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An Investigation of the Influence of Varying Lengths of Rest Following Differential Amounts of Practice on the Practice Effect in Tachistoscopic Word Recognition

John G. Platt
Wilfrid Laurier University

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by

John G. Platt, B.A.

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AUTHOR: John G. Platt, B. A. (University of Western Ontario)

SUPERVISOR: Dr. Janet M. Hay

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SCOPE AND CONTENTS:

An experiment was carried out to investigate the influence of varying rest periods after three different amounts of practice on the practice effect in word recognition.

Analysis of the data revealed: (1) rest resulted in a sharp increment in recognition thresholds except at short rest intervals after a brief practice period, (2) the threshold scores immediately after rest were found to be an inverse function of the length of the rest period, and (3) larger threshold increments were observed following greater amounts of practice than after lesser amounts.

The results were discussed in terms of two interpretations of the practice effect in word recognition, that is response probability and the development of a tachistoscopic skill.

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INTRODUCTION

Recent research in tachistoscopic word recognition has been directed toward investigating the variables which influence the practice effect, that is,the decrement in thresholds found when a series of words is presented for recognition. Howes and Solomon (1951) described this practice effect as a negatively accelerating, decreasing curve with three-quarters of the decrement occurring over the first quarter of the list of words and with the curve still falling at the sixtieth word.

Variables which have been found to influence the practice effect include amount of practice, length and frequency of the word stimuli, and transfer from one kind of stimuli to another. Studies dealing with these variables will be discussed in the historical review.

The present study examined the influence of varying lengths of rest after differential amounts of practice on the practice effect in tachistoscopic word recognition.

letters were only partially affected.

Tachistoscopic word recognition as a function of the distance of a word from a defined fixation point[2] was investigated by Korte (1923). He reported that correct recognition was influenced by the length of the word as well as the distance of the word from the fixation point; that is, a longer word must be presented closer to the fixation point than a shorter word in order to be recognized. He found, further, that capital letters could be identified at greater distances from the fixation point than lower-case letters when the number of letters was held constant, and that single letters, whether they were capital or lower case, could be identified at a further distance from fixation than multiple-letter words.

These early studies showed that characteristics of the stimulus such as general shape, type of print, length, and position relative to fixation are important determinants of recognition.

Whereas the earlier studies were concerned with stimulus variables, a study by Bruner and Goodman (1948) instigated a new orientation to perception, that of concentrating on research dealing with organismic variables such as motives, needs, values etc. A considerable amount of experimental work resulted (e.g. Postman, Bruner, and McGinnies, 1948; McCleary and Lazarus, 1949; McGinnies, 1949; Lazarus and McCleary, 1951) which showed that organ-

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2. A fixation aid, which is usually in the form of a point (dot) or a series of lines, is presented in the pre-exposure field of the tachistoscope so that the eyes of the subject will be directed to that spot when the stimulus appears.

ismic variables did indeed affect recognition thresholds. In criticizing these studies, however, Howes and Solomon (1951) pointed out that an additional important variable was the frequency of occurrence of the stimulus.

Since frequency, and not organismic variables, is more relevant to the present paper, a more detailed review of studies dealing with frequency will be discussed.

Word frequency refers to the approximate number of times that a word occurs in the subject's repertoire. An estimate of word frequency can be obtained either by reference to the Thorndike-Lorge (1944) word count[3] which established empirically the incidence of words in the language, or by differential amounts of training with the stimulus words in the experimental setting.

The relationship between the frequency of occurrence of words and their recognition thresholds was first examined by Howes and Solomon in 1951. These authors presented tachistoscopically seventy-five words for recognition. They found that the recognition thresholds of high frequency words were lower than for low frequency words. Howes and Solomon (1951) reported that the exposure duration required

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3. The Thorndike-Lorge estimates were calculated after extensive examination of five popular magazines published between 1928 and 1939 to determine the number of times different words occurred in the written language. The words range in frequency from very common ones which occur about 100 times in every million words to extremely uncommon words which occur about once in every four million words. Wispé and Dramberean (1953), Howes (1954) and Zigler and Yospe (1960) have all reported correlations ranging from +.78 to +.88 between the Thorndike-Lorge estimates and students ratings, thus validating the Thorndike-Lorge list of words.

for recognition of a word was a linear, decreasing function of the relative log frequency of usage of that word. In a later study, Howes (1954) used words with frequencies which were obtained from both the Thorndike-Lorge (1944) word count and students ratings and found that tachistoscopic recognition thresholds were an inverse function of word frequency. This recognition threshold-frequency relationship was reported in later studies by Freeman and Engler (1955), Engler and Freeman (1956) and Newbigging (1961).

From the results cited above, it is evident that frequency of occurrence is an important variable affecting tachistoscopic word recognition.

Studies which employed the training method include that of Solomon and Postman (1952) which established the frequencies of the words in the experimental situation. In their study, ten nonsense syllables were placed either 1, 2, 5, 10, or 25 times amongst a series of nonsense syllables which were read aloud by the subject before these syllables were presented tachistoscopically for recognition. The thresholds were found to be an inverse function of the amount of prior practice with the relevant nonsense syllables. Similar findings in experiments which used the same procedure have been reported by Vanderplas (1953), Cohn (1954), and Leytham (1957). On the basis of their frequency findings, Solomon and Postman (1952) suggested that two processes were involved in the tachistoscopic recognition of words; amount of stimulus information obtained when the word was presented, and the response probability of that word. The former, amount of stimulus information, depended upon the size of the fragment perceived

each time the stimulus was presented. At brief exposures only a small fragment could be seen, resulting in a broad range of possible responses that incorporated that fragment. Since the probability of a response, the second process proposed, could be adequately predicted from its frequency of past usage, the responses elicited at brief exposures would be high frequency words. Therefore, if the stimulus presented was a high frequency word, the correct response was more probable than if the stimulus was an infrequent word. The authors further suggested that, with repeated exposures, the size of the fragment perceived increased, thereby reducing the number of competing responses. It followed that correct recognition of a low frequency word would require both an increase in the size of the word fragment perceived and a reduction in the number of competing responses. In summary, "which verbal response will be given depends upon the relative strengths of association which have been established through generalization between the particular stimulus fragment and the different response words" (Solomon and Postman, 1952, p. 199).

Solomon and Postman's (1952) proposals concerning stimulus information and response probability stimulated further research. The primary question raised was whether frequency influenced the process of perceiving the stimulus or of reporting what was seen.

In a study by Neisser (1954) subjects were presented with twelve words to study for one minute prior to the tachistoscopic test procedure. Five of these words were then presented randomly in the testing situation with five words which were homonyms of the words in the training list and five control words. The recognition thresholds

for the words which had been previously studied were lower than the thresholds for the homonyms and control words. The authors concluded that the subjects were predisposed to see the former words and therefore predisposition to perceive rather than verbal response (which was the same for the formerly studied words and their homonyms) facilitated perceptual recognition.

Postman and Conger (1954) presented both part words ("trigrams") and whole words for tachistoscopic recognition. The frequency of the part words was obtained from a count of such stimuli published by Pratt (c.f. Postman and Conger, 1954), while the Thorndike-Lorge (1944) word count was referred to for the frequency of occurrence of the whole words. The results of this experiment indicated that the word thresholds varied inversely with their frequency of occurrence, while such a relationship was not evident for the part-words. Postman and Conger (1954) concluded that it was the frequency of responding to stimuli, and not simply their frequency of visual exposure, which determined how quickly they were recognized.

In a subsequent experiment, Goldiamond and Hawkins (1958) established the frequency of nonsense syllables using the method of differential training. The subjects were then informed that these same stimuli would be presented for tachistoscopic recognition. However blank cards rather than the nonsense syllables were presented in the tachistoscope. Goldiamond and Hawkins (1958) reported that the usual inverse frequency-threshold relationship occurred. These authors concluded that the sole determinant of tachistoscopic word recognition was response probability. However Newbigging (1960) noted that, in the

studies by Neisser (1954) and Goldiamond and Hawkins (1958), the number of responses the subject could make was experimentally restricted because they were informed beforehand that the training words would appear in the tachistoscopic testing situation. If the number had not been so limited, different results might have been obtained.

The effects of response restriction were studied in an experiment by Postman, Bronson, and Gropper (1953). In this instance the experimenters gave the subjects information about what stimuli would appear before these stimuli were tachistoscopically presented. The decrease in the recognition thresholds obtained was attributed to an increase in the response probability of the correct response being given, that is, prior information about the class of stimuli to be presented raised the probability of the correct response being made. Freeman (1954) and Taylor (1956) reported similar findings using this method and also accounted for these results with a response probability formulation.

These studies consistently demonstrate that response probability influences tachistoscopic recognition thresholds when the number of possible responses that can be given is restricted.

The investigation of the other concept proposed by Solomon and Postman (1952), the degree to which stimulus information contributed to the recognition process, was also considered in later studies. Boardman (1957) and Newbigging (1961 b) attempted to discover the process by which the correct response was derived by analyzing pre-recognition responses, that is, answers given prior to the correct response. Both authors reported that the similarity be-

tween pre-recognition responses and the stimulus word itself increased progressively with successively longer exposures, that is, each presentation of the stimulus resulted in the gaining of more stimulus information. Newbigging (1961 b) proposed that a redintegration process occurred whereby the size of the word fragment seen increased on successive exposures and was then incorporated into the verbal response given by the subject. Newbigging (1961 b) analyzed his results further and found that there was a greater similarity between a low frequency stimulus word and the last pre-recognition response than there was between a high frequency word and the response prior to the one on which it was identified. This finding was consistent with Solomon and Postman's (1952) proposal that a larger fragment had to be perceived for recognition of a low frequency word than for the correct identification of a high frequency word.

The results of the studies carried out by Boardman (1957) and Newbigging (1961 b) lend support to the belief that amount of stimulus information, together with response probability, are the important determinants of recognition thresholds.

The studies discussed up to this point have been concerned with variables which affect the average thresholds for a series of stimuli presented tachistoscopically. A second group of experiments, more pertinent to the present paper, deal with factors which influence the change in thresholds with practice when a list of stimuli are presented.

The first study in this area was performed by Howes and Solomon (1951) who presented a list of sixty words which varied in

their frequency of occurrence according to the Thorndike-Lorge (1944) word count. These authors found that the recognition thresholds of successive words were a negatively accelerated, decreasing function of amount of prior practice. Three-quarters of the decrement occurred over the first fifteen words although the thresholds were still decreasing at sixty words. Howes and Solomon called this the"practice effect."

In a later study Newbigging and Hay (1962) examined the effects of both word length and frequency on the practice effect. Nine lists of words were presented for tachistoscopic recognition, each list being made up of different frequencies and/or different lengths of words. Frequency and length were found to significantly affect the decrement in thresholds, with the curves for the longer and infrequent words being higher than those for shorter and frequent ones. In addition the decrement was more pronounced for the threshold scores of the long and infrequent words.

Newbigging and Hay further analyzed the similarity (i.e. the number of identical letters) between the response given immediately preceding correct recognition of the stimulus word (RT-1) and the stimulus word itself. Similarity was found to decrease with increasing practice in recognizing words in the list. The authors suggested that this might be explained in terms of an increasing response probability for the frequency class of words presented. In other words, with increasing practice the subject began to expect a particular frequency of word and restricted his responses to that frequency class. Thus the correct response was elicited earlier with each new word presented.

The response probability interpretation of the practice effect was investigated in a study by Hay (1963) who presented three lists of thirty words for tachistoscopic recognition, each list consisting of either all high frequency words, all low frequency, or a mixed frequency (high and low frequency) list of words. Significant differences in recognition thresholds were found between those groups presented with words of the same frequency and the group receiving the list of mixed frequency words. Of particular interest was the graphical representation of the threshold data for the three groups. This showed the mixed frequency group falling midway between the high and low frequency groups at the beginning of tachistoscopic practice, but after the identification of six words, the curve for the low frequency group fell below and continued to decrease at a faster rate than the curve for the mixed frequency group. These results were interpreted in terms of a response strength being established for low frequency words when that frequency was presented alone in a list; such a response probability for a frequency class could not be built up when both high and low frequency words were presented in the same list.

Further evidence in support of a response probability interpretation of the practice effect in tachistoscopic recognition was provided by a study by Postman and Leytham (1951). These authors presented a list of fifteen adjectives, followed by two nouns to a group of subjects. The usual decrement in thresholds with practice was reported for the list of adjectives but when the first noun was presented there was a significant increase in thresholds followed by

a sharp decrease for the second noun. They attributed the high threshold noted for the first noun presented to a "set" or high response probability which had been established for adjectives. Thus, after seeing fifteen adjectives, the individual had a low response probability of guessing the first noun that was presented.

To examine the response probability hypothesis further, Hay (1963) presented four different classes of stimuli, nine high frequency words, nine low frequency words, nine series of digits or blank cards (that is, the control group), to four different groups of subjects and then tested all four groups with the same list of low frequency words. The results showed that none of the three groups which were presented with stimuli differed significantly from each other, while the control group differed from all three. On the basis of response probability it had been expected that training with high frequency words and numbers would increase the response strength for those stimuli and this would interfere with the subsequent recognition of low frequency words. However, the type of training stimuli employed was not found to be an important variable in the recognition of the low frequency test words presented afterwards.

Only nine training stimuli were used in the previous experiment and it was felt that this amount might be insufficient to establish a strong response tendency for a particular class of stimuli. To build up a stronger response strength, Hay (1963) trained 3 groups of subjects with twenty-seven, three or one high frequency words and then tested all groups with the same list of low frequency words. She found an inverse relationship between <u>amount</u> of training with high frequency words and

the subsequent recognition of low frequency words. Thus, increased training with high frequency words facilitated, rather than interfered with the recognition of low frequency words. On the basis of these findings, Hay (1963) concluded that it was the amount of practice in recognizing stimuli, and not the particular class of stimuli identified, that influenced the thresholds of the test list of words. These findings were confirmed in a later study by Platt (1966).

The results of these studies suggest two variables as determinants of the practice effect in tachistoscopic recognition. The first of these is a response strength developed through exposure to a particular class of stimuli (Postman and Leytham, 1951; Hay, 1963). The second is a tachistoscopic skill which is learned during the process of recognizing successive stimuli presented tachistoscopically, (Hay, 1963; Platt, 1966).

The nature of the skill developed in tachistoscopic recognition has been the subject of a number of experiments. Evidence for such a skill was first suggested by Weber (1942) and Renshaw (1945) when they found that subjects who had practice in the tachistoscopic recognition of stimuli displayed improved reading speed. In a later study, Mishkin and Forgays (1952) found that when words were exposed either to the left or to the right of a fixation point, they were more easily recognized on the right. To determine if this was a learned phenomenon, Mishkin and Forgays presented a list of English and Yiddish words in a random order either to the right or left of a fixation point to a group of subjects who were able to read both languages equally well. The results

showed that the English words were recognized more readily to the right of fixation, while the Yiddish words were identified sooner on the left. Later studies reported the same results (Forgays, 1952; Orbach, 1953). Mishkin and Forgays interpreted these findings in terms of habits developed in reading. An individual reading English initially fixates the beginning of the line to the left and then moves his eyes to the right to scan the rest of the line. The initial fixation when reading Yiddish is at the right and the scanning movement then takes place from right to left. When an English word is presented to the right or a Yiddish word to the left of a fixation point, the subject's eyes are immediately set at the first letters of the word, while when the opposite presentations are made, the subject first had to move his eyes to the beginning of the word before making the scanning movement.

Heron (1957) described the visual mechanisms employed in reading more fully following an experiment in which he projected a row of letters <u>simultaneously</u> to the left and to the right of a central fixation point. When presented in both fields at the same time, the letters to the left of fixation were recognized earlier than those to the right. From the results of these experiments Heron concluded that there were two main eye-movements involved; the first, and dominant one, was to move the eyes so that they fixated near the beginning of the line and the second to move the eyes along the line of print from left to right. Thus, if a subject knew exactly where a word would appear in the tachistoscopic field, he could fixate the beginning of the word and only need the second eye-movement in his attempt to recognize the stimulus.

In a review of the studies on the practice effect in tachistoscopic word recognition it was noted that no precise fixation point was provided. In some two black horizontal lines were employed, (Newbigging, 1961 a, 1961 b; Newbigging and Hay, 1962; Hay, 1963) while in other experiments the pre-exposure field was blank (Howes and Solomon, 1951; Postman and Leytham, 1952). In these studies the subject had to learn where to fixate in order to gain the maximum amount of information concerning the stimulus.

Hay (1963) investigated the possibility that the practice effect in tachistoscopic recognition might be determined in part by the subject's learning precisely where to fixate prior to the presentation of the word. The pre-exposure field for one group of subjects contained a fixation point placed so that the middle letter of the stimulus word fell directly above it. For the second group of subjects the pre-exposure field was blank. Hay found that the practice curve for the fixation-point group was significantly lower than that for the no-fixation group, indicating that a knowledge of the exact exposure location of the stimulus was an important determinant of the level of the practice effect. These results suggested that after a little practice the group used the fixation point as an aid for locating the first letters of the word and thus were able to make the scanning movement from left to right sooner than the group without such an aid. Since both groups showed the usual threshold decrement with practice, Hay concluded that some factor other than learning this tachistoscopic fixation skill must be operative.

In summary, at least two determinants appear to account for

the practice effect in tachistoscopic word recognition. One is response probability which is built up by presenting a list of the same class or type of stimuli for identification. The second is a skill involving learning to fixate and scan the word.

While these two factors were not investigated in the present study, it was necessary to consider their effects when designing the procedure to be followed.

Specifically,the present experiment investigates the effects of three rest periods introduced at three different stages of practice on the practice effect in tachistoscopic recognition. In the study described earlier by Newbigging and Hay (1962), fifteen of the words of the thirty-word list were presented one day, and the remaining fifteen words were given twenty-four hours later. A finding, which was only incidental to the purpose of the study, was that the one-day interruption in recognizing stimuli resulted in a sharp increment in thresholds for the first words presented on the second day. This increase was followed immediately by a sharp drop in thresholds to approximately the same level attained on the last words recognized the previous day.

Several of the conditions employed in the Newbigging and Hay (1962) study are replicated in the present experiment. First, the stimuli consist of a list of thirty of the same low frequency, seven-letter words; secondly, the same fixation aid in the pre-exposure field consisting of two black horizontal lines set two inches apart is used; thirdly, the subjects in one group are treated in the same manner in that they are presented with fifteen words, followed by a

one-day rest period, and then receive the remaining fifteen words for recognition.

To compare the effects of different lengths of rest following varying amounts of practice in tachistoscopic recognition, two further rest periods and two other levels of pre-rest practice are introduced into the experimental design. The three rest periods of five minutes, one day and one week are combined factorially with three amounts of pre-rest practice; six, fifteen and twenty-four words, to give nine experimental conditions. This design permits a study of the effects of rest following different levels of practice in recognizing words as well as the influence of varying lengths of rest with the same amount of practice.

The following hypotheses will be tested in the present experiment: First, the introduction of a period of rest during the presentation of a list of words for tachistoscopic recognition will result in an increase in the thresholds of words immediately following this rest; Secondly, with amount of practice held constant, the recognition thresholds of words immediately following rest will be a function of the length of the rest period; Thirdly, a greater threshold increase will occur following a small number of practice words than after a larger number of practice words with length of rest held constant.

METHOD

Subjects

The subjects were 135 students enrolled in the Introductory Psychology course at Waterloo University College. Their ages ranged from 17 to 34 years, the average age being 18.3 years.

Apparatus

The apparatus was a Gerbrand's tachistoscope. This is essentially an L-shaped box with a half-silvered mirror inside, set so as to bisect the L at right angles. A viewing aperture is located at the base of the L so that the subject looks directly at the middle of the mirror. Provision is made for independently illuminating the field at either end of the box. The pre-exposure field is situated at the base of the L and to the subject's right. When it is illuminated, the stimulus material is reflected by the mirror into the subject's eyes. Illumination of the other end of the box, which faces the subject, allows him to see the stimulus material through the mirror. This field is referred to as the exposure field and is used for the presentation of the stimulus words.

A mechanical timer is employed to control the illumination in both fields. When it is set for a particular exposure duration, the pre-exposure field is darkened while at the same time the exposure field is illuminated. At the end of the stimulus exposure, the pre-exposure field is again illuminated automatically. Thus, the pre-exposure field is constantly illuminated except when the exposure

field is "on". The timer provides for illuminating the exposure field for an interval between 10 milliseconds and one full second, in 10 millisecond gradations.

In the present experiment a fixation pattern was present when the pre-exposure field was illuminated. It consisted of two black, horizontal, parallel lines four inches in length and two inches apart. The stimulus always appeared in the exact centre of these two lines.

The stimulus material consisted of a list of thirty, seven letter words which were randomly selected from the Thorndike-Lorge (1944) word count. According to this count, these words occur approximately three times in every million words in the English language. Each of the words selected as stimuli was typed in black élite capital letters on a white card in such a way that when the word was presented in the tachistoscope, it always appeared in the exact centre of the two fixation lines.

All the subjects in the experiment were presented with this same list of words in a different random order. Randomness was obtained by shuffling the thirty cards prior to their presentation to each subject.

Experimental Design

The design was a balanced 3 x 3 factorial in which three different amounts of practice were combined with three different lengths of rest. Thus there were nine different treatment groups each composed of fifteen subjects. Each group received one of the following treatments:

NUMBER OF PRE-REST WORDS	LENGTH OF REST	NUMBER OF POST-REST WORDS
6	5 minutes	24
6	1 day	24
6	1 week	24
15	5 minutes	15
15	1 day	15
15	1 week	15
24	5 minutes	6
24	1 day	6
24	1 week	6

Subjects who had a five-minute rest period remained in the experimental room during that time and were engaged in general conversation with the experimenter. The topics discussed were never related to the experimental situation. Subjects who had intervening rest periods of one day or one week were asked to return after the appropriate time had elapsed and were treated in a similar fashion on their return. The subjects were informed simply that the second part of the experiment was a continuation of the first.

Procedure

The following instructions were read aloud to each subject before the experiment commenced:

> "I am going to present some words to you, one at a time. If you look in the eye-piece of this apparatus, you will see two lines. The words I shall show you will appear directly between the lines. Each word will be presented for a very short period of time, and you may not be able to tell what it is at first. However, after each presentation I would like you to make a guess

> as to what the word was. Remember, even if you do not recognize the word, I still want you to tell me what you think it was. Each word will be presented to you several times until you correctly recognize it. I shall inform you when you are correct and then I shall show you another word. I shall say "ready" before each word is flashed. Are there any questions?"

If the subject asked any questions, relevant parts of the instructions were re-read to him. After the rest periods, all subjects were asked if they remembered what they were required to do. If there were any doubts, the pertinent parts of the instructions were again related. All further questions about the experiment were answered after it had been completed.

Each word was presented in the tachistoscope until correctly identified by the subject. The ascending method of limits was used for successive presentations of each stimulus word. The initial exposure duration was 30 milliseconds with each successive exposure duration being increased by 10 milliseconds until the word was correctly identified. The exposure duration at which each word was identified was recorded on a score sheet.

RESULTS

The 30 threshold values for each subject were averaged over blocks of three words, yielding ten blocks of three words each. When the mean scores for the nine groups of subjects were plotted as a function of serial position of words[4] in blocks of three, they tended to fall at approximately the same point on the graph; thus for a clearer graphical presentation of these data, the groups were separated according to the amount of pre-rest practice given.

Figure 1 shows the results of the three 6-word practice groups, while Figures 2 and 3 portray the average threshold scores of the 15 - and 24-word practice groups respectively. An examination of the three Figures indicates that the nine curves decrease sharply following the first block of words, and then begin levelling off except at the points where rest is introduced. Here, an increase in the thresholds of the initial block of words is evident for all except the 5 minute group in Figure 1 where the curve continues to decrease after rest. The thresholds of the second block of post-rest words for all groups tend to approach the minimum threshold level attained on the practice words preceding rest, with the scores of the 1 day - and 1 week - rest groups falling below this level (see Figure 1).

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4. Serial position of words is the order in which the words appeared in the list for each subject.

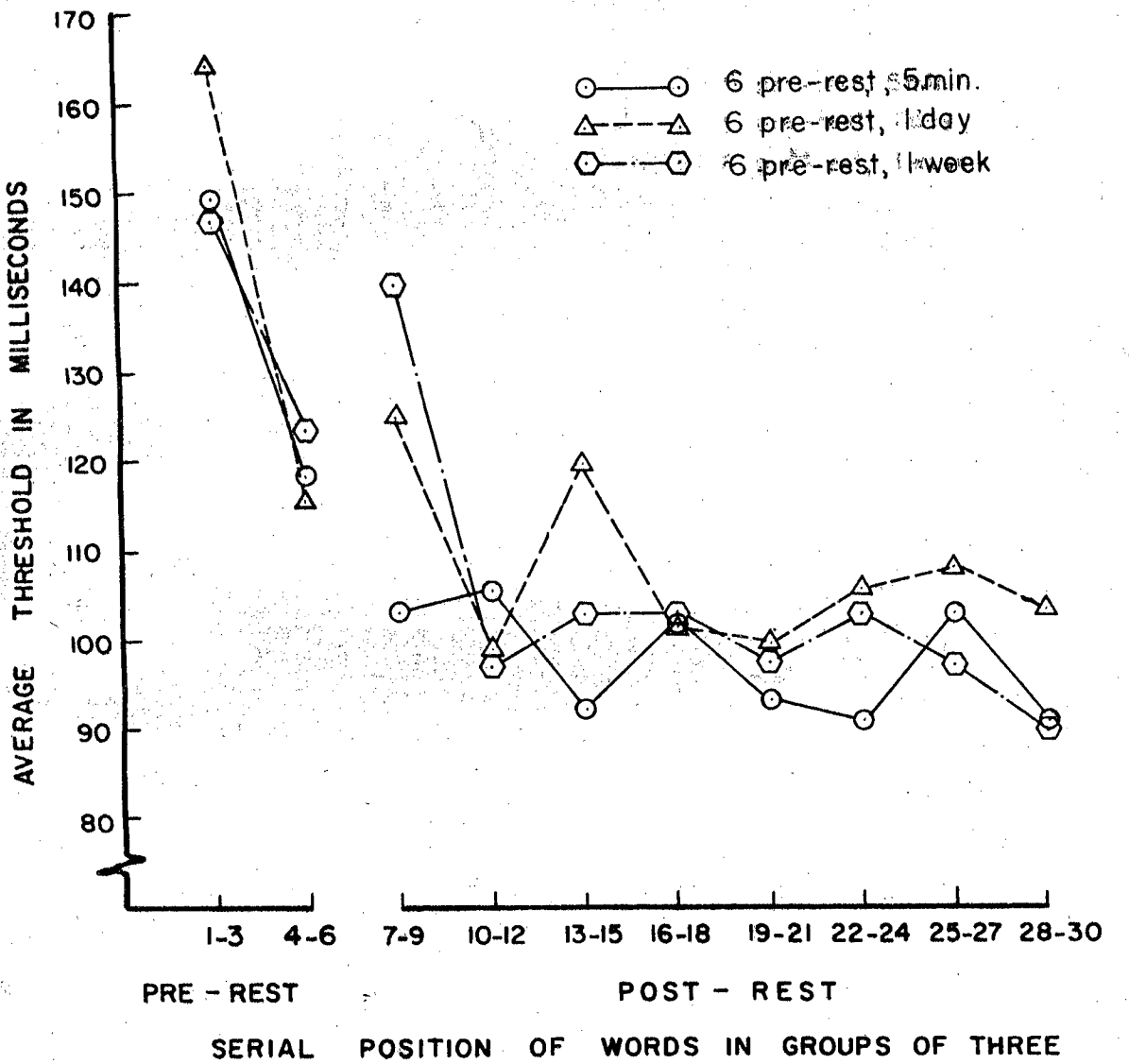

FIGURE I Average thresholds in milliseconds as a function of words in groups of three

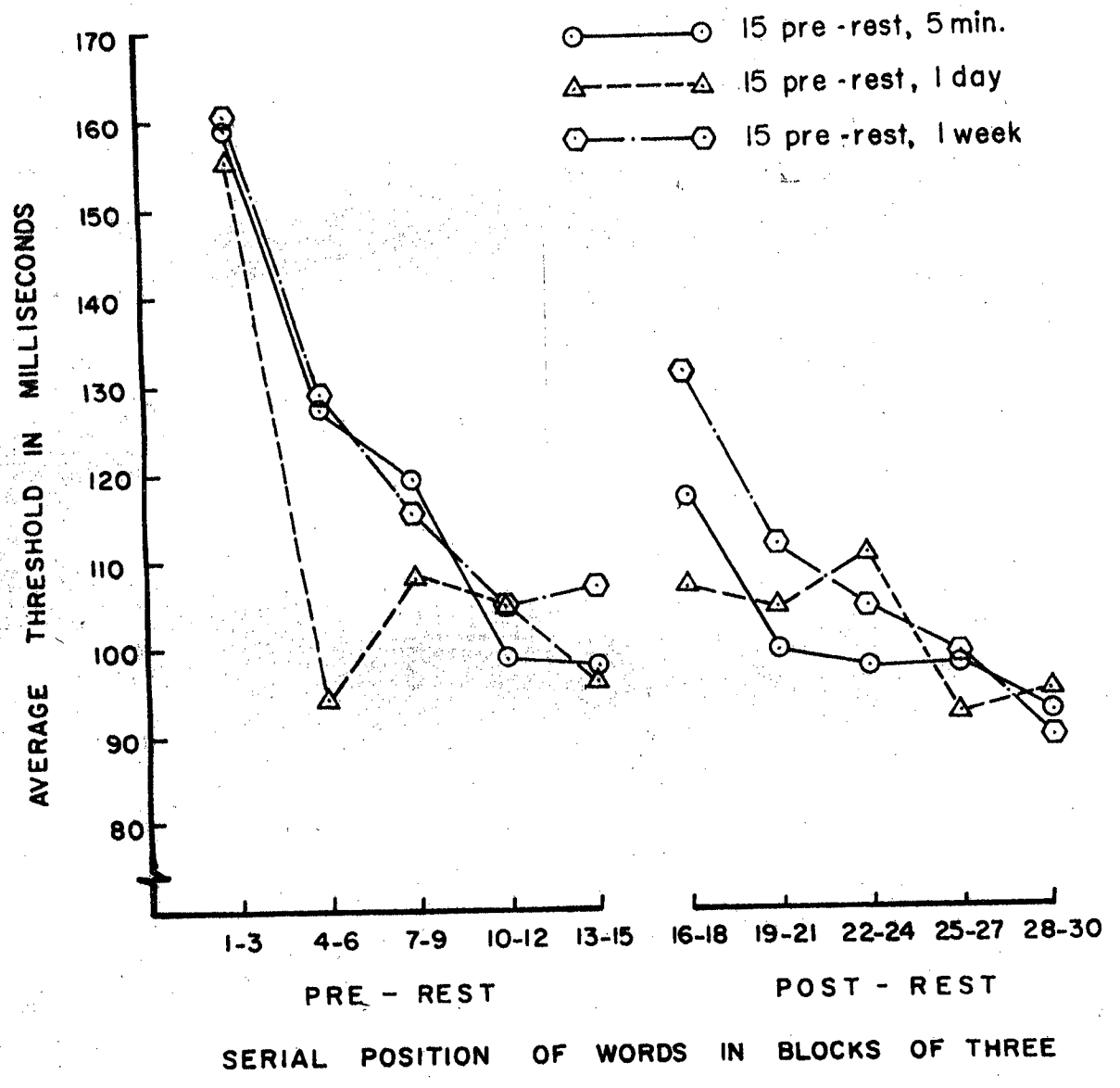

FIGURE 2 Average thresholds in milliseconds as a function of words in groups of three

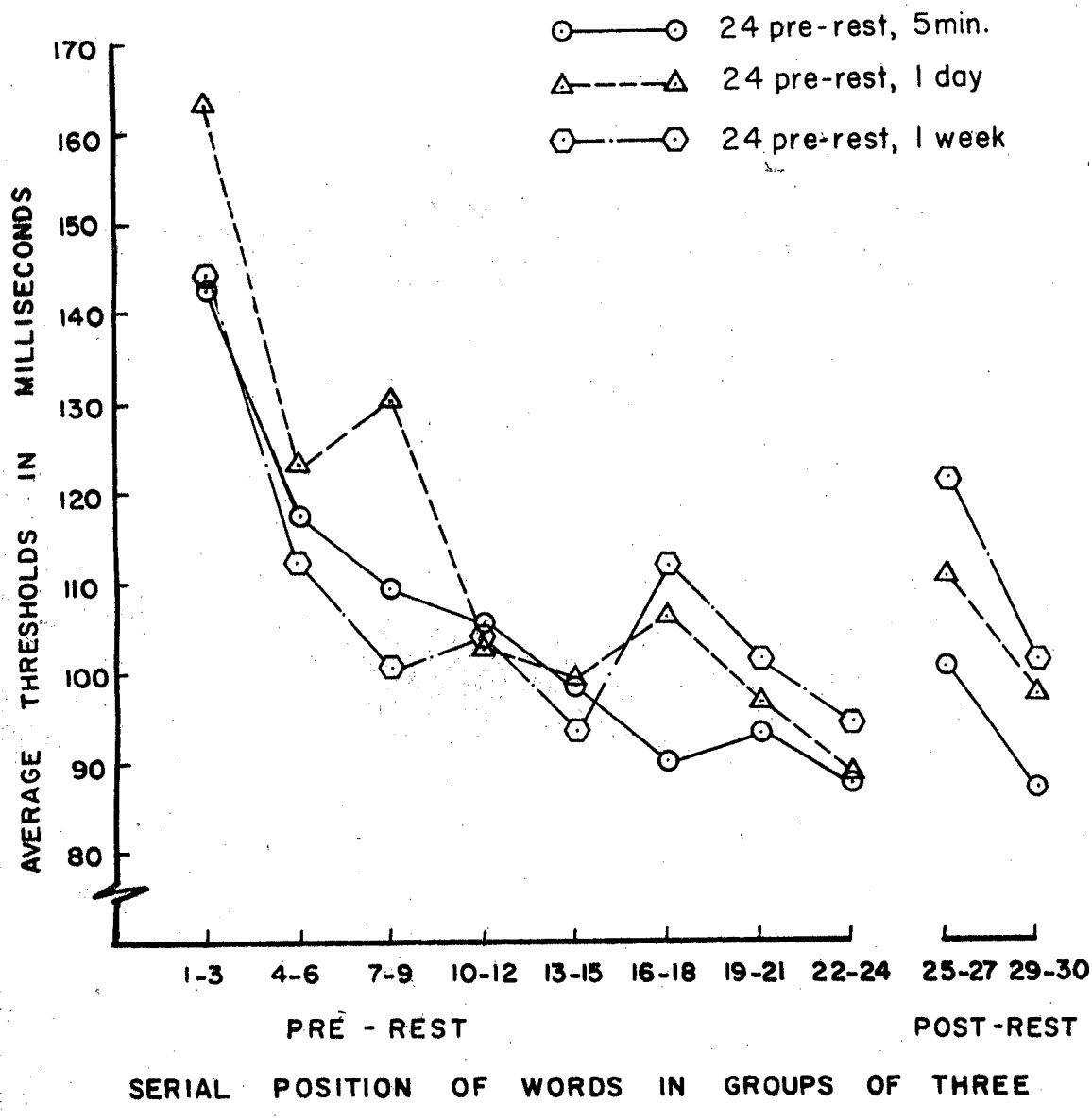

FIGURE 3 Average thresholds in milliseconds as a function of words in groups of three.

A summary of an analysis of variance performed on the overall data is presented in Table I[5]. The between group effects of amount of practice, length of rest, and the interaction of these two main effects are not significant. These results are not surprising since the ten threshold scores for all groups are similar except at the points where rest periods were introduced. The within group effect of serial position is significant ($F_{.95} = 1.95$ with 9 and 1134 degrees of freedom) indicating differences in thresholds as a function of serial position of words. It is evident from the three Figures that this is due to a general decrement of thresholds over the word list for all nine groups, except for the initial increases after introduction of the rest periods.

Since the effects of length of rest and amount of practice were obscured in the overall analysis because of the similarity of the data for the nine groups, the three threshold values related to the periods of rest were examined further. Figure 4 shows the average threshold scores for the last pre- and first two post-rest blocks of words as a function of serial position.

Consider first the threshold curves for the 6-word practice groups to the left of the Figure. Evidently when the effect of practice is greatest, a short rest period of 5 minutes has little if any effect upon the curve, while a rest of 24 hours results in an initial increase in the thresholds of the post-rest words, and a greater increase occurs after a longer rest period of 1 week. The thresholds of

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5. A Hartleys F MAX. Statistic (c.f. Winer, 1962), used to check homogeneity between the nine treatment groups, showed that the variances were not significantly different (F MAX. .95 = 4.07 with 9 and 14 degrees of freedom.)

TABLE 1

SUMMARY OF ANALYSIS OF VARIANCE
OF THRESHOLD DATA

Pre-rest and Post-rest Words

Source	d.f.	M.S.	F	P
Amount of Practice (A)	2	32909.63	.93	NS
Length of Rest (B)	2	24461.09	.69	NS
A x B	4	33553.48	.95	NS
Error (b)	126	35382.88		
Serial Position	9	1704.96	1.95	<.05
C x A	18	943.40	1.08	NS
C x B	18	757.85	.87	NS
C x A x B	36	858.35	.98	NS
Error (W)	1134	873.66		

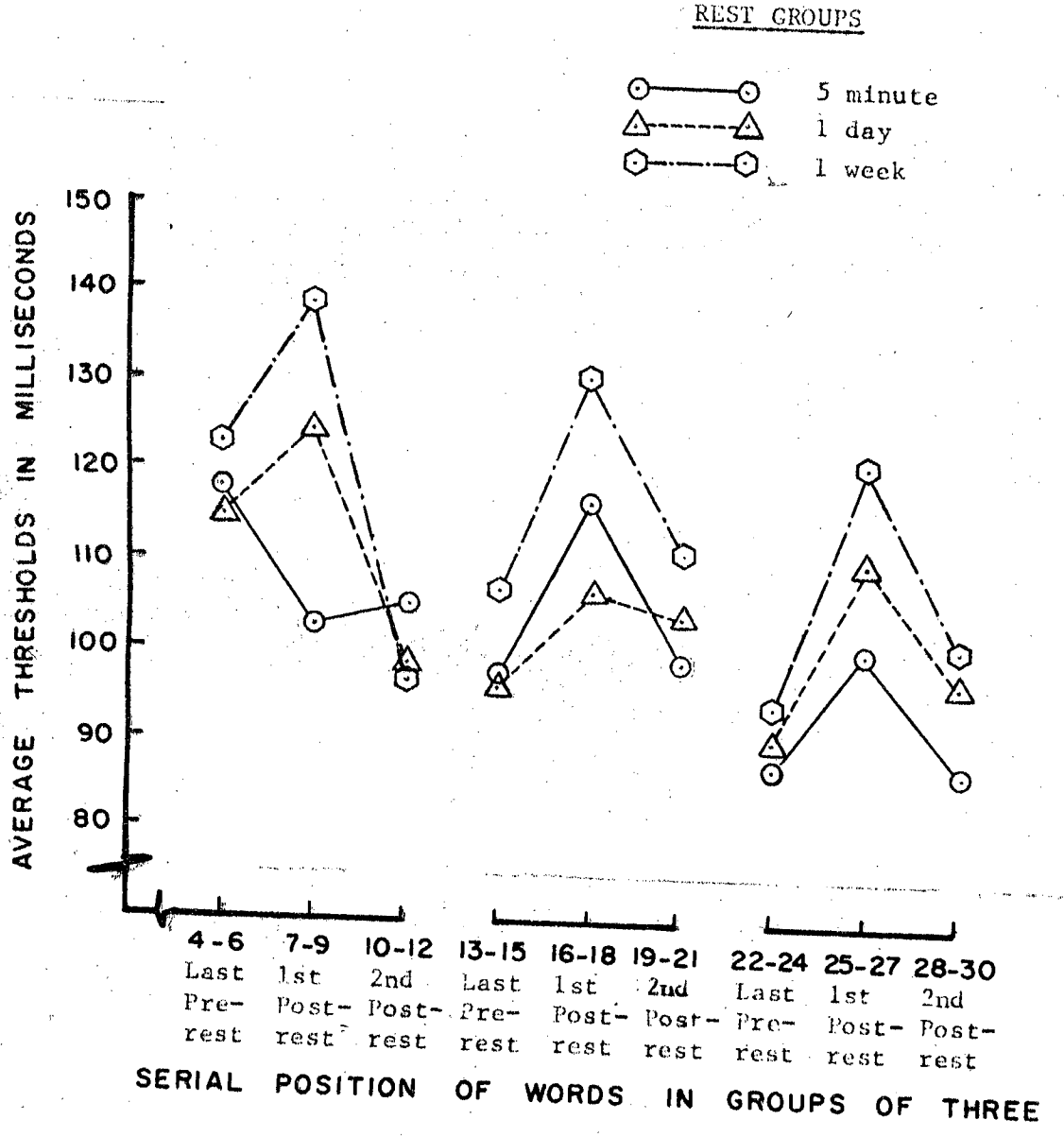

FIGURE 4 Average threshold in milliseconds as a function of position of words pre- and post-rest.

the second post-rest blocks of words for the 24 hour and one day rest groups drop well below the threshold level observed at the end of practice with six words.

Table II presents a summary of an analysis of variance performed on these data[6]. The effect of word position[7] is seen to be significant (F.95 = 5.67 with 2 and 84 degrees of freedom), while the effects of rest and the interaction of rest and word position do not achieve the significance level. A Neuman-Keuls Test for means (Winer, 1962) was employed to determine the between group differences for each block of words (see Appendix C, Table I). Significant differences were found between the thresholds of the three rest groups on the first post-rest block of words, while no differences were found between these groups on either the last pre- or second post-rest blocks of words. These findings can be clearly seen in Figure 4; the scores of the three groups fall at approximately the same point on the last pre-rest and second post-rest blocks of words, while on the first post-rest blocks of words they are widely separated. A second Neuman-Keuls test to determine within group differences on the thresholds of these three blocks of words (see Appendix C, Table II) yielded the following significant differences: 1) between the last pre- and first post-rest blocks of words for the three groups, 2) between the last pre- and second post-rest blocks of words for all groups, and 3) between the first post- and second post-rest blocks of words for the 1 day and

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6. A Hartleys F MAX. Statistic indicated that the between group variances were not significantly different (F. MAX. .95 = 2.55 with 3 and 14 degrees of freedom).

7. Word position refers to the position of the blocks of words relative to rest, that is last pre-rest, first post-rest and second post-rest blocks of words.

TABLE II

SUMMARY OF ANALYSIS OF VARIANCE
OF THRESHOLD DATA

6 Practice - Last Pre-rest, First Two Post-rest Blocks

Source	d.f.	M.S.	F	P
Length of Rest (A)	2	119.08	.27	N.S.
Error (b)	42	447.43		
Word Position (B)	2	561.30	5.67	$<.05$
A x B	4	180.93	1.83	N.S.
Error	84	99.00		

1 week rest groups. It appears that the initial variation in thresholds is a function of the length of rest, that is, larger thresholds occur on the first post-rest blocks of words following a longer rest period than after a shorter rest.

Turning now to the three curves shown in the middle of Figure 4, which represent the threshold scores for the three 15-word practice groups, it is evident that the initial post-rest increase in thresholds is greatest for the 1 week group, while the increase for the 5 minute group exceeds that of the 1 day group.

A summary of an analysis of variance of these data shown in Table IIIa, indicates that the word position effect is significant ($F_{.95} = 6.14$ with 2 and 84 degrees of freedom) while the effects of rest and the interaction of rest and word position are not significant.[8] Between group comparisons, using a Neuman-Keuls Test, (see Appendix C, Table III) indicate significant differences between: 1) the 1 week group and the other two groups on the last pre-rest block of words, 2) the 5 minute, 1 day, and 1 week groups on the first post-rest block of words, and 3) the 5 minute and 1 week group on the second post-rest block of words. The within group differences on these blocks of words were examined employing a Neuman-Keuls Test for means (see Appendix C, Table IV). The following significant differences were obtained: 1) between the last pre- and first post-rest blocks of words for the three groups, 2) between the first and second post-rest blocks of words for

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8. A Hartleys F MAX. Statistic indicated that the between group variances were not significantly different (F MAX. .95 = 1.95 with 3 and 14 degrees of freedom).

TABLE IIIa

SUMMARY OF ANALYSIS OF VARIANCE
OF THRESHOLD DATA

15 Practice - Last Pre-rest, First Two Post-rest Blocks

Source	d.f.	M.S.	F	P
Length of Rest (A)	2	236.10	.51	N.S.
Error (b)	42	462.94		
Word Position (B)	2	356.54	6.14	< .05
A x B	4	29.99	.52	N.S.
Error (W)	84	58.03		

TABLE IIIb

SUMMARY OF ANALYSIS OF COVARIANCE
OF THRESHOLD DATA

15 Practice - Last Pre-rest, First Post-rest Blocks

Source	d.f.	M.S.	F	P
Between	2	68.74	.38	N.S.
Within	41	178.56		

the 5 minute and 1 week groups, and 3) between the last pre- and second post-rest blocks of words for the 1 day group. Because of the differences between groups found on the pre-rest blocks, an analysis of covariance was employed to evaluate the significance of the differences between the thresholds of the first post-rest blocks of words when adjustment had been made for the differences in the pre-rest thresholds. The summary of this analysis is presented in Table IIIb. Despite the non-significant between-group effects, a Neuman-Keuls test of evaluation was made on the adjusted values of the first post-rest block of words (see Appendix C, Table V). Only the difference between the 1 day and 1 week groups was found to be significant with this adjustment.

To the right of Figure 4 can be seen the curves of the three groups having 24 practice words before rest. A summary of an analysis of variance performed on these data, presented in Table IVa, reveals that the word position effect is significant while the effects of length of rest and the rest x word position interaction do not attain significance.[9] Between group comparisons on the three blocks of words, using a Neuman-Keuls Test (see Appendix C, Table VI), yielded significant differences between: 1) the last pre-rest blocks of words for the 5 minute and 1 week groups, 2) the first post-rest block of words for all groups, and 3) the second post-rest blocks of words for the 5 minute and 1 week groups. Another Neuman-Keuls Test was used to examine the differences within groups on these three blocks of words (see Appendix C, Table VII), significant differences were found be-

9. A Hartleys F MAX. Statistic demonstrated that the between group variances were not significantly different (F MAX. .95 = 1.93 with 3 and 14 degrees of freedom).

TABLE IVa

SUMMARY OF ANALYSIS OF VARIANCE
OF THRESHOLD DATA

24 Practice - Last Pre-rest, First Two Post-rest Blocks

Source	d.f.	M.S.	F	P
Length of Rest (A)	2	197.10	1.15	N.S.
Error (b)	42	172.12		
Word Position (B)	2	439.59	10.10	< .05
A x B	4	18.67	.43	N.S.
Error(w)	84	43.52		

TABLE IVb

SUMMARY OF ANALYSIS OF COVARIANCE
OF THRESHOLD DATA

24 Practice - Last Pre-rest, First Post-rest Blocks

Source	d.f.	M.S.	F	P
Between	2	90.88	.86	N.S.
Within	41	105.59		

tween: 1) the last pre- and first post-rest blocks for all groups, 2) the first and second post-rest blocks of words for all groups, and 3) the last pre- and second post-rest blocks of words for the 1 day and 1 week groups. The results of an analysis of covariance employed to adjust the thresholds of the first post-rest blocks of words are shown in Table IVb. Despite the non-significant between-group effects, a Neuman-Keuls test was made on the adjusted values of the first post-rest block of words (see Appendix C, Table VIII). All the scores were found to be significantly different.

To summarize these results, the between-group effects will be considered first. Although the analyses of covariance showed no significant differences between groups, the Neuman-Keuls tests provided some indication that there might be significant differences between the groups at all three levels of practice with one exception. Following 15 words of practice, the 5 minute group did not differ from either of the other two groups. It can be seen in Figure 2 that the score for the 5 minute group at this point is higher than that of the 1 day group.

Turning to the within-group results, significant differences in threshold scores were found between the last pre-rest and first post-rest blocks of words for all nine groups. An examination of these points of the curves in Figure 4 reveals that in all cases these differences are due to an increase in scores following rest except for the decrease shown by the 5 minute group after six practice words. A comparison of the scores for the first post-rest with the second post-rest blocks of words indicated that only two groups did not differ significantly; the 5 minute group after recognizing six words and the 1 day group after receiving 15 practice words. It is

evident from Figure 4 that all the other groups show a sharp decrement in thresholds following the initial increase after rest. The last within-group comparison was made between the last pre- and second post-rest blocks of words. These results showed that all groups differed on these two scores following 6 words of practice, only the 1 day group differed following 15 practice words, while both the 1 day and 1 week group were different after 24 practice words. These effects are readily apparent in Figure 4, where the differences early in practice are shown by a decrement in scores, while after 15 and 24 practice words, an increase is noted.

A further analysis of the data was carried out to compare the amounts of increase in thresholds following rest at the three different stages of practice. To obtain some measure of the increase in scores following the various amounts of practice, difference scores were derived by subtracting the threshold values of the last pre-rest block of words from those of the first post-rest block. t tests were then used to compare the differences between groups having the same rest at the various levels of practice.[10] For the three groups with 5 minute rest intervals the following significant differences were found: 1) between the 15- and 24-word practice groups ($t_{.95} = 2.38$ with 28 degrees of freedom), 2) between the 6- and 15-word practice groups ($t_{.95} = 6.34$ with 28 degrees of freedom), as well as between the 6- and 24-word practice groups ($t_{.95} = 5.42$ with 28 degrees of freedom). Significant differences were noted for the following groups having a

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10. All t tests were two-tailed.

24-hour rest period: 1) between the groups which received 6 and 24 pre-rest words (t.95 = 2.25 with 28 degrees of freedom), and 2) between the groups which were presented with 15 and 24 practice words (t.95 = 2.28 with 28 degrees of freedom). In the groups with a 1 week rest interval the following significant differences were found between: 1) 6 and 15 word practice groups (t.95 = 2.44 with 28 degrees of freedom), and 2) those having 6 and 24 words of practice (t.95 = 3.36 with 28 degrees of freedom).

To summarize these findings, the t tests revealed that with a 5 minute rest period, all three comparisons were significantly different, with a 1 day rest, the scores of the 6 and 24 and the 15 and 24 word-practice groups were different as were the 6 and 15, and 6 and 24 word-practice groups after 1 week's rest.

In summary, the results of this experiment indicate that rest periods affect the recognition thresholds of words at the three different stages of practice. Early in practice, a short rest period apparently has little effect, but longer rest intervals result in a sharp increase in thresholds. As the slope of the practice curve is approaching an asymptotic level after considerable practice, even a short rest interval causes a sharp rise in scores. Further, it is evident that the effect of rest is only temporary, since on the second block of words following rest, thresholds return to the same level as they had reached prior to rest.

DISCUSSION

Howes and Solomon (1951) described the practice effect in tachistoscopic recognition as a negatively accelerated, decreasing curve, with approximately three quarters of the decrement occurring in the first quarter of the list. Newbigging and Hay (1962) reported finding similar curves following a study in which they used nine lists of thirty words which varied in frequency and/or length of word. An interesting finding in their study was that rest, introduced halfway through the presentation of the list, resulted in a sharp increment in the curves, followed by a decrease to the levels reached on the last words given prior to rest.

The findings in the Newbigging and Hay study (1962) raised the interesting question of whether rest would result in similar increase in the practice curve when varying lengths of rest were introduced at different stages in the word list. The present study investigated this question. The results were quite consistent in showing that this increase was a function of the length of the rest period after each of the stages of practice. The characteristics of the practice curve at these various points will now be considered.

At the early stages of practice, the threshold curves are still relatively high but decreasing rapidly. A brief rest period of 5 minutes does not seem to interfere with the downward trend of the curve. However, longer rest periods of 1 day and 1 week result in the same sharp increment noted by Newbigging and Hay (1962) immediately following

rest. The threshold curves of the two groups having longer rests decrease below the low point attained before rest, while the curve for the 5 minute rest groups exhibits a slight increase.

When rest is introduced at an intermediate point in the list, the curves for the three groups show an initial increase on the post-rest words and then decrease and approach the asymptotic level attained on the pre-rest words. The initial increases are not completely a function of the length of rest, as the point for the 5 minute group falls between that of the 1 day and 1 week groups.

Late in practice, the differential effects of length of rest are evident; the longest period of rest results in the sharpest increment in the threshold curve, while the group having a short rest shows the least increment. The curve for the group having the medium length falls between the other two. A Neuman-Keuls test provided a slight indication that all of the increment points are significantly different from each other and are a function of the length of preceding rest.

It is clear that rest introduced during the course of practice in tachistoscopic word recognition interferes with this perceptual task. These findings support the hypothesis, stated in the Historical Review, that the introduction of rest during the presentation of a list of words for tachistoscopic recognition will result in an increase in the thresholds of words immediately following the rest. That the 5 minute rest group does not show this interference effect early in practice can be explained by the rapid decrement in thresholds at this stage. Apparently the influence of practice at this point is able to over-

The first, response probability, assumes that practice in recognizing a particular class of stimuli will increase the response probability for that class, thus explaining the decrement in thresholds observed when a list of words of the same frequency are presented for recognition. A number of experiments have supported this interpretation of the practice effect (Solomon and Howes, 1952; Postman and Leytham, 1952; Newbigging and Hay, 1963).

Now, if response probability is built up during the course of practice in recognizing a certain class of words, it can be expected that during a rest period other response tendencies will accrue which will interfere with the earlier established responses. If this is the case, it can be predicted that a rest period, introduced during the practice session, will result in an increase in thresholds for words presented immediately after rest. The threshold increments following rest in the present experiment are in agreement with such an interpretation. Another prediction from the response probability explanation is that the longer the rest, the more interference there will be and thus, the higher will be the immediate post-rest thresholds. The results also generally tend to support this proposal. Further, it seems reasonable to suggest that the more practice given in recognizing infrequent words, the greater the response strength for that frequency class, and the less the increase in thresholds with more practice if the same rest period is given.

The results of this study provide some indication that the first two predictions, but not the third, may be in agreement with a response probability interpretation.

The second explanation for the practice effect is in terms of the development of a skill, involving fixation and scanning, during the course of recognizing words presented in a tachistoscope. The present study employed two black horizontal lines in the pre-exposure field as a fixation aid, thus allowing the subject considerable scope in learning where to fixate prior to word presentation. As was noted in a study by Hay (1963), this type of fixation aid results in a much steeper practice curve than does an exact fixation point. Since the purpose of this study was to determine the influence of rest on the practice effect, a practice curve with a sharper decrement followed by a slower levelling off was desirable. For this reason, a less precise fixation aid was used.

By employing such a fixation aid, however, it is impossible to control for the development of the tachistoscopic skill during practice. Thus, the finding that rest results in an increase in threshold scores above the level attained by practice may well be attributed to interference with the development of such a skill. If this is the case, then it would follow that the longer the rest, the greater would be the increase in threshold scores. It is more difficult, however, to explain the finding that a longer practice period results in a greater increase in threshold scores than does a shorter one. It may be that an individual who has developed the tachistoscopic skill of fixating and scanning to a high degree loses more of this skill than one who has not practiced as much. This, of course, is merely an assumption that will have to be investigated further.

The procedure used in the present experiment did not separate the variables which determine response probability from those responsible for the development of a tachistoscopic skill. Both interpretations of the practice effect seem to explain the results of this study equally well.

While the results of this research confirm the hypothesis that the effect of rest is to raise the thresholds of tachistoscopic word recognition, they leave unanswered a number of questions. For example, does the type of activity carried out during the rest period affect the increase in thresholds? To what extent are the recognition thresholds influenced when the perceptual task has been practiced until an asymptotic level in the threshold curve has been reached? These, and many other problems, will have to be resolved before an adequate explanation of the practice effect can be given.

Studies to determine the relative influence of response probability and tachistoscopic skill on the practice effect are possible. One means of controlling the development of a tachistoscopic skill would involve presenting a more defined fixation aid to the subject. This would remove to a great extent the first movement of the eyes to the left which was an important component of the double eye movement formulation proposed by Heron (1957) to occur in the tachistoscopic recognition process. A method which could be employed to control response probability would consist of presenting a list of adjectives, nouns and verbs of varied frequencies for recognition. Response probability could not be established to any particular type or class of stimuli under these conditions. These two methods will be employed in

future studies to test the effects of response probability and/or tachistoscopic skill on the practice effect in word recognition.

A procedure which would perhaps give a purer measure of speed of fixation and scanning would be to use an apparatus which measures retinal eye movement, and which records traces of such movement. By measuring the traces themselves, one could not only find the manner in which the eyes move over a series of words, but also the speed of their movement.

Through such experiments as those mentioned above, further knowledge may be obtained about the practice effect in tachistoscopic word recognition, and the variables which influence this effect.

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APPENDICES

APPENDIX A

LIST OF STIMULUS WORDS

LOW FREQUENCY WORDS

Words occurring on the average of three times per million*

ACOLYTE	FADDIST	PIEBALD
ANNULET	FLOTSAM	PILLION
BEDIZEN	GALLOON	PRIMULA
BIOTITE	GOSHAWK	SALABLE
CLINKER	INANITY	SERRIED
CROUTON	LAMELLA	SLEIGHT
CUMULUS	MASQUER	SPICULE
ENCHASE	ORTOLAN	STROPHE
EPOCHAL	PALATAL	TOLUENE
EUGENIC	PARQUET	VOLTAIC

*Frequency of occurrence according to the Thorndike-Lorge (1944) general count.

APPENDIX B

RAW DATA

GROUP 1 - SIX WORDS FOLLOWED BY FIVE MINUTE REST

THRESHOLD SCORES IN HUNDREDTH OF A SECOND

Serial Position of Words

	Pre-rest						Post-rest								
Subjects	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	13	15	8	10	10	20	10	11	7	11	7	9	8	9	8
2	19	13	8	7	12	7	5	10	10	6	19	8	8	8	7
3	8	33	6	34	14	8	12	9	7	8	10	9	9	8	9
4	18	20	8	9	7	31	28	7	8	43	20	10	10	11	7
5	15	8	5	6	7	6	9	8	7	8	7	9	7	8	26
6	24	60	12	40	11	32	26	10	10	14	9	25	16	9	7
7	18	10	13	13	18	11	19	11	12	11	10	8	8	10	9
8	39	18	13	14	10	12	19	13	12	9	10	13	10	17	8
9	26	13	10	13	10	10	9	9	14	14	11	10	10	12	11
10	8	7	6	8	10	7	7	7	6	5	7	6	8	6	7
11	13	6	16	11	8	10	6	10	8	7	7	8	9	7	12
12	22	22	8	7	9	8	8	9	7	7	8	6	8	8	7
13	15	10	7	5	9	7	7	8	5	7	8	10	18	5	7
14	12	8	13	11	8	9	7	10	8	7	7	6	6	8	5
15	32	6	7	6	9	8	15	16	9	27	7	7	8	10	5

Serial Position of Words

Post-rest (cont.)

	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
1	8	10	10	11	11	10	10	8	9	8	6	6	10	9	7
2	6	5	6	18	10	9	9	8	11	7	5	7	6	10	6
3	8	7	7	6	9	7	22	7	8	7	8	7	10	7	6
4	10	10	10	8	8	19	8	7	12	13	9	9	23	7	12
5	20	11	9	8	9	6	17	7	7	8	6	9	6	30	5
6	12	13	7	14	10	16	12	11	10	30	11	20	10	12	11
7	21	12	7	7	9	14	16	7	8	13	9	15	10	8	7
8	7	9	21	14	13	13	11	11	13	14	9	11	17	13	12
9	50	8	11	12	8	8	9	9	10	9	9	12	7	9	9
10	6	7	8	7	7	7	7	6	5	6	7	7	7	7	7
11	7	7	12	7	7	8	7	6	7	9	7	6	6	9	8
12	9	7	8	8	8	8	7	7	8	7	20	8	9	10	7
13	14	7	8	7	6	7	6	8	6	6	9	9	5	7	7
14	8	6	6	8	7	7	6	7	6	13	6	9	6	8	6
15	6	10	8	7	8	9	7	11	13	33	16	6	9	6	5

GROUP II - SIX WORDS FOLLOWED BY ONE DAY REST

THRESHOLD SCORES IN HUNDREDTH OF A SECOND

Serial Position of Words

	Pre-rest						Post-rest								
Subjects	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	15	11	5	18	12	9	22	13	9	10	11	9	8	7	8
2	27	10	10	14	13	38	46	8	11	12	10	10	44	13	8
3	34	13	46	14	13	11	8	8	16	9	8	7	9	7	11
4	24	20	18	16	17	10	13	34	29	13	15	15	28	23	13
5	8	8	28	9	12	10	23	10	6	8	7	9	7	8	13
6	17	17	10	7	17	6	10	14	6	22	9	19	8	33	8
7	20	16	8	9	14	11	7	6	13	9	8	7	9	9	8
8	21	17	21	8	9	9	12	8	7	8	6	7	5	9	15
9	13	15	7	8	7	9	12	15	10	10	6	11	13	13	10
10	11	7	17	16	26	10	9	8	11	6	7	9	10	10	7
11	23	11	10	7	8	7	8	12	10	9	13	8	10	8	7
12	16	18	11	12	5	10	7	9	10	11	9	14	19	13	13
13	54	10	15	15	13	13	12	15	10	12	9	12	8	14	11
14	18	13	13	12	9	5	6	18	14	10	13	7	8	7	13
15	11	9	12	7	7	8	10	7	10	8	7	6	7	20	7

Serial Position of Words

Post-rest (cont.)

	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
1	16	13	10	8	9	9	11	10	7	15	9	10	11	7	10
2	12	44	11	8	11	20	13	10	13	9	29	19	21	9	9
3	10	7	9	9	6	16	8	8	10	14	9	9	8	10	11
4	30	12	17	9	11	23	27	27	29	9	10	12	29	22	19
5	8	7	6	10	8	7	9	9	10	9	21	9	6	12	7
6	8	8	10	7	9	7	7	7	17	9	9	6	6	9	6
7	9	11	9	7	8	8	6	8	9	11	9	9	9	10	10
8	7	8	11	9	6	11	10	5	5	9	22	6	23	6	7
9	9	6	5	11	8	7	9	6	12	7	10	9	6	6	7
10	7	7	8	10	11	14	9	6	12	7	8	14	11	10	8
11	7	8	9	7	7	10	7	8	8	12	7	11	8	9	9
12	8	6	8	6	5	6	5	8	7	8	6	5	9	8	6
13	12	7	8	7	10	19	7	20	10	16	13	11	10	13	11
14	7	7	16	9	13	10	20	10	11	7	13	14	21	7	7
15	7	6	6	18	8	7	10	8	7	8	8	8	8	6	6

GROUP III - SIX WORDS FOLLOWED BY ONE WEEK REST

THRESHOLD SCORES IN HUNDREDTH OF A SECOND

Serial Position of Words

	Pre-rest						Post-rest								
Subjects	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	11	10	10	8	5	8	7	8	10	7	7	12	8	7	5
2	10	17	7	12	6	8	23	18	10	8	7	7	6	14	13
3	11	7	9	8	17	13	15	7	8	8	8	6	14	11	6
4	40	13	11	10	9	10	9	7	10	7	7	17	8	7	7
5	23	6	9	11	7	8	7	7	9	6	5	6	9	5	5
6	15	14	60	8	25	22	60	12	11	18	9	14	10	11	37
7	10	8	11	12	9	17	5	7	8	9	8	6	9	7	14
8	23	15	11	40	8	12	30	28	10	11	9	15	8	8	11
9	8	8	9	7	8	10	6	8	7	9	7	9	8	11	5
10	11	7	17	12	8	7	7	15	9	15	16	8	7	8	14
11	30	12	41	34	17	13	19	35	35	11	22	13	27	22	14
12	9	17	33	18	11	19	13	28	8	15	14	12	11	17	7
13	20	14	10	14	25	16	11	14	36	12	8	14	11	10	11
14	8	5	6	9	8	6	8	13	6	5	6	6	6	8	6
15	7	19	7	6	7	7	8	5	8	5	6	7	6	5	8

Serial Position of Words

Post-rest (cont.)

	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
1	6	6	6	5	5	8	10	6	6	5	7	5	26	7	6
2	6	7	12	7	9	6	7	8	8	9	8	7	8	7	5
3	9	6	8	19	7	7	9	7	7	9	8	8	11	7	7
4	12	8	7	13	8	6	8	6	7	10	8	8	7	7	6
5	7	6	5	7	5	5	5	7	24	5	5	6	5	5	6
6	8	24	33	45	9	11	8	46	11	45	18	13	16	13	9
7	6	6	7	7	9	7	6	7	10	7	9	10	8	7	6
8	9	13	31	6	17	15	13	9	9	10	8	13	10	9	15
9	11	5	6	6	6	7	6	32	6	7	6	6	7	10	6
10	6	8	6	5	5	7	6	7	8	6	7	6	15	7	8
11	15	18	16	13	16	16	18	19	17	14	23	26	11	19	9
12	11	13	12	10	10	20	14	8	12	10	8	10	14	11	8
13	16	18	14	18	8	8	8	9	10	10	10	6	8	8	12
14	6	6	7	8	6	6	7	5	6	6	8	6	5	8	7
15	5	6	8	6	7	7	5	6	7	8	6	7	5	7	7

GROUP IV - FIFTEEN WORDS FOLLOWED BY FIVE MINUTE REST

THRESHOLD SCORES IN HUNDREDTH OF A SECOND

Serial Position of Words

Pre-rest

Subjects	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	10	14	6	10	6	8	16	6	9	7	11	6	11	15	10
2	9	8	6	6	6	6	9	8	6	8	5	7	6	7	8
3	16	10	7	9	9	21	7	9	7	11	8	8	8	7	7
4	20	13	29	27	11	6	8	9	10	12	11	11	13	7	12
5	48	27	31	19	34	43	23	33	28	25	12	17	34	15	19
6	22	14	12	12	13	11	21	14	10	15	8	10	10	8	7
7	29	14	18	14	17	24	12	9	10	8	12	11	8	9	7
8	9	7	16	9	6	6	9	7	9	6	8	7	6	7	5
9	36	11	7	6	8	10	17	7	8	8	6	7	7	6	8
10	10	13	15	18	14	18	18	12	41	14	11	11	8	9	9
11	13	7	8	7	10	8	12	6	8	14	7	7	14	7	6
12	10	25	22	14	7	14	7	8	14	11	13	17	6	13	8
13	33	28	10	16	14	35	17	11	12	12	12	16	13	27	12
14	8	8	25	6	7	5	13	6	9	6	7	5	7	6	8
15	7	8	6	6	9	6	7	7	6	5	6	5	5	8	7

Serial Position of Words

Post-rest

	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
1	11	7	7	6	11	8	9	6	8	8	9	7	7	6	9
2	6	5	6	7	6	6	6	6	6	5	5	6	7	6	5
3	7	24	11	10	9	7	10	7	34	10	7	8	8	11	9
4	27	8	8	9	19	9	5	8	37	7	20	7	29	5	10
5	21	14	38	18	20	23	16	25	14	29	20	28	8	37	10
6	9	10	19	9	9	21	14	7	10	8	16	7	7	12	8
7	31	8	15	10	11	7	7	7	6	13	8	8	6	12	7
8	13	9	16	11	7	7	6	8	7	6	7	6	6	8	7
9	11	10	8	8	8	9	10	7	8	8	6	7	8	7	9
10	9	11	12	14	12	12	13	10	10	9	14	10	11	12	10
11	9	8	9	8	7	8	8	7	6	8	6	9	6	6	6
12	9	11	12	10	12	8	7	6	9	11	7	8	9	8	11
13	10	15	15	15	15	8	11	14	10	13	13	13	13	8	10
14	8	7	5	6	6	5	7	5	6	7	6	14	10	6	7
15	6	5	6	6	5	5	5	5	5	5	5	6	5	7	5

GROUP V - FIFTEEN WORDS FOLLOWED BY ONE DAY REST

THRESHOLD SCORES IN HUNDREDTH OF A SECOND

Serial Position of Words

Pre-rest

Subjects	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	38	18	22	8	15	9	15	7	22	9	7	27	23	8	12
2	12	8	5	6	8	6	6	5	6	5	25	5	16	6	5
3	15	14	10	14	12	12	9	7	8	11	12	9	12	30	8
4	18	10	7	8	8	10	8	7	10	16	10	14	8	11	7
5	44	21	18	9	17	8	11	8	30	17	9	13	12	7	11
6	22	23	9	12	12	8	37	9	9	8	7	8	11	7	18
7	10	10	6	5	7	6	6	6	7	5	21	16	8	5	8
8	24	27	9	8	6	20	14	8	8	7	11	16	7	7	13
9	9	9	16	12	7	6	6	7	31	8	7	7	6	7	8
10	11	20	9	14	20	9	10	9	7	9	22	6	7	8	8
11	30	15	10	8	12	9	10	8	10	8	15	7	9	6	6
12	30	22	17	11	7	7	9	33	10	6	10	7	9	7	26
13	13	7	11	8	7	8	7	8	11	10	8	6	10	9	6
14	19	13	7	5	8	5	6	6	7	8	7	6	5	7	6
15	11	11	9	9	7	10	9	9	12	8	10	7	9	6	7

Serial Position of Words

Post-rest

	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
1	9	13	9	16	9	15	7	8	15	7	11	8	17	8	9
2	8	8	9	6	8	8	5	7	14	6	7	7	7	6	8
3	12	8	10	10	27	6	8	11	11	18	15	8	6	7	13
4	7	9	19	8	11	21	7	9	9	8	9	9	9	13	8
5	17	10	10	8	12	10	9	7	8	11	9	9	14	13	15
6	10	12	7	10	7	8	34	8	8	8	7	8	11	9	9
7	6	8	12	8	11	7	9	7	6	5	7	5	7	5	16
8	13	8	8	6	11	8	26	15	13	7	10	9	15	6	16
9	8	6	11	8	8	8	10	12	7	9	8	7	8	10	6
10	19	27	17	8	13	14	23	13	7	18	8	14	9	9	10
11	9	8	7	17	9	10	9	11	8	7	7	6	6	8	10
12	9	10	19	16	19	13	12	30	14	10	8	17	20	6	8
13	10	13	14	7	12	8	10	8	11	10	8	8	7	7	7
14	10	9	6	12	6	6	9	7	6	9	8	19	6	8	11
15	7	7	14	7	7	9	6	13	8	10	9	6	7	9	7

GROUP VI - FIFTEEN WORDS FOLLOWED BY ONE WEEK REST

THRESHOLD SCORES IN HUNDREDTH OF A SECOND

Serial Position of Words

Pre-rest

Subjects	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	13	12	8	7	6	6	12	9	8	7	8	7	7	7	9
2	28	47	26	24	17	42	8	10	10	31	7	8	10	14	9
3	21	7	9	10	8	12	8	11	12	7	9	9	6	11	8
4	26	34	9	10	20	12	12	15	9	10	10	8	8	14	26
5	27	28	34	34	28	21	38	23	17	22	18	22	15	30	26
6	23	25	9	8	9	21	18	16	11	9	11	7	9	6	9
7	8	8	7	17	7	14	8	9	7	11	7	7	7	6	13
8	22	11	10	15	9	11	13	16	13	19	7	8	20	9	7
9	17	10	9	8	13	12	14	13	10	8	11	9	14	13	11
10	13	7	7	6	6	5	6	6	5	5	9	5	5	10	5
11	9	8	9	8	8	6	5	6	6	7	6	5	6	7	5
12	28	12	14	11	9	22	9	6	10	12	8	8	9	8	8
13	21	9	24	16	8	7	8	5	6	6	13	6	14	5	11
14	11	16	19	9	10	9	20	30	8	10	18	12	20	9	10
15	8	10	9	12	14	12	11	8	5	14	19	12	9	9	8

Serial Position of Words

Post-rest

	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
1	9	8	11	7	8	7	12	6	10	9	7	9	9	6	7
2	23	20	16	14	9	10	9	14	10	7	17	7	12	7	14
3	14	16	12	9	6	9	7	10	7	5	6	10	8	10	9
4	23	8	8	21	11	8	11	7	25	7	13	6	22	8	8
5	60	12	42	13	22	50	19	29	13	12	22	11	13	9	7
6	11	10	10	13	10	10	9	20	9	15	10	8	10	6	7
7	9	7	6	7	8	8	6	8	7	7	7	6	6	13	10
8	21	14	15	9	42	8	9	11	9	10	22	14	10	9	17
9	8	6	5	9	6	20	6	18	6	6	7	6	7	6	6
10	9	7	9	6	6	5	6	6	5	5	6	5	6	8	6
11	8	6	7	5	8	6	9	8	7	8	8	6	6	6	10
12	7	7	17	7	7	8	10	12	13	8	10	15	9	8	8
13	7	20	18	8	7	13	7	6	18	8	9	13	12	5	6
14	7	21	6	13	9	7	7	7	7	9	6	7	8	6	8
15	8	11	11	12	12	9	12	12	10	20	18	8	12	10	10

GROUP VII - TWENTY-FOUR WORDS FOLLOWED BY FIVE MINUTE REST

THRESHOLD SCORES IN HUNDREDTH OF A SECOND

Serial Position of Words

Pre-rest

Subjects	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	9	8	9	10	7	10	7	10	8	9	7	8	7	10	7
2	28	10	11	19	8	24	9	9	8	8	7	8	6	6	8
3	11	19	8	10	9	11	8	10	8	15	6	7	10	7	9
4	22	10	10	11	15	12	9	13	10	11	9	12	10	9	12
5	21	18	14	13	10	10	10	11	16	14	11	9	13	7	9
6	16	13	26	12	26	11	12	7	11	7	10	7	15	14	10
7	8	7	8	11	8	11	7	10	14	9	14	7	6	14	12
8	22	7	13	11	23	12	9	7	10	10	9	8	8	9	7
9	35	24	12	9	6	10	10	13	12	20	24	20	8	19	11
10	15	10	11	12	11	10	40	10	13	13	18	9	8	9	15
11	12	11	17	8	8	6	7	10	8	9	5	9	10	5	6
12	28	6	16	13	10	8	10	8	7	9	10	7	10	7	7
13	11	8	9	6	9	7	15	13	9	8	10	10	10	9	8
14	10	7	17	9	8	8	8	7	10	7	7	7	8	7	7
15	11	13	29	36	13	18	17	13	21	18	13	21	13	19	21

Serial Position of Words

	Pre-rest (cont.)									Post-rest					
	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
1	11	7	8	10	10	7	9	7	10	7	7	7	7	10	8
2	6	6	5	5	6	7	7	8	8	6	5	12	6	5	7
3	10	8	6	7	11	9	9	7	8	7	7	7	10	8	11
4	7	7	11	11	7	11	12	10	8	7	36	14	9	10	14
5	10	7	7	7	11	18	8	9	10	8	12	8	7	10	8
6	11	10	10	9	17	11	10	9	11	12	9	8	11	12	12
7	8	7	7	11	11	6	7	8	7	21	10	7	6	7	16
8	6	7	9	13	8	6	10	10	9	7	6	13	6	10	6
9	8	42	10	11	10	8	7	7	12	11	10	8	7	12	13
10	7	9	10	7	11	6	8	14	7	10	8	10	8	8	8
11	10	8	9	6	6	6	7	8	6	7	11	12	8	5	8
12	6	6	5	7	7	6	8	9	5	8	9	5	7	7	6
13	6	6	10	10	9	8	7	7	8	11	8	7	6	7	6
14	7	6	6	7	7	10	7	6	7	6	8	7	7	6	7
15	17	18	8	22	16	10	11	27	6	14	28	12	16	15	9

GROUP VIII - TWENTY-FOUR WORDS FOLLOWED BY ONE DAY REST

THRESHOLD SCORES IN HUNDREDTH OF A SECOND

Serial Position of Words

Pre-rest

Subjects	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	15	15	16	15	11	14	14	13	12	13	8	14	8	9	10
2	12	6	6	20	18	7	10	21	8	10	6	8	5	8	5
3	19	18	18	11	10	7	10	12	7	8	7	12	8	15	11
4	21	14	41	21	12	17	11	14	13	9	7	9	14	11	16
5	11	12	12	8	7	8	14	20	7	8	10	13	7	7	6
6	20	10	22	16	16	7	10	32	16	22	12	7	8	15	15
7	18	12	18	13	24	12	11	7	10	7	17	7	7	7	12
8	11	8	8	8	13	6	21	25	9	14	25	9	5	8	13
9	25	14	10	11	12	10	11	9	9	9	13	12	13	7	9
10	25	9	15	8	9	9	18	9	13	8	10	8	12	13	13
11	18	12	19	29	13	6	13	9	27	9	5	7	10	7	11
12	18	14	15	14	14	10	13	8	12	15	9	10	12	13	10
13	13	20	13	10	19	11	14	10	19	19	9	10	12	7	13
14	23	14	15	8	7	8	8	11	9	8	8	7	8	10	10
15	38	29	14	21	10	16	12	18	8	9	7	8	9	7	12

Serial Position of Words

	Pre-rest (cont.)									Post-rest					
	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
1	9	11	7	9	11	8	7	10	7	13	8	9	8	7	8
2	9	7	9	11	9	6	8	8	8	12	8	10	6	8	8
3	8	9	7	9	7	6	7	5	8	7	14	11	6	14	7
4	16	10	16	11	7	22	7	9	10	20	9	21	39	10	5
5	7	11	7	10	8	11	5	8	6	10	12	9	8	8	10
6	10	10	8	13	9	10	7	9	9	7	11	9	16	15	6
7	14	8	9	7	16	7	10	9	12	6	7	7	7	6	8
8	16	7	23	9	7	8	16	10	16	12	6	21	8	16	8
9	9	12	10	9	14	7	8	10	8	16	8	9	10	7	8
10	11	7	15	9	8	11	6	10	15	8	14	8	9	10	8
11	7	33	9	10	6	10	9	7	13	13	23	14	16	9	13
12	8	9	14	9	11	8	10	7	10	10	13	8	9	9	9
13	14	9	12	9	18	19	8	9	15	10	11	10	9	10	9
14	8	9	11	9	9	6	8	8	10	8	8	10	8	9	8
15	7	7	9	7	10	6	8	7	10	17	10	10	12	7	9

GROUP IX - TWENTY-FOUR WORDS FOLLOWED BY ONE WEEK REST

THRESHOLD SCORES IN HUNDREDTH OF A SECOND

Serial Position of Words

Pre-rest

Subjects	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	16	9	12	31	16	11	10	7	11	8	10	10	12	5	9
2	10	9	7	7	7	6	7	7	6	17	8	6	9	6	6
3	12	9	13	29	9	8	10	6	24	11	8	10	7	5	6
4	17	30	16	14	8	18	20	13	10	38	6	10	12	8	7
5	7	8	5	13	12	9	8	8	7	8	9	12	7	11	7
6	55	7	9	8	7	9	14	18	6	9	26	10	6	16	6
7	10	8	8	8	8	8	8	6	8	7	9	16	8	6	19
8	16	20	11	8	9	6	9	16	21	19	9	16	6	37	9
9	10	8	7	13	7	10	7	11	9	7	8	7	10	8	8
10	27	20	8	21	11	10	10	9	14	8	10	22	9	18	9
11	16	6	6	8	13	8	7	9	6	6	6	8	9	12	10
12	36	8	34	7	29	19	7	9	13	7	8	10	6	11	8
13	13	22	32	7	11	7	12	8	6	14	7	7	7	7	7
14	13	10	14	6	7	5	6	12	7	5	6	7	6	8	11
15	8	7	19	12	18	7	9	14	7	8	7	8	6	9	12

Serial Position of Words

	Pre-rest (cont.)									Post-rest					
	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
1	7	8	10	9	10	8	6	7	7	31	18	13	16	15	21
2	6	5	9	8	8	8	7	7	23	7	6	6	7	9	6
3	8	6	8	7	7	41	25	7	7	12	25	9	10	7	5
4	15	7	12	13	15	6	24	7	7	9	18	7	7	11	8
5	9	6	7	13	7	13	7	6	6	8	10	11	7	8	7
6	30	21	11	7	12	8	7	9	8	7	14	29	7	27	12
7	7	8	7	7	9	8	8	10	9	9	12	6	7	8	8
8	22	8	8	13	22	32	9	33	7	40	8	12	12	14	19
9	8	8	8	8	10	6	8	8	9	8	8	14	7	8	9
10	33	11	12	13	10	8	9	8	29	13	17	17	19	11	10
11	8	9	11	6	6	10	6	7	7	8	8	10	8	10	5
12	13	43	13	8	6	9	8	8	6	19	8	8	21	6	9
13	7	12	8	5	7	7	8	6	6	7	19	7	7	7	7
14	11	6	20	6	6	8	5	7	6	6	9	7	8	6	7
15	6	6	6	10	9	9	7	8	7	7	11	8	10	13	10

APPENDIX C

TESTS OF MEANS

TABLE I

NEUMAN-KEULS TEST FOR MEANS - 6 PRACTICE GROUPS

Last Pre-rest Blocks - Between Groups

1 day	5 min.	1 week
115.56	118.22	123.33
115.56	2.66	7.77
118.22		5.11
123.33		

First Post-rest Blocks - Between Groups

5 min.	1 day	1 week
103.33	124.89	138.89
103.33	21.56*	35.56*
124.89		14.00*
138.89		

Second Post-rest Blocks - Between Groups

1 week	1 day	5 min.
97.11	98.89	105.56
97.11	1.78	8.45
98.89		6.67
105.56		

$q.95\ (3,42) = 10.83$

$q.95\ (2,42) = 9.01$

TABLE II

NEUMAN-KEULS TEST FOR MEANS - 6 PRACTICE GROUPS

Last Pre-, First Two Post-rest Groups - Within Groups

5 minute

	1st Post	2nd Post	Last Pre
	103.33	105.56	118.22
103.33		2.23	14.89*
105.56			12.66*
118.22			

1 day

	2nd Post	Last Pre	1st Post
	98.89	115.56	124.89
98.89		16.67*	26.00*
115.56			9.33*
124.89			

1 week

	2nd Post	Last Pre	1st Post
	97.11	123.33	138.89
97.11		26.22*	41.78*
123.33			15.56*
138.89			

$q.95\ (3,84) = 8.68$

$q.95\ (2,84) = 7.22$

TABLE III

NEUMAN-KEULS TEST FOR MEANS - 15 PRACTICE

Last Pre-rest Blocks - Between

	1 day	5 min.	1 week
	96.00	97.78	107.11
96.00		1.78	11.11*
97.78			9.33*
107.11			

First Post-rest Blocks - Between

	1 day	5 min.	1 week
	107.11	116.89	131.11
107.11		9.78*	24.00*
116.89			14.22*
131.11			

Second Post-rest Blocks - Between

	5 min.	1 day	1 week
	99.33	104.00	111.56
99.33		4.67	12.23*
104.00			7.56
111.56			

$q.95\ (3,42) = 11.04$

$q.95\ (2,42) = 9.18$

TABLE IV

NEUMAN-KEULS TEST FOR MEANS - 15 PRACTICE

Last Pre, First Two Post-rest Blocks - Within

5 minute

	Last pre	2nd Post	1st Post
	97.78	99.33	116.89
97.78		1.55	19.11*
99.33			17.56*
116.89			

DIFFERENCES - Last pre, 1st Post
- 1st post, 2nd post

1 day

	Last pre	2nd Post	1st Post
	96.00	104.00	107.11
96.00		8.00*	11.11*
104.00			3.11
107.11			

1 week

	Last pre	2nd Post	1st Post
	107.11	111.56	131.11
107.11		4.45	24.00*
111.56			19.55*
131.11			

$q.95\ (3,84) = 6.69$

$q.95\ (2,84) = 5.56$

TABLE V

NEUMAN-KEULS TEST FOR MEANS - 15 PRACTICE

First Post-rest Blocks (Adjusted) - Between

	1 day	5 minute	1 week
	110.85	119.08	125.19
110.85		8.23	14.34*
119.08			6.11
125.19			

q.95 (3,41) = 11.90

q.95 (2,41) = 9.90

TABLE VI

NEUMAN-KEULS TEST FOR MEANS - 24 PRACTICE

Last Pre-rest Blocks - Between

	5 min.	1 day	1 week
	87.78	90.44	94.67
87.78		2.66	6.89*
90.44			4.23
94.67			

First Post-rest Blocks - Between

	5 min.	1 day	1 week
	100.67	110.44	121.33
100.67		9.77*	20.66*
110.44			10.89*
121.33			

Second Post-rest Blocks - Between

	5 min.	1 day	1 week
	87.11	97.78	101.33
87.11		10.67*	14.22*
97.78			3.55
101.33			

$q.95\ (3,42) = 6.71$

$q.95\ (2,42) = 5.58$

TABLE VII

NEUMAN-KEULS TEST FOR MEANS - 24 PRACTICE

Last Pre-, First Two Post-rest Blocks - Within

5 minute

	2nd Post	Last Pre	1st Post
	87.11	87.78	100.67
87.11		.67	13.56*
87.78			12.89*
100.67			

1 day

	Last Pre	2nd Post	1st Post
	90.44	97.77	110.44
90.44		7.33*	20.00*
97.77			12.67*
110.44			

1 week

	Last pre	2nd Post	1st Post
	94.67	101.33	121.33
94.67		6.66*	26.66*
101.33			20.00*
121.33			

$q.95\ (3,84) = 5.76$

$q.95\ (2,84) = 4.79$

TABLE VIII

NEUMAN-KEULS TEST FOR MEANS - 24 PRACTICE

First Post-rest Blocks (Adjusted) - Between

	5 minute	1 day	1 week
	102.58	110.75	119.10
102.58		8.17*	16.52*
110.75			8.35*
119.10			

q.95 (3,41) = 6.74

q.95 (2,41) = 5.61