subject's S-R system are stronger under high T-L and cause more interference leading to more errors. Under high P, such greater interference under high T-L must still be overcome but it is easier because of the greater associative strength between the stimuli and responses to be learned. Hence, a smaller increment in performance is obtained as T-L frequency is increased under the high P condition.

An alternative explanation may be invoked by using mediation theory to explain the attenuated effects of m value under high P. Saltz proposes the possibility that increasing m is facilitative because "...with greater numbers of associates to a stimulus, the possibility increases that Ss will find mediators between the stimulus and its response in the paired-associates list" (Saltz, 1967, p. 477). Perhaps the effect of increased m can be best explained in terms of mediators because it is a measure of association and lends itself directly to such an interpretation. On the other hand, T-L is not dependent on the number of associations and while correlated with m value, this cannot be considered the critical aspect of T-L frequency. As m increased under high P, errors decreased. It can be assumed that the more associations a subject has to a stimulus the greater the possibility of
these being available to use to attach to the required responses. But while more correct responses were made under high P as \( m \) increased, the overall effect was less than under low P. Thus, under high P the different number of mediators available to a subject at different levels of \( m \) would seem less important. It could be assumed that under high P, given a response to learn which has some medium associative strength to the stimulus, the necessity of making use of mediators was lessened. The fact that a particular response already could be directly linked with the given stimulus would seem to make redundant the necessity of using other associations as mediators. Since the responses were of similar associative strength across \( m \) levels, a reduced dependence on the use of mediators would be consistent with the attenuated effects of \( m \). Thus the results of this study do not rule out a mediational interpretation for the attenuated effects of increased \( m \) under the high P condition.

Clearly, the results of the present study, considered in conjunction with the findings of Saltz (1967) throw into question the adequacy of the interference paradox of associative probability first described by Underwood and Schulz (1960a), and propounded by Postman (1964). In the first place, while frequency, as measured by Thorndike-Lorge count, and meaningfulness, as measured by \( \xi \) value, are correlated variables, the experimental evidence indicates that they are not comparable measures. The part
of the present investigation that replicated Saltz's (1967) study bore out his findings, which were that with new learning, (i.e., with low-probability responses) increased stimulus m leads to fewer errors, while increased T-L frequency leads to an increase in errors. The danger in considering these two measures to be comparable is obvious.

Secondly, the part of the present study that broke new ground by investigating the effects of increased stimulus m and T-L frequency in a learning situation where responses have a high probability of occurrence to their stimuli produced results that raise further questions concerning the adequacy of the interference paradox of associative probability as an explanatory device. According to Postman (1964), both facilitation and interference may be expected to increase as the meaningfulness of items in a list increases. Further, he maintained that the extent to which prescribed associations (i.e., responses to be learned) conform to the learner's language habits, facilitation will result, but as the new associations diverge from prior language habits, interference will develop. It would follow from this that as association value, as measured by m, is increased, greater facilitation should occur when the responses to be learned are high-probability responses from the subject's S-R system than when the responses to be learned are low-probability responses which diverge from the subject's prior language habits. The results of the
present investigation indicate precisely the opposite. While increased \( m \) produced fewer errors under both the low P and high P conditions, the effect was attenuated under the high P condition. If, as Postman maintains, facilitation will result to the extent that the prescribed associations conform to the learner's language habits, it seems difficult to understand why increasing the meaningfulness of stimulus items should produce less of a reduction in errors for responses of high probability than for responses of low probability. While, according to Postman, both facilitation and interference may be expected to increase with the meaningfulness of the stimulus items, it would follow that the more the responses to be learned conform to the subject's prior language habits, the greater should be the increase in facilitation as compared to the increase in interference. The phenomena appear more complex than the interference paradox of association probability would indicate.

The significance of the interaction effects will now be considered.

While for low and high P, T-L and \( m \) operated differently, the T-L x \( m \) interaction was significant (see Tables 6 and 7), and it cannot be concluded that these two variables are independent of each other. Saltz likewise found a significant interaction between the two variables, which he wished to attribute to methodological factors, although his data also suggested that such an interaction may
reflect the tendency of high m material to be relatively insensitive to variations in T-L frequency. For example, at low m, relatively small differences in T-L frequency may produce large effects, whereas at high m, the same amount of variation in T-L might produce no detectable effect. This seems to be a reasonable assumption, and, inspection of the present data reveals trends that are consistent with such an interpretation. Noble (1963) has noted that familiarization (f) of stimuli facilitates PAL but that there is an imperfect curvilinear correlation (.83) between f and m. That is, at higher levels of m, f was high also but decreasingly so. Because Noble feels that meaningfulness is produced by frequency plus multiple associations and familiarity produced by frequency alone, it may be that once an item has a large number of associations, it is no longer made more meaningful by additional familiarity.

The m x T-L x P interaction was significant at the .05 level in Experiment II, but was non-significant in Experiment I, indicating that the m x T-L two-way interactions were not the same at the different levels of P in Experiment II. As is the case with all three-way interactions, the experimental meaning of the significant F is difficult to interpret. Since P produced a difference in the magnitude of the effects of both m and T-L frequency and since increases in m and T-L frequency produced opposite effects on rate of learning, it is not surprising to find the inter-
action of \( m \) and T-L to be different at the different levels of \( P \). On the other hand, the absence of a significant \( m \times T-L \times P \) interaction in Experiment I would indicate that the three-way interaction effect may be due to methodological factors peculiar to Experiment II.

There have been relatively few studies which have attempted to deal with EEI. Perhaps one reason is that there is a dearth of literature on group norms of responses to stimuli. Thus, it was necessary to obtain such norms for the present study. When the need for investigating this aspect of behavior becomes more apparent, perhaps these group data will be collected and more readily accessible. While it would have been possible to use Saltz's (1967) \( m \) values no norms for relative frequency of occurrence of responses existed. Hence it was necessary to determine these values. The Kent-Rosanoff list (Russell & Jenkins, 1954) gives 100 common responses to 100 words but these items are all of high frequency, and \( m \) value has not been determined. Mandler (1961), too, points out that the "...hierarchy of associations derived from the Minnesota norms, where single associations were used, is not necessarily the same as the hierarchy of continued associative sampling" (Mandler, 1961, p. 125).

To obtain the frequency of responses, the Thorndike-Lorge word list was used as a reference. There are some difficulties with this list. These data were obtained in the 1940's on large groups of people from a metropolitan
setting. They were used approximately 28 years later with individuals in a university setting. It is difficult to determine whether there is any difference in frequency of usage between these two groups. However, since the words are all fairly frequent, it was decided that this reference would be used in order to replicate as closely as possible Saltz's procedures. Other norms are now available, such as those determined by Howes (1966).

There is always the issue of whether or not group data can or should be used for individual Ss. Because the stimulus values used in Saltz's study were based on group norms, it was felt that it was necessary to continue with this approach. As the T-L values and m values were group norms, it was felt that the actual associations that were used should also be based on group norms in order to be consistent. A second point is that these associations are of a reasonably high probability level. That is, most subjects readily give all of the associations employed in the high P condition to the stimuli used. If responses of lower frequency of occurrence had been used, there might have been difficulty because what is of low probability to one subject might be a non-existent association to other Ss.

In summary, the interpretation of the results obtained under high P (relevant to Hypotheses IIa and IIIa) is consistent with Saltz's theorizing. Namely, under high P as well as under low P the effects of m and T-L frequency can be attributed to proactive interference factors.
It now seems apparent that m and T-L frequency must be considered as separate factors operating differentially. While they are correlated variables, they effect PAL performance differently. It can be predicted that on other verbal learning tasks such as serial learning they will continue to operate differently and therefore should be controlled separately. The interference paradox of associative probability first described by Underwood and Schulz (1960a) and later used by Postman (1964), appears to be an oversimplification in that it equates meaningfulness and frequency and ignores their differential effects.

In conclusion, the results of this study contribute to our understanding of PI in terms of response competition. An explanation for the ambiguous effects of meaningfulness on learning is offered by separating T-L and m as factors operating differentially and further support is given to Saltz's (1967) theoretical interpretation of the differential effects of stimulus m and T-L frequency in paired-associate learning.
CHAPTER V

SUMMARY

The present study investigated a complex issue in paired-associate learning, namely, the operations of stimulus frequency and meaningfulness. Generally, increased stimulus frequency leads to improved performance. On the other hand, Postman (1962) has obtained a nonmonotonic relationship between stimulus frequency and rate of learning. Saltz (1967) held that some of the difficulties lie in conceptualizing meaningfulness (m) and Thorndike-Lorge (T-L) frequency as comparable measures. In studying the differential effects of these two factors, he obtained the following results. With increased stimulus m, performance in new learning improved when T-L was held constant; whereas, with increased stimulus T-L, performance was poorer when m was held constant. Saltz felt that this was due to the greater average associative strength of pre-experimental associations in the case of lower m, so that overcoming proactive interference from pre-experimental associations to learn a new response was more difficult at low m than at high m. Similarly, high T-L indicates stronger average pre-experimental associations, which would be more resistant to interference from new associations than those at low T-L, leading to more errors in new learning.

The present investigation was based upon the follow-
ing rationale. It was predicted that if responses which were strongly attached to the stimuli being presented were used (i.e., responses which were highly probable as pre-experimental associations to those stimuli), some interesting results would be obtained. Under such a condition, learning should be more rapid under low stimulus $m$, since the associative strength of a response that is already part of the learner's repertoire should be greater at low $m$ when $T-L$ is held constant. Further, it was predicted that as stimulus $T-L$ was increased and $m$ held constant with high-probability responses, errors would decrease because at higher levels of $T-L$ the response to be learned, presumed to be part of the learner's repertoire of responses, would be more strongly associated to the stimulus.

The investigation produced the following results. First, it was found that learning was more rapid under conditions in which responses of a high probability of occurrence were learned. This was attributed to facilitation of the associative or hook-up stage of paired-associate learning.

In addition, Saltz's original findings were borne out under the low response-probability condition. That is, as stimulus $m$ level was increased, performance improved when $T-L$ frequency was held constant, and as stimulus $T-L$ frequency was increased, performance was poorer when $m$ value was held constant.

Lastly, the predictions made with regard to the high
response-probability condition were not supported. Rather, results similar to both Saltz's and the current findings under the low-probability condition were obtained. That is, as stimulus g level was increased with T-L frequency held constant, errors decreased. As stimulus T-L frequency was increased with g held constant, errors increased. However, the magnitude of these effects under the high-probability condition were attenuated.

The interpretation was made that the attenuated effects occurred because of a balance of two factors, i.e., the nature of the interference of the competing responses and the associative strength of the response to be learned. Under high response probability, interference from competing responses is greater at low g than at high g. But the response to be learned is also stronger on the average at low g. Hence, the stronger association of the response to be learned is balanced by the stronger interference under low g as compared to high g. A parallel analysis can be made for T-L frequency.

It is concluded that Saltz's reasoning is theoretically sound, and that the hypotheses that were originally set forth for the high response-probability condition logically follow from his position. However, it may not be possible to obtain empirical support for them, because at very high probability levels learning is so rapid that differences between the effects of high and low g and high and low T-L may not be detectable.
The results of this investigation emphasize the necessity for considering the differential manner in which stimulus and T-L frequency function. Saltz's (1967) interpretation, based upon proactive interference resulting from pre-experimental associations, was given further support, and explanations that equate meaningfulness and frequency were called further into question.
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Appendix 1

Instructions to Subjects for Obtaining Noble's m values

Thank you all for coming today. This is part of a research project that deals with language. We are not concerned with interpreting any individual's performance but we would like each of you to do the very best that you can.

What we are doing today is essential to a whole research project. Therefore your co-operation is extremely important and will be greatly appreciated. This task, I realize, is a large one but a great deal depends on getting your responses this afternoon. Please give us the very best effort that you can because your help is crucial to the success of the larger project.

You each have a booklet. Please open it and on the first sheet put your name and the date in the appropriate spot. Does anyone need a pencil?

Now let's read the instructions: "This is a test to see how many words you can think of and write down in a short time. You will be given a key word and you are to write down as many other words which the key word brings to mind as you can. These other words which you write down may be things, places, ideas, events, or whatever you happen to think of when you see the key word.

For example, think of the word KING. Some of the
words or phrases which KING might bring to mind are written below: queen, King Cole, ruler, Sky-King, kingdom, England, imperial and kingfish.

You may use two-word phrases, slang, long words or short words, as long as they are associates of the key words.

No one is expected to fill in all the spaces on a page, but write as many words as you can which each key word calls to mind. If you can think of more words than there are spaces for, continue onto the back of the page. Be sure to think back to the key word after each word you write down because the test is to see how many other words the key word makes you think of. A good way to do this is to repeat each key word over and over to yourself as you write.

Any questions so far? You will have a minute for each word with a short rest period in between. Let's try a couple of practice words. When I give the signal, turn to the key word and write down as many associations as you can. Continue until I say Stop and then wait until I say Next word before going on to the next item. Any questions? Ready, begin...Stop...Next word...Stop.

Any problems or questions?...Remember, be sure to think back to the key word after each word you write down because the test is to see how many other words the key word makes you think of. A good way to do this is to repeat each key word over and over to yourself as you write.

O.K. Let's begin.
Appendix 2

Instructions to Subjects on Learning Task

This is an experiment in learning in which we are trying to find out which of several methods is better. We're not concerned about any individual's performance although we'd like you to do the best that you can.

In the first part of this experiment you will be asked to learn to associate words and numbers. It is very important that you follow the instructions. Should you fail to follow any instructions, be sure to tell me, since the results may be affected.

The list will consist of five pairs of items like the pair on this card. (E gives S the example card). These pairs will be presented in the windows in front of you. When we begin, the word will always appear in the left window alone, while the number is covered by a shutter. (E demonstrates by covering the right-hand item of the card). After a short time, the shutter will lift and reveal the number on the right-hand side. Your task is to associate or connect the number with the word, so that you will be able to say the number while the word is in the left window alone, that is, before the shutter goes up on the right. The order in which the pairs follow each other will not always be the same, so learn these pairs as pairs and not in the particular order in which the pairs follow each other.
When I start the memory drum, we will go through the list once so that you can study the list and try to make associations between the members of the pairs. After we have gone through the five pairs once, three asterisks will appear. They mean that we are starting another trial, in this case, the second trial. When the word appears on the left, you should try to say the number that goes with it aloud before it appears in the right window. We will then go through the list while you try to anticipate the numbers of the pairs before they appear in the right window. Please continue until I stop you.

Always try to anticipate the number just after the word has appeared and before the other shutter opens. Always try to get as many of the pairs correct as you can on each trial. Try to do the best you can on each trial, even though you may have them all correct on some of the preceding trials. If you are having trouble anticipating some of the numbers or are giving some incorrectly, don't let this discourage you or prevent you from doing the best that you can. We have found that most students find this type of learning a little more difficult than they first thought it would be.

Are there any questions? All right let's begin.

In this part of the experiment you will now learn a list which consists of ten pairs of words. The procedure is the same as on the first list that you learned, of pairs of words and numbers. That is, a word will appear in the left window and you will try to give the word that goes
with it before the shutter is raised and the response is
exposed in the right window. Watch the list through one
trial before you start to anticipate the correct items
aloud. Please continue until I stop you.

Any questions? Let's begin.
**APPENDIX 3**

**Table 14**

The Practice List Presented to All Subjects

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>VOLVAP - 3</td>
</tr>
<tr>
<td>2.</td>
<td>GOJEU - 2</td>
</tr>
<tr>
<td>3.</td>
<td>NEGLAN - 5</td>
</tr>
<tr>
<td>4.</td>
<td>MEARDON - 1</td>
</tr>
<tr>
<td>5.</td>
<td>TAROP - 9</td>
</tr>
</tbody>
</table>
BIOGRAPHICAL DATA

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