INTERVAL EFFECTS IN

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By

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SCOPE AND CONTENTS:

Three experiments, involving 250 subjects, were performed which support the conclusion that a tone cue presented shortly before a tachistoscopic stimulus facilitates tachistoscopic recognition. With tone-stimulus intervals below two seconds no threshold differences occurred. With intervals between two and eight seconds, the shorter the interval was, the lower thresholds were, and the more practice decrement observed. Experiment II showed that while the tone-stimulus interval affects thresholds the most, the interval between successive exposures of a stimulus affects thresholds. We concluded that as this interval is lengthened, the subject forgets information already gained. Experiment III showed that training in a reaction time task transferred positively to a tachistoscopic task when a two second tone-stimulus interval was used in both tasks. Reasons for the facilitative effect of the tone were discussed.

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CHAPTER I

HISTORICAL INTRODUCTION

The work described in this thesis is specifically concerned with determinants of the practice effect in tachistoscopic recognition, which is taken as an example of the general process of perceptual learning. The work follows from a series of experiments discussed by Newbigging (1965). Those experiments dealt with two perceptual learning tasks; the practice decrement in tachistoscopic word recognition and the practice decrement in the Muller-Lyer Illusion task. Newbigging concluded that the practice effect in these tasks is not specific to the particular stimulus used in training, but that some mediating mechanism must be involved which is, to a large extent, independent of the specific stimulus. In this historical part of the thesis we will first discuss perceptual learning theory, then review the literature concerned with tachistoscopic practice decrement. Finally, we shall try to develop the point that the mechanism needed to account adequately for tachistoscopic learning has some relevance to perceptual learning observed in other tasks.

We should note immediately that the perceptual learning literature may be placed in either of two main categories. The first category consists of the changes in perception that occur over the life span of the organism with special emphasis on the formative years. The second consists of changes which occur within limited experimental sessions. It is the second category that we deal with in this thesis.

A formal definition of the "changes" which are taken to be evidence of perceptual learning within an experimental session present some problems. Two definitions, one by Eleanor Gibson (1963), the other by Postman (1955), illuminate the deep division of opinion that exists over the problem of what is learned in perceptual learning. Gibson defines such learning as "any relatively permanent and consistent change in the perception of a stimulus array, following practice or experience with this array" (1963, p. 29). Postman offers a quite different definition; perceptual learning is "changes in stimulus-response relationships under controlled conditions of practice" (1955, p. 440). Before discussing the merits of these definitions we should note another point of disagreement between the Gibsons' and Postman about what can be taken as evidence of perceptual learning. Gibson (1953) and Gibson and Gibson (1955) specifically reserve the term perceptual learning for those situations in which the subjects' responses indicate that perception has become more veridical. Postman (1955) rejects this limit. For example, consider a subject put into an experimental situation in which lines are presented and the subject is required to estimate their length. If by means of reinforcement contingencies the subject is lead to make progressively more erroneous estimations, the Gibsons would reject this as a case of perceptual learning, while Postman would accept it.

This basic disagreement stems from their definitions. In this case of line length estimations changes in S-R relationships are taking place in an orderly fashion so Postman's definition fits the case. But when we consider the Gibsons' definition the question is has there been a change in the subject's perception of the lines? The Gibsons would say no; these changes are not perceptual changes, but response changes. This points out one strong point of Postman's definition since in any experiment response changes are the basic data. But the Gibsons' definition implies that Postman has dealt with only one problem of perception, that is learning how to name or identify what we see. The Gibsons' maintain that perceptual learning is a matter of perceiving progressively more subtle attributes of the stimulus.

In the Gibsons' terms the stimulus is perceived differently, since by some process (as yet unspecified by them) the subject comes to respond to different and more detailed features of the stimulus. Any stimulus (even such a simple one as might be involved in the estimation of the two-point limen) has complex attributes. S-R formulations such as Postman's are inadequate according to the Gibsons, since rather than stressing the differentiation of complex attributes, they imply that perception as it improves becomes less and less dependent on present stimulation and more dependent on past associations.

Lawrence (1959) uses the two-point limen as an example to show how an integration of these two theories is possible. The usual S-R relationship is divided into two parts with learning occurring both in the perceptual and response components. Mukhurjee (1933) showed that the minimum separation of two points which can be discriminated on the forearm can be reduced with practice from one-third to one-sixth of its original value. Lawrence uses the paradigm S-SAC-R to explain this result. Lawrence here assumes that the S-R relationship is never direct, but that the correlation between the proximal stimulus and the response is always dependent on some intervening event. The SAC is the result of this intervening event and means "stimulus as coded". The SAC (the result of an internal process) arises when there is a sensory input which is acted upon by a "coding response". So in any perceptual learning task two things are involved. On the perceptual side of the paradigm (S-SAC) the subject develops an appropriate coding response which by processing the proximal stimulus results in the SAC. The second part of learning consists of learning the appropriate response (verbal label) to describe the experienced event, i.e., the SAC-R correlation. These two types of learning take place simultaneously by trial and error.

But what constitutes a coding response and how is it developed? By coding Lawrence means "if there is a set of objects or events and to each of them a different label is assigned, then the labels code these objects or events" (p. 188). Any proximal stimulus has many attributes (eg., size, colour, shape, texture) which can be the effective variable of stimulation for behaviour. The coding response selects an attribute(s) as the effective stimulus (SAC) for a response. This response will either be reinforced or not reinforced. If reinforced the subject will continue to respond on the basis of the coding response he used on the reinforced trial. If not reinforced, sooner or later the subject will code the stimulus on the basis of another stimulus attribute. The coding response can be refined, as it were, in that the subject may code a SAC based on both colour and texture and be reinforced. However, if the crucial attribute of the stimuli is colour, then the subject will be presented with stimuli in which the texture cue dictates a different response from the colour cue. Those responses based on texture will not be reinforced so that the coding response will gradually become one based on colour.

How does this work in the case of the two-point limen practice decrement. Let us assume that, as the Gibsons maintain, perceptual learning is a matter of discovering new aspects of the stimulus. The changing and modification of coding responses as used by Lawrence is the mechanism by which such attributes emerge. At the start of practice the subject discriminates on the basis of a SAC correlated with pressure components of the stimulus. As practice continues he may develop an SAC correlated with the tactual stimulation from skin deformation, thus permitting a finer discrimination. This example illustrates one problem with both the Lawrence and Gibson formulations. One can concede that any stimulus has complex attributes, even such ones as used in the two-point limen determination. But fashioning reasonable suggestions as to what these attributes may be proves extremely difficult. Lawrence in using this example avoids stating the difference between "pressure components" of the stimulus and "tactual stimulation from skin deformation". At any rate the second part of learning (SAC-R) is the response "one" or "two" and in this case is learning already established before the testing session.

Let us note that this explanation by Lawrence has one theoretical advantage over both the Gibson and the Postman formulations. This advantage is that he has suggested a mechanism to account for transfer effects in perceptual learning. The Gibsons' theory, since it places the main stress on differentiation of the particular stimulus item in question, implies that transfer effects will not be pervasive. Eleanor Gibson (1953) gives support to this implication by maintaining that in fact transfer effects are not pervasive and that they generally exist only to the extent that the training and tests tasks are similar. Postman has not discussed a mechanism which might mediate transfer.

Yet extensive transfer effects have been found in many areas of perceptual learning. The experiment by Mukherjee already mentioned found that practice in reducing the two-point threshold on the forearm resulted in threshold decrement in other areas of the same arm. Bruce and Low (1951) found that a group given training in recognizing airplanes and surface craft had better visual acuity when tested with brief exposures of a Landolt C figure than a group which did not have such training. Renshaw (1945) showed that tachistoscopic training improved the skill of Navy pre-flight trainees in plane recognition when the tachistoscopic training consisted of digits.

Transfer effects have also been shown in a quite different perceptual task. Parker and Newbigging (1963) trained subjects on a version of the Muller-Lyer Illusion in which the conventional arrowheads were replaced by circles. They found the amount of illusion on the Muller-Lyer figure itself to be a direct function of the amount of pre-training with this figure. Another experiment by Dewar (1965) showed that subjects trained on a Muller-Lyer figure with 60^{o} obliques had a smaller illusion on a figure with 120^{o} obliques than did a group trained from the outset on a figure with 120^{o} obliques. A more dramatic example of transfer effects is that found by Rudel and Teuber (1963). They had two groups of subjects. The first group made eighty visual settings of a Muller-Lyer figure, then six tactual settings were attempted with the subjects blindfolded. For the second group the order was reversed, i.e., eighty tactual settings followed by six visual settings. They found (1) the illusion exists tactually as well as visually (2) the initial amount of illusion for both modalities is roughly equal (3) illusion decrement takes place in both modalities with practice, and there is no statistical difference between the amount of decrement in each modality (4) transfer of the decrement effect works both ways, but the transfer from touch to vision is greater than from vision to touch. These experiments taken as a whole seem to suggest that transfer effects are more pervasive than Gibson (1953) concluded.

We now turn to a discussion of a series of tachistoscopic experiments which will provide a background for the experiments later described. Our discussion will be limited to those relatively few studies which have a direct bearing on the practice effect.

The practice effect in such experiments is simply that when a number of different stimulus items are presented to subjects for recognition each successive item takes fewer exposures to be identified than did the previous item. Most of the work on tachistoscopic recognition has been concerned with variables that raise or lower the absolute threshold values. Such variables as connotative meaning, word frequency, different psychophysical methods, meaningfulness and word length have been shown to affect thresholds. The experiments involved are beyond the scope of this thesis since they do not account for the practice decrement typically observed in tachistoscopic recognition. However, we should note that the effects of both word frequency and word length interact with the serial position of stimuli. This is because with extremely short words and with high frequency words, the threshold of the stimulus which is first exposed is so low that little practice decrement occurs. However, with long words and low frequency words a sizeable practice decrement is typically found.

The first experimenter to mention a practice effect in tachistoscopic recognition was Renshaw (1945). The primary purpose of his study was to determine if tachistoscopic training with numbers could improve airplane recognition, but he also noted that the recognition threshold was reduced over trials. Howes and Solomon (1951) did a more comprehensive evaluation of the practice effect, although they were primarily concerned with the word frequency effect. In their experiment sixty words of mixed frequency were used as the stimulus items. They found that about 75% of the practice effect took place in the first quarter of the list, although improvement did continue throughout the whole experiment.

The magnitude of the improvement is not overwhelming, since in a typical experiment of the type, even the worst subject rarely has a threshold over 500 msecs. However, in the Howes and Solomon experiment, the second word showed an average threshold of about 315 ms., the highest recorded. The lowest average threshold of about 110 ms. occurred for word fifty-five. Each of these figures is based on the scores of nineteen subjects. We might also note that their data, although based on nineteen subjects and showing a clear practice effect, is extremely erratic. So while improvement does indeed take place, it seems to be very much subject to the effect of random variables. For instance, the threshold for the first word in this experiment was almost 100 msecs. lower than the threshold for the second word.

The next study to mention practice was by Speilberger (1956) who found an interesting interaction effect. Speilberger was concerned mainly with the perceptual defense controversy. To test the defense hypothesis he had two groups of subjects, stutterers and non-stutterers. He measured their thresholds under two conditions of responding, oral and written. He found a practice effect for three of his groups. Under both conditions of responding, non-stutterers showed a practice effect, as did the stutterers when their response was written. But, under the oral condition stutterers did not improve their performances. Speilberger interpreted this difference as a case of response suppression by the stutterers. He contends that the stutterers could recognize the word, but the anxiety of saying it prevents lowered thresholds.

Doehring (1962) supplied evidence that the practice effect in tachistoscopic learning is very pervasive. The studies discussed so far only assessed practice effects during one experimental session. Such sessions usually last about one hour. He tested subjects over four experimental sessions. During each session the subject was presented with twenty-seven words to recognize tachistoscopically. The first three words in each session were practice words and data was not collected for them. Of the twenty-four test words six were low frequency, six were high frequency, six were "good" words (eg., rose, heal) and six were "bad" words (eg., rage, thief). The good and bad words were matched for frequency. The sessions were separated by two to six days and different lists of words were used in each session.

All four of the word conditions showed a practice effect. This effect seemed to have reached its limit by the third session since the fourth session produced no further improvement. This is to be expected since by the beginning of the fourth session the subject had recognized seventy-one items. Doehring presents his data averaged over sessions, so it is impossible to tell exactly the form the practice effect took within sessions.

The only study using the Ascending Method of Limits which has not found a practice effect is one by Koplin and Speilberger (1964). In a study designed to test the effects of meaningfulness, they constructed twelve CVC trigrams (three letter syllables) which were homogeneous for pronounceability. The trigrams were broken into three equal groups of low, medium, and high meaningfulness. Koplin and Speilberger found a significant interaction between meaningfulness and stimulus position. Low meaningful trigrams showed a decrement in threshold between the first and second halves of training, but medium and high trigrams both produced higher thresholds in the second half of training than in the first half. One point in their procedure renders the results difficult to interpret. The "stimulus words were presented one at a time in the <u>same fixed order</u> to each subject" (p. 208). Therefore, it seems entirely possible that their results are attributable to the order of the particular stimulus items used rather than a crucial finding about the practice effect.

The traditional explanation of the practice effect is that the effect is due to the establishment of a set. It will be recalled that Speilberger (1956) felt that response suppression by stutterers in his experiment was responsible for their inability to improve thresholds when responses were oral since they did show a practice effect in the written condition. Haber (1966) identifies four ways in which set could influence threshold values. The first is a "tuning" hypothesis which maintain that the relevant attribute defined by the set stands out and is perceived more vividly as a result of the set. The other three ways may be characterized as "response" hypothesis. Set could (1) increase the probability of a given response (2) cause the subject to attend to the relevant stimulus attribute, so that it is reported before the memory of the stimulus dissipates (3) modify the memory trace. Haber concludes his article by stating that the necessary experiments have not been done to permit a choice between "tuning" and "response" hypotheses.

One way in which set can influence thresholds has been put forth by Tulving (Tulving and Gold, 1963; Tulving, Mandler and Baumal, 1964). The tachistoscopic situation is one in which the subject has two sources of information (1) from the tachistoscopic exposure and (2) from other sources. The task of the subject is to "select a previously learned response from a set of alternative responses" (Tulving and Gold, 1963, p. 319). Therefore, the examination of this source is directed to evaluating the effects on recognition thresholds of amount of information content and degree of congruity of the stimulus materials with the pre-exposure situation. A number of experiments show this approach to be important. Miller, Bruner, and Postman (1954) found that with letter sequences of eight that the closer the approximation of the sequence to an English word, the more letters could be identified at sub-threshold exposure. Morton (1964) found that the threshold of a word was lowered in a context based on the probability of that word in the context.

The following experiment is important for showing the effects of set within a series of trials. Blake and Vanderplus (1950) identified two types of stimulus words - those words which had been incorrectly identified before being correctly identified, and those which had not. Those that had been incorrectly guessed had higher thresholds. The authors conclude that the act of guessing establishing a set which will act to confirm the guess, thus raising thresholds.

It seems from this type of data that one explanation of tachistoscopic practice decrement is that a set (even if not stated or implied by the experimenter in instructions to the subject) is established which raises the probability of certain responses which then lower thresholds. One experiment which supports this notion is that of Postman and Leytham (1951). No explicit set was established by instructions. The first three words were practice words, then twelve words representing personality traits were presented, followed by two "neutral" words (mileage and apparel). It was expected that a set for trait names would develop which should have some effect on response probability thus raising the thresholds for the final two words which were inconsistent with the set. This is the result that was obtained. Postman and Leytham controlled for word frequency, so that it cannot be used to explain the results. The sixteenth word (the set breaker) had a higher threshold than the first word used, but the word immediately after had a threshold considerably lower. The authors conclude this to mean that the set can be easily dissipated. This group in which set was built up implicitly was compared with a group who had explicit instructions regarding the set. There was no difference between the two groups.

The only methodological criticism that can be made of this study is that the same seventeen words were used for each subject and always in the same order. Therefore, the evidence for this effect is based on responses to only the one word mileage. This is a possible source of error since it has shown that frequency is not the only tachistoscopic variable, and that frequency estimates are not precise.

We must question the results of this experiment because a series of experiments (Newbigging and Hay, 1962; Hay, 1963; Munoz, 1963; Newbigging, 1961, 1965) originally designed to test a set response-probability explanation for the practice effect concluded that this was not the primary influence, although it may play a minor role.

Newbigging (1961) showed that the size of the fragment of a tachistoscopically presented word that was perceived was a direct function of exposure duration. So if establishing a set for a certain type of word increases response-probability, then on each succeeding stimulus the correct response should be elicited by smaller and smaller fragments of the stimulus. The size of the fragment was estimated from the degree to which the incorrect response approximated the stimulus. Two criteria were used by Newbigging and Hay (1962) to estimate the size of a given fragment. One point was given for each letter in the response word that corresponded to a letter in the stimulus word and one point was given for each pair of letters which was correct, adjacent, and in the right order. Hay (1963, p. 47) points out as example that the response "COAT" to the stimulus "CODE" would receive three out of a possible seven points. Thus, this fragment could be scored as 43% similar.

Newbigging and Hay (1962) reasoned that if a response-probability notion is correct the fragment size which elicits the correct response for word n should be smaller than the fragment necessary to elicit the correct response for the first word. Two exposures of a stimulus word are important here. First, the exposure on which the word is correctly identified (RT) and second the exposure immediately before that one and identified as RT-1. Newbigging and Hay showed that over stimulus presentations the size of the fragment on RT-1 decreased in line with the hypothesis. You will note then that Newbigging and Hay are not actually measuring the size of the fragment necessary to elicit a correct response, but the size of the fragment on the preceding exposure. So, as Hay (1963) points out this method of estimation may involve a faulty assumption. This assumption is simply that the amount of information gained on the exposure which results in recognition for the first word is the same as the amount of information gained on the recognition exposure for word n. This assumption may be invalid if a general non-specific tachistoscopic skill is developed in training.

Their basic finding is that the size of the fragment necessary to elicit a correct response decreases over trials. This can mean (1) that response-probability is increasing (eg., the assumption above holds) or (2) the subject is perceiving more per exposure, that is, on the identifying exposure on word n he picks up more letters then on the identifying exposure on the first word or (3) a combination of the two is happening. So the Newbigging and Hay experiment while being instructive is far from conclusive as there are no reasons a priori for accepting or rejecting the key assumption.

Hay (1963) did three experiments attacking the problem in another way. First, she compared the learning effects of three lists. She found that a mixed frequency list had higher thresholds than either a low frequency or a high frequency word list. This is what a response-probability hypothesis would predict since in an homogeneous list (i.e., a list composed of words with similar frequencies) the population of possible responses is smaller than in a hetergeneous (mixed frequency) list. Hay's next experiment however contradicts Postman and Leytham (1951) and is damaging to a response-probability hypothesis.

She trained four groups of subjects (1) on numbers (2) on low frequency words (3) high frequency words (4) adaptation; a group given tachistoscopic exposures, but with no stimuli presented. Then, without interruption, all groups were presented with eighteen low frequency words for recognition. A response-probability hypothesis must predict threshold differences for these four groups on the eighteen low frequency words. The group given adaptation trials and the group trained on numbers should have the highest thresholds. For the adaptation group no population of responses has been defined and for the group presented with numbers, a set for numbers should be elicited which would raise thresholds in the test series of low frequency words. Similarly, differences in threshold should be found between the group trained on high frequency words and the group trained on low frequency words. Thresholds for the group that was trained on low frequency words should continue to decline since there is no change in word frequency of the stimuli presented for recognition. However, the group trained on high frequency words should have raised thresholds since a set inconsistent with low frequency word responses has been established.

However, Hay found that all groups had threshold values which were not significantly different, except for the adaptation group. In this study Hay had only nine training words so it is possible that she did not run enough trials to seriously affect response-probabilities. So in her next study she gave three different groups either one pre-training trial, three pre-training trials or twenty-seven pre-training trials, all with high frequency words before having them recognize a common list of low frequency words. A response-probability interpretation of the practice decrement would predict that the more prior practice with high frequency words the higher the threshold should be for the low frequency words. The finding was exactly opposite to this prediction. This seems to support a notion that some sort of general tachistoscopic skill is being developed, which is to some extent independent of the specific stimulus items used in training (Hay, 1963, p. 105).

A question then arises as to what features of the tachistoscopic situation are responsible for the practice decrement found. Hay (1963) noted a procedural difference in tachistoscopic experiments. Some experimenters (eg., Newbigging and Hay, 1962) have provided fixation aids to indicate to the subject where the stimulus word would be exposed, while other experimenters have left the exposure field blank (eg., Howes and Solomon, 1951). Using a list of low frequency words as stimuli, Hay did an experiment to test the effects of fixation aids on tachistoscopic recognition. She tested two groups of subjects. One was provided with a fixation point which indicated where the middle letter of each word would appear. The second group had no fixation point. She found that the group with the fixation point had a lower threshold on the first stimulus than did the group provided with no fixation point. Both groups showed a significant practice effect, but the group with no fixation aid showed a greater practice effect than did the other group. There was no significant difference in threshold between the two groups on the last test stimulus. This, then, suggests that when the subject is not provided with a fixation point, he gradually, over a number of exposures, learns approximately where the stimulus will appear.

Munoz (1963) explored another feature of the tachistoscopic situation which seems to be a factor in the practice effect. It was noted in the earlier experiments done by Hay that a micro-switch lever made an audible click about two seconds before each stimulus exposure. Munoz tested for the possible cue effect of this click.

The stimuli were eighteen words having a frequency of occurrence of 1/3.6 million as determined by the Thorndike-Lorge (1944) word count. In place of the lever click he used a 60 db., 880 cps. tone of one second duration which was delivered to the subject through earphones either two, four, or eight seconds before the stimulus was exposed. He found that thresholds for the group with the two second tone-stimulus interval were lower than thresholds for the eight second tone-stimulus interval group. More important he also observed that a greater practice decrement occurred when the two second interval was used than when the eight second interval was used. The first three stimulus items of the eight second interval group had an average threshold of about 162 msecs., while the last three stimuli (of eighteen) had an average threshold of about 143 msecs. The two second interval group however started at 171 msecs. for the first three stimuli, but by the last three stimuli the threshold was down to 110 msecs.

In another experiment he studied the effects of such a tone cue as compared to the effects of a fixation aid such as Hay had used. He ran three groups of subjects in this experiment which are of interest to us. One of these groups was provided with a fixation point, but no tone cue, a second group was not provided with a fixation aid but a tone cue was delivered two seconds before the stimulus exposure. A final group had both a fixation point and a tone cue which was delivered two seconds before the stimulus exposure. Munoz found that the group with the tone cue and no fixation point was slightly better than the group that had a fixation point but no tone cue. However, the group provided with both a fixation point and tone cue was best of all suggesting that the effects of these two aids are cumulative.

Newbigging (1965) addressed himself to the problem of what mechanism is needed to explain these data. He also discussed in this paper the work on the Muller-Lyer Illusion done by Parker and Newbigging (1963) and Dewar (1965) which we have already mentioned. From these studies the following results are crucial to his argument: (1) Parker and Newbigging showed that practice with an illusion figure in which the obliques of the Muller-Lyer Figure were replaced with circles resulted in less illusion effect when subjects were switched to the Muller-Lyer Figure; (2) they also showed that adaptation trials with the apparatus but with no stimulus pattern resulted in no illusion decrement in the test series. This is comparable to Hay's (1963) finding that similar adaptation trials had no effect on subsequent word recognition thresholds; (3) Dewar showed that the amount of illusion decrement is greater when the angle of the obliques is smaller; (4) and that training with 60° obliques on this figure resulted in more illusion decrement when the test figure had obliques of 120° than did training with 120° obliques.

These experiments (the Hay and Munoz work on tachistoscopic recognition and the Muller-Lyer Illusion work just referred to) have some common features. First, the learning exhibited in both of these perceptual learning tasks shows a marked independence of the specific stimulus display used. Second, in both tasks learning exhibited on one type of stimulus readily transfers to a task using another type of stimulus. For instance, as mentioned, Hay found training with high frequency words produced a threshold decrement in tachistoscopic recognition for subsequently presented low frequency words. Dewar found training on a Muller-Lyer figure with 60° obliques showed positive transfer when the subject was tested on a figure with 120° obliques. Newbigging concludes that these experiments taken as a whole suggest that attentional responses which are not specific to the stimulus used in training mediate the practice decrement found in both of these tasks. In the case of tachistoscopic word recognition the attentional responses are acquired to cues temporally related to the stimulus presentation. In the case of the Muller-Lyer figure the subject's attentional responses are elicited by the horizontal portions of the figure and practice helps the subject overcome the distracting effects of the obliques. Newbigging in this paper was primarily concerned with putting forward the point that attentional responses might mediate learning in two such different tasks as tachistoscopic recognition and illusion decrement and states "the nature of these attentional responses ... needs fuller specification" (p. 330). This is a point we shall take up in the discussion.

Another way of regarding such data is that perceptual learning is a problem in discrimination learning and that relevant "observing responses" must be made to make appropriate discriminations. An observing response can be defined as any response which exposes the subject to the relevant dimension to be discriminated. Thus observing responses used in this way seem to be the same as the attentional responses of Newbigging. House and Zeaman (1960) have made a start at this type of analysis. They started with the experimental knowledge (Lawrence, 1959) that to train a hard discrimination task it is best to begin with an easy discrimination and gradually increase the difficulty of the task. House and Zeaman tested this observation on retardates. Such children have extreme difficulty learning a discrimination task in which the stimuli are patterns painted on a background. However, an object discrimination is learned more easily even if the relevant cues are identical in both cases. They found that pre-training on the easy discrimination task, i.e., the object discrimination did transfer to the hard task, (i.e., the pattern on background task).

This experiment can be interpreted in terms of Wyckoff's (1952) model of observing responses in discrimination tasks. He regards observing responses as being any type of response that exposes the subject to a relevant dimension of discrimination. The probability of an observing response occurring is affected by the rate of the learning of the discrimination, and the increased rate of an observing response raises the level of discrimination. That is, for the operant rate of the observing response to increase, it must be reinforced by the making of a correct discrimination. This in turn raises the level of discrimination. In terms of the House and Zeaman experiment, pre-training on an easy discrimination raises the probability of the correct observing response being made in the hard discrimination task.

The House and Zeaman experiment bears a resemblance to Dewar's finding in that training on one task aids learning in another task more than continued training with the second task.

The experiments which we have done were designed to test and extend an attentional interpretation of the practice decrement in tachistoscopic recognition. The first experiment that will be described extends the Munoz (1963) experiment. He found that a rising linear function describes the effects on recognition thresholds of lengthening the cue-stimulus interval. We have used more cue-stimulus intervals to see over what range a linear function describes this effect. A second experiment was done essentially as a control for memory effects which could account for our results. Briefly, it is possible that the cue-stimulus interval is not important because of its effect on attentional responses, but because it lengthens the time between successive exposures of a given stimulus resulting in the forgetting of fragments of the stimulus already identified by the subject. In the last experiment a transfer design was used. Since the first two experiments strongly suggest that the temporal interval separating the ready signal or cue and the presentation of the stimulus to be recognized is of crucial importance, it was of interest to see if practice with a particular interval in one task would transfer to a second, different, task. The subject was trained in a simple reaction time experiment. A one second tone preceded the stimulus by two seconds. The subject was then tested in tachistoscopic recognition with the same tone preceding each exposure by two seconds. This was to see if such training would transfer to tachistoscopic recognition.

CHAPTER II

EXPERIMENT I

INTRODUCTION

This experiment studied the effects of a tone cue preceding the tachistoscopic exposure of a stimulus to be recognized. Munoz (1963) used three tone offset-word onset intervals in his experiment to determine the effects of a ready signal on tachistoscopic thresholds. He found that both two second and four second intervals resulted in lower thresholds than did an eight second interval, but that there was no significant differences between the thresholds found with the two and four second intervals. He also found a significant interaction of serial position by interval. This was attributable to the fact that a larger practice decrement was found when the two second interval was used than when an eight second interval was used.

A review of reaction time experiments concerned with foreperiod effects reveals some interesting correspondences with these data. Teichner (1954) in a review of RT experiments concluded that the use of a preparatory cue lowered thresholds. Although the findings in different experiments are not in complete agreement, the results seem to indicate that the optimal interval is between one and four seconds, but within this range it is difficult to specify an optimum time.

Breitweiser (1911) concluded that the range one to four seconds was the best for reducing RT thresholds, but that no differences occurred within this range. Telford (1931), however, stated that a one second foreperiod was best and that RT increased systematically as the foreperiod was increased to four seconds. Woodrow (1914; 1916) concluded that two to four seconds was optimal, however, Teichner in his 1954 review suggested that for statistical reasons Woodrow's data actually showed an optimal range of two to eight seconds. At any rate Munoz's findings fall into this range in that the two intervals (two and four) were not different, but were both better than the eight second interval.

Newbigging (1965, p. 319) showed that over a large range of intervals as used in Munoz's experiment, a linear function described the data. The experiment now to be reported is an extension of Munoz's findings in that a wider range of intervals was used.

METHOD

The apparatus, stimulus materials, and procedure used in this experiment were also used in the following two experiments. Thus, a detailed description will be given only for Experiment I. For Experiments II and III only those details with differences from those of this experiment will be described.

Subjects

The subjects were 160 male and female students enrolled in Psychology 1a6 during the winter session 1965-66. They had a mean age of 21.8.

Apparatus

The stimuli were presented in a standard Gerbrand's tachistoscope; the pre-exposure field was a uniform milk glass screen.

The subjects wore earphones throughout the experiment. A tone of one second duration at 880 cps. and 60 db. generated by a standard tone generator was delivered through them. The tone was controlled by an interval timer so that it could be presented at any interval before the onset of the stimulus in the tachistoscope.

Each trial was initiated by the experimenter so that a one second tone would come on, then an interval would occur, and then the stimulus would be exposed.

Stimulus Materials

The stimuli were twelve sequences of seven letters. They were typewritten in capital letters. The sequences were:

IDSYGOB	DIWOLPY	NEHUPSC
ADHIVUL	BDUOSYN	FIAHYRO
GYOSNPL	CHGOALP	LKEWCAY
ZESRUDL	YNDHEBL	VOKAMHE

These stimuli were derived from Underwood and Schulz (1960, p. 336-369). These authors obtained a frequency count for trigrams (three letter combinations). Three different estimates of the frequency of each trigram are given. First is the T-L count based on the Thorndike-Lorge word frequency count. The T-L count is given in number per 1,000,000 words. Second is a U-count based on a sampling of 15,000 words randomly selected by Underwood. The 15,000 words consist of 150 selections of 100 words where the 100 words were part of a longer selection. The selections were selected to represent a cross section of English usage, eg., novels, advertisements, newspaper articles, etc. The third count is a Pratt count, based on Pratt (1939). The Pratt count is given in number per 25,000 words. Since these samples do not yield equivalent frequencies, Underwood and Schulz added the number of times a trigram appeared according to each count to yield what we will call the total count.

From this total count list Allan (personal communication) constructed seven letter sequences which met the following restrictions (1) any trigram appearing in any sequence must have a frequency of exactly one as given by the total count, (2) no sequence must begin with a letter that begins any other sequence, (3) no letter may appear twice in any sequence, (4) no trigram may be used more than once.

An example will best illustrate how the sequences were assembled. Consider ADHIVUL. The first trigram ADH appears only once in the three counts, that is, it appears in the U-count, but in neither the T-L count or the Pratt count so its total count is one. Having ADH we must now find a trigram beginning DH which has a total count of one. Two such trigrams are available, DHI, and DHE -- but DHI is selected because further study of the counts show that HIV has a count of one as does IVU and VUL. Note that our restrictions have been met. Any three consecutive letters in ADHIVUL has a total count one, no letter has appeared twice in any sequence, no trigram has been used twice and none of these trigrams are used in any other sequence.

In this manner Allan assembled twenty-one sequences. Of these, twelve were selected at random to be used in these experiments.

Experimental Design

The experimental design used was a Lindquist Type I (Lindquist, 1953). Each of the 160 subjects was randomly assigned to one of eight groups with the restriction that each group of twenty subjects consist of twelve males and eight females. Each subject was presented with all twelve letter sequences for recognition with one tone offset-sequence presentation interval. For different groups, the interval was one of

.5, 1, 1.5, 2, 4, 6, 8 seconds. For the eighth group the tone offset-word onset interval was random. It included twenty intervals within the range 400 msecs. to 8,000 msecs. The intervals differed by 400 msecs. These twenty intervals were used in a random order which is given in detail in Appendix A.

Procedure

Subjects were tested individually in a single session lasting from twenty minutes to one hour.

The subject was read the following instructions:

"You are going to be presented with seven letter sequences. These sequences will appear on the screen in front of you. The sequence is typed in upper case letters. Your task will be to identify the seven letters in the order they are presented to you. Since the sequences are not words, you will be required to spell them.

They will be exposed for very short intervals of time so you will not be able to identify the sequence immediately. So I will present the same sequence repeatedly until you identify it correctly. (I will tell you that it is right.) Then we will repeat this with another sequence.

However, each time a sequence is flashed I want you to give me as many letters of the sequence as you can, even if you don't know all seven.

You will also be wearing those headphones. A tone will sound shortly before each sequence is presented. Are there any questions?"

If the subject had questions, the relevant part of the instructions were read to him again.

The ascending method of limits was used. The initial presentation of each sequence was at a duration of 150 ms. Each time the subject failed to correctly identify the sequence the exposure was increased by ten ms. The exposure duration at which the sequence was correctly identified was recorded as the threshold.

The twelve sequences were presented in a different random order to each subject.

RESULTS

Table I presents a summary of the analysis of variance (Lindquist, Type I, 1953) done on the data from this experiment. Both main effects, serial position and tone offset-sequence presentation interval are significant. As Table I shows the serial position x interval interaction was also significant.

Figure 1 shows the main effect of serial position takes place in all tone-sequence interval groups. Figure 2 presents the main effect of interval. The data conforms quite closely to the Munoz (1963) finding in that a straight line (fitted by inspection) describes the data when the intervals from two to eight seconds inclusive are considered. Figure 2 also shows that for intervals of two seconds or less no significant differences in threshold are found. This was confirmed by application of Tukey's Multiple Comparison Test (Ryan, 1959). With the exception of the one second interval group, the threshold value for intervals of two seconds or less are almost identical. Figure 1 shows that the shapes of the practice decrement for the two seconds and below interval groups are also highly similar.

The significant interval x serial position interaction is also

Table I

Analysis of Variance for Eight Groups with Different Tone Offset-Sequence Presentation Intervals

Source	df	M.S.	F.	P.
Between Ss	159			
Interval	7	359,461.84	10.56	<.001
Error (b)	152	34,044.57		
Within Ss	1760			
Serial Position (S.P.)	11	118,339.34	59.25	<.001
S.P. x Interval	77	3,151.98	1.58	<.01
Error (w)	1672	1,997.45		
Total	1919			

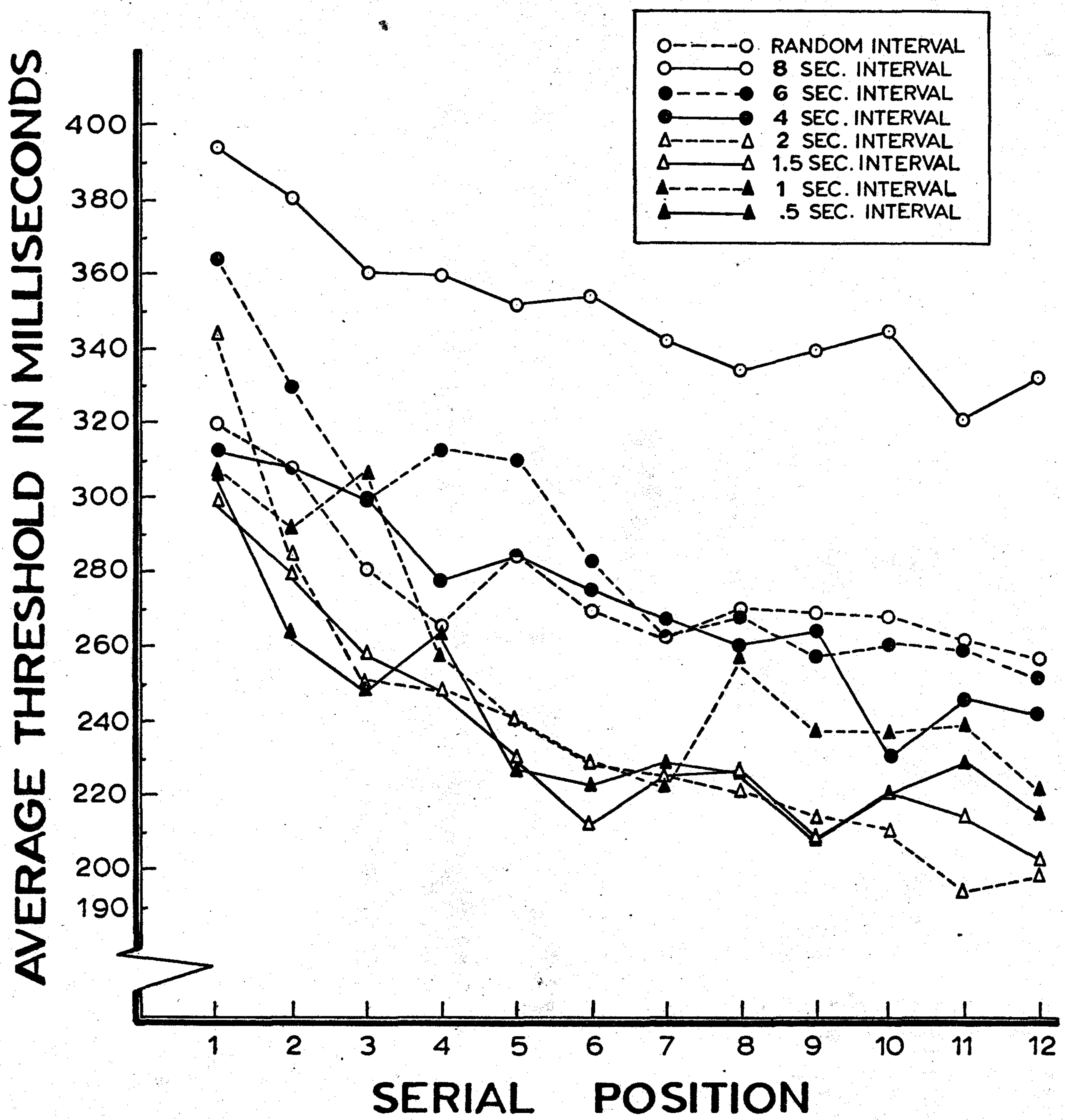

Figure 1: Average thresholds in milliseconds plotted as a function of serial position of stimuli for groups receiving eight different tone offset-sequence presentation intervals.

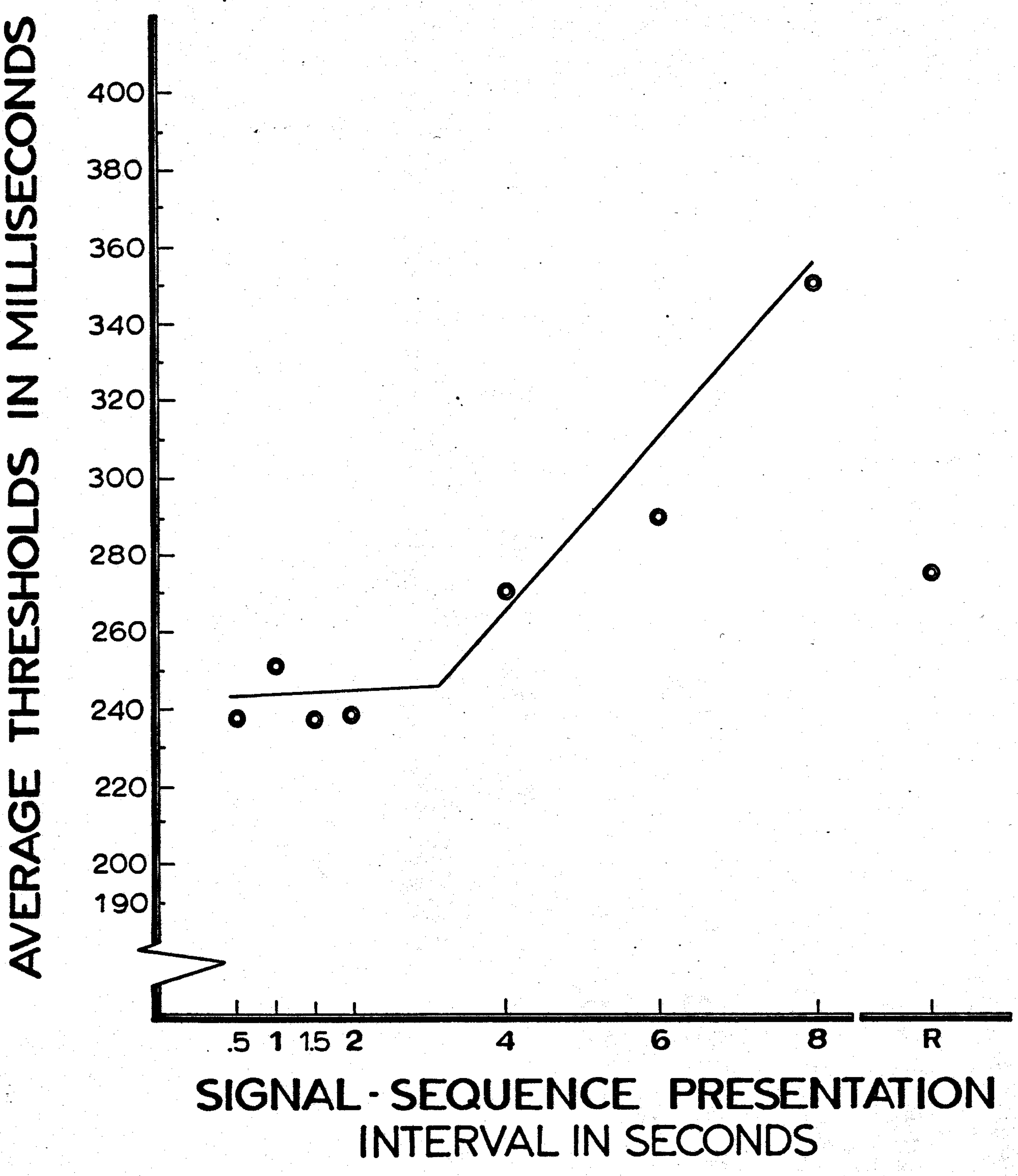

Figure 2: Average thresholds in milliseconds over all blocks of trials plotted against tone offset-sequence presentation interval in seconds.

consistent with Munoz's findings. We found, as did he, that as the tone-sequence interval is increased, the practice decrement decreases. For instance, in our experiment the two second interval group had an average threshold of 349 msecs. on the first stimulus, but on the twelfth stimulus the average threshold was 198 msecs. For the first stimulus the eight second interval group had an average threshold of 394 msecs. but this improved only to 331 msecs. by the twelfth stimulus.

The only point of disagreement between the results of the Munoz experiment and this one is that we found a significant difference between the two second and four second interval groups. We will put forward reasons for this in the discussion section.

The random group is of special interest. As may be noted in Figure 2 this group performed better than either the six second or eight second groups, and is only slightly worse than the four second group. That the random and four second groups are so similar is interesting since four seconds is close to the mean value of the intervals used in the random group. Therefore, one explanation of the results that seems plausible is that the shorter intervals in the random schedule accounted for the learning. That is, the subject prepared himself for a short interval. Munoz (1963, p. 40) suggests that the differences found between long and short interval groups may be due to the fact that it is harder to retain fixation over a long interval. What these two possibilities predict is that recognition of stimulus items should take place significantly more with the shorter intervals of this random group than with the longer intervals.

We tested this notion and it is not supported by the data. If the data is divided and separate examination made of those cases where correct recognition occurs at intervals of 4000 ms. or shorter and those where correct recognition occurs at intervals larger than 4000 ms. then 114 recognitions were made at short intervals and 126 were made at long intervals. We should point out however that this cannot be taken as a conclusive rejection of this line of reasoning. Remember that the subject does not recognize the stimulus at one exposure, but builds it up over successive exposures. The real test of this hypothesis is to determine at what exposures the subject took in the most information. Since this requires the response to every exposure to be recorded, we have no data which can answer this question.

At any rate this experiment provides two findings which will be explored further in the discussion. First, is this matter of the random group and second is our finding that the two and four second groups are different when Munoz found them to be not significantly different.

CHAPTER III

EXPERIMENT II

INTRODUCTION

One feature of the previous experiment is that it leaves the time spent in the experimental session uncontrolled. Two time intervals can be defined. First, is the tone offset-sequence onset interval which was varied in the experiment just reported. But we may also consider the interval between successive exposures of a letter sequence which we will call the inter-stimulus interval. Consider the case of the subject in the tone offset-sequence onset condition of two seconds. He hears a tone of one second, a two second interval occurs, he reports as much of the sequence as he can, and a new trial is initiated. The inter-stimulus interval here is three seconds (tone + interval) plus whatever length of time (typically two to seven seconds) it takes him to report. However, in the case of the eight second tone offset-sequence onset subject the inter-stimulus interval is nine seconds plus the time of reporting, since each exposure is initiated by the experimenter.

It is possible that this difference may affect threshold values. There is a definite reason to expect so. A number of experiments have shown that, as might be expected, the subject does not identify the stimulus in one exposure but builds it up over successive exposures (eg., Newbigging and Hay, 1962).

Thus, we have the situation of the subject building up to seven letters. In the one situation he has three seconds over which to retain the letters he has recognized, in the other case he has nine seconds. Also, during these time intervals he is engaged in attempting to recognize and remember more letters which may compete with the task of remembering letters already identified.

It is difficult to find experimental evidence to suggest whether this type of difference could be critical. The typical paired-associates type of experiment is not directly relevant since our situation does not supply an associate for the to-be-remembered sequence and only one item (of varying length) must be remembered over the interval. However, Peterson (1966) in a review of short-term memory has listed the following experiments which give us reason to suspect that the type of forgetting we are suggesting here might take place. Keppel and Underwood (1962) presented a brief auditory trigram (three letter sequence), then the subjects counted for a retention interval. The test taken eighteen seconds later showed 50% decrement in recall. Peterson (1963) showed that rate of presentation is important. With one intervening event between presentation and test he found two seconds to produce better recall than four seconds.

While experiments like these suggest a memory factor may play a role in tachistoscopic thresholds, the role may not be large. Peterson and Peterson (1962) found that when one pair of words had to be remembered little forgetting occurred up to intervals of sixteen seconds when this interval was occupied with counting. Also, although differences are found in thresholds when the Ascending Method of Limits and the Method of Random Series have been compared, these differences are not great. This suggests the memory factor is not an overwhelming one because the

Ascending Method of Limits should result in lower thresholds since it allows successive exposures of the same stimulus.

This next experiment was designed to determine if a memory factor does affect thresholds. Both tone-stimulus intervals and inter-stimulus intervals are controlled so that the length of time a subject must wait for each exposure is under direct experimental control.

METHOD

Subjects

The subjects were 40 students taking Psychology 1a6 in Summer School, 1966. They had a mean age of 25.2.

Apparatus

The apparatus was identical to that used in Experiment I except that for three of the four groups successive exposures were controlled by a recycling timer rather than being initiated by the experimenter. For one group, however, the exposure was initiated by the experimenter as in Experiment I. For two of the groups the inter-stimulus interval was held constant at fifteen seconds by means of interval timers. For the final group the inter-stimulus interval was held constant at ten seconds.

Stimulus Materials

These were the same as in Experiment I.

Experimental Design

The design used was a Lindquist Type I (Lindquist, 1953). Each subject was randomly assigned to one of four groups with the restriction that each group be composed of five males and five females. The four groups were as follows: (1) a group receiving a tone offset-sequence presentation interval of eight seconds with the inter-stimulus interval constant at fifteen seconds, (2) a group receiving a tone offset-sequence presentation interval at two seconds with the inter-stimulus interval constant at fifteen seconds, (3) a group receiving a tone offset-sequence presentation interval of two seconds with the inter-stimulus interval constant at ten seconds, (4) a group receiving a tone offset-sequence presentation interval of two seconds, but with the inter-stimulus interval controlled by the experimenter and therefore necessarily somewhat variable.

Procedure

The procedure was identical to that of Experiment I.

RESULTS

The four groups will be identified by both the tone offset-sequence presentation interval and the inter-stimulus interval. For instance, the 8-15 group is one which received an eight second tone offset-sequence presentation interval and a fifteen second inter-stimulus interval: the 2-R group had a two second tone offset-sequence presentation interval and a random inter-stimulus interval.

Tables II, III, and IV show the results of three analyses of variance done on the data of this experiment. Table II is an analysis done on the data of the 2-15 and the 8-15 groups. A significant effect of both serial position and tone offset-sequence presentation interval. This means that a practice decrement was observed for both groups. More important, we should note that since the inter-stimulus interval for these groups is the same the difference between these two groups cannot be attributed to the forgetting of information gained on previous exposures. This analysis, however, also shows no significant interval x serial position interaction effect between the two groups. This is an interesting finding since both our previous experiment and Munoz (1963) found such an interaction. We shall discuss reasons for this in the discussion section.

Tables III and IV represent analyses done on the 2-15, 2-10, and 2-R groups. So, for these three groups the only parameter varied was the inter-stimulus interval. Table III shows that when all three groups are compared the only significant effect is that of serial position. However, Figure 3 shows that this failure to find an effect of inter-stimulus interval is probably due to the fact that the 2-10 and 2-R groups are extremely similar. This is because the random tone offset-sequence presentation interval is for practical purposes almost the same as a ten second interval.

When the 2-R and the 2-15 groups are compared (Table IV) two significant effects are found. First, once again a significant effect of serial position was observed. No significant effect of inter-stimulus interval was found, but a significant interaction of serial position x inter-stimulus interval was observed. This means that the inter-stimulus interval does not affect thresholds early in training, but does affect thresholds late in training. Figure 3 shows that the 2-15 group shows little improvement after the sixth stimulus whereas the 2-R group shows improvement at least to the tenth stimulus. Why this should show as an interaction factor rather than raising thresholds for all stimuli is a problem we shall turn to in the discussion. At that time we will also

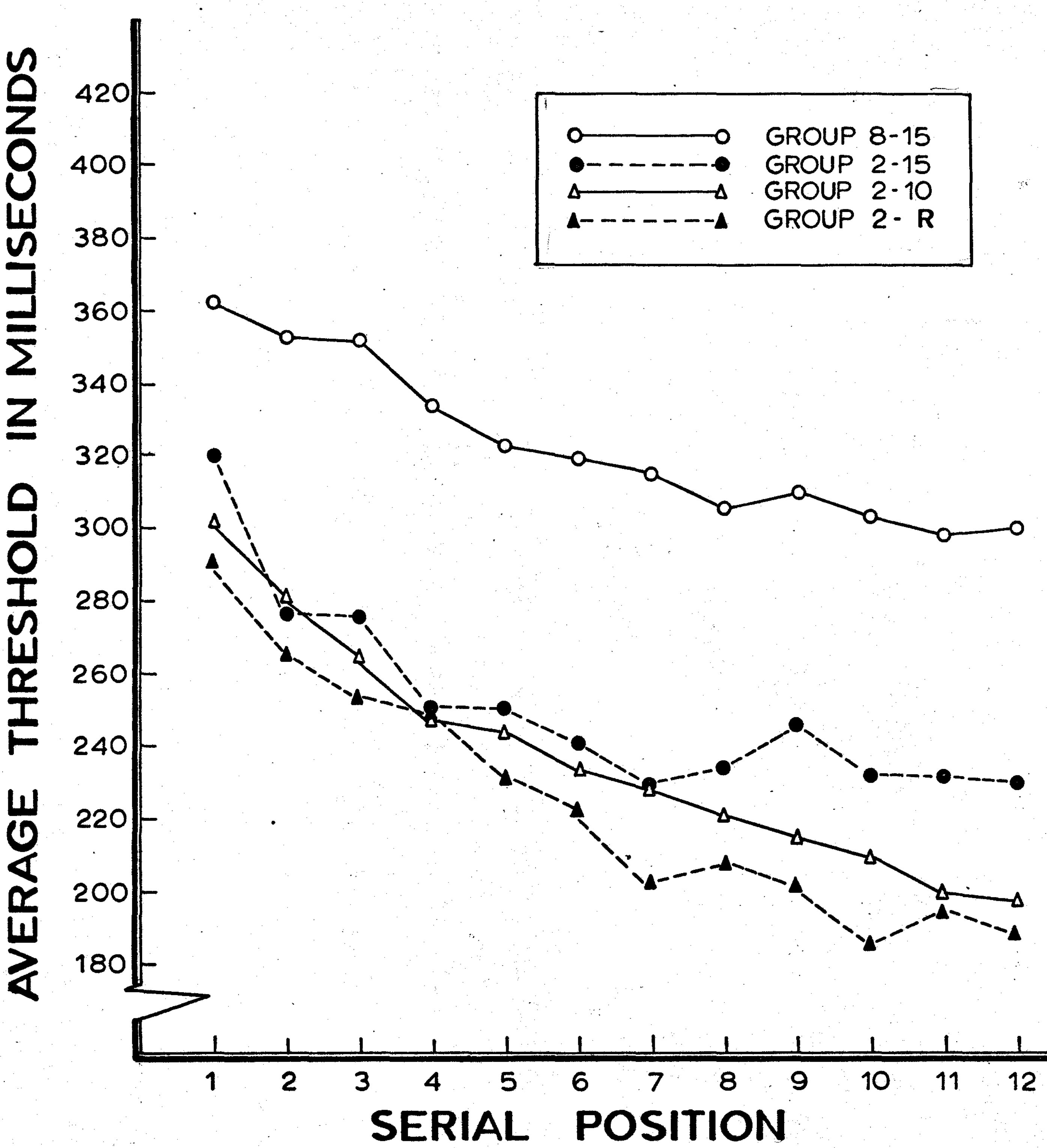

Figure 3: Average thresholds in milliseconds plotted as a function of serial position of stimuli for groups receiving two different tone offset-sequence presentation intervals and three different inter-stimulus intervals.

consider why no interaction of interval x serial position was found between the 2-15 and 8-15 groups, when our previous experiment and Munoz (1963) both found such an interaction.

Table II

Analysis of Variance for the
2-15 and 8-15 Groups

Source	df	M.S.	F.	P.
Between Ss	19			
Interval	1	306,735.00	13.86	$<$.001
Error (b)	18	22,117.87		
Within Ss	220			
Serial Position (S.P.)	11	11,810.33	13.43	$<$.001
S.P. x Interval	11	715.00	$<$1	
Error (w)	198	878.98		
Total	239			

Table III

Analysis of Variance for the
2-15, 2-10, and 2-R Groups

Source	df	M.S.	F.	P.
Between Ss	29			
Interval	2	22,460.28	1.87	N.S.
Error (b)	27	11,992.87		
Within Ss	330			
Serial Position (S.P.)	11	28,228.86	44.85	$< .001$
S.P. x Interval	22	629.42	< 1	
Error (w)	297	839.17		
Total	359			

Table IV

Analysis of Variance for the
2-15 and 2-R Groups

Source	df	M.S.	F.	P.
Between Ss	19			
Interval	1	44,826.68	3.54	N.S.
Error (b)	18	12,646.79		
Within Ss	220			
Serial Position (S.P.)	11	10,356.84	10.16	< .01
S.P. x Interval	11	8,561.24	8.39	< .01
Error (w)	198	1,019.31		
Total	239			

CHAPTER IV

EXPERIMENT III

INTRODUCTION

In the Introduction Section of this thesis we stated that one inadequacy of both the Postman and the Gibson formulations of perceptual learning was their failure to deal adequately with the transfer phenomena found in many perceptual learning tasks. This last experiment was designed to determine if training subjects in a simple reaction time (RT) experiment, in which a tone signalled a two second foreperiod, would produce lower thresholds in a subsequent tachistoscopic task in which the same foreperiod was used. The foreperiod is defined as the time between the ready signal and the stimulus for the reaction response in the one task and the interval between the ready signal and the tachistoscopic exposure of a seven letter sequence in the other.

This experiment is important for any interpretation of perceptual learning phenomena. It will be recalled that Hay (1963) found that tachistoscopic training with numbers and high frequency words resulted in lower thresholds for low frequency words. This result, considered together with the results of Dewar (1965) experiments on the Muller-Lyer figure suggest that perceptual learning is to a large extent, independent of the specific stimulus items used in the learning. Our experiment not only varies the specific stimuli that are used, but more important the tasks performed by the subject are different in the training and test situations. In the training task the subject was required only to lift his finger from a key as quickly as possible after a light stimulus came on. The test task was to recognize the same seven letter sequences which we have used in our previous experiments. The only feature that these two tasks have in common is the use of a tone to signal that an exposure of the stimulus (the light in the first task, the sequence in the second) is imminent.

METHOD

Subjects

The subjects were 60 male and female students enrolled in Psychology 1a6 in Summer School, 1966. Their mean age was 26.7.

Apparatus

Two pieces of apparatus were used in this experiment. The first apparatus was a tachistoscope which recycled every ten seconds. This apparatus has been described for Experiment I.

A training series was done on reaction time equipment. The subject was seated before a 2'x2' grey panel. A round light with a diameter of $\frac{1}{2}$" was located 9" from the top of the panel and halfway between the two sides. The panel was situated so that the light was at about the subject's eye-level. A black key was situated out from the panel on his right side.

Stimulus Materials

These were the same as in Experiment I, except for the inclusion of the RT apparatus.

Experimental Design

Six groups were formed so that each group consisted of six males and four females. The groups were as follows: (1) a group which received twelve stimuli using the tachistoscope (2) a group which received the equivalent of two tachistoscopic stimuli on the RT apparatus, then ten tachistoscopic stimuli (3) a group which received the equivalent of four tachistoscopic stimuli on the RT apparatus, then eight tachistoscopic stimuli (4) a group which received the equivalent of six tachistoscopic stimuli on the RT apparatus, then six tachistoscopic stimuli (5) a group which received the equivalent of eight tachistoscopic stimuli on the RT apparatus, then four tachistoscopic stimuli (6) a group which received the equivalent of ten tachistoscopic stimuli on the RT apparatus, then two tachistoscopic stimuli.

What constitutes the equivalent of a tachistoscopic trial on the RT apparatus can be explained by an example. Suppose a subject in Group 1 correctly identified the first sequence he was shown at 240 ms., and the second sequence at 190 ms. Then, since in each case his first exposure was at 150 ms., he required ten exposures to identify the first sequence and five exposures to identify the second sequence. Therefore, the equivalent of these two tachistoscopic trials on the RT apparatus is fifteen presentations and reactions to the light.

Each subject in the first group (tachistoscope only) was matched with five subjects, one in each of the other five groups. The subjects in these five groups were given the equivalent of the practice on the tachistoscope of the subject with whom they were matched. This equivalent practice was given on the RT apparatus. Thus, if the first subject in Group 1 took seventeen exposures to identify the first two stimuli presented tachistoscopically then the first subject in Group 2 received seventeen RT trials before being tested on the tachistoscope. The first subject in Group 3 would receive seventeen trials on the RT apparatus plus whatever number of exposures it took the first subject in Group 1 to identify the third and fourth tachistoscopic items.

Procedure

The procedure for Group 1 was the same as outlined in Experiment I.

In the RT training task the subject was seated in front of the RT apparatus and the following instructions read:

"I want you, when we are ready to start, to put your finger on that black key. This light will come on, and I want you to release the key as fast as you can when this happens. After the light goes off, put your finger back on the key and wait for the light to come on again. Then once again release the key.

You will be wearing these earphones. A tone will sound shortly before the light comes on."

If the subject had questions, the instructions were read again.

A trial consisted of the subject pressing down on this key and releasing as soon as possible after the light came on. His response terminated the stimulus. His reaction time was recorded by a Hunter Klock Kounter (Model 120A). Interval timers were used to time an inter-stimulus interval constant at ten seconds, to time a tone of one second duration (60 db., 880 cps.) delivered through earphones, and to time a tone offset-light-onset interval of two seconds.

After the subject had completed the necessary number of RT trials, he was directed to the tachistoscope where the instructions of Experiment I were read to him.

RESULTS

Reaction Time

Table V presents an analysis of variance done on the RT data. Since the subjects each received a different amount of RT training, an average was taken of each subjects first ten and last ten trials. The five groups represented in the analysis are those which receive the equivalent of two, four, six, eight, or ten tachistoscopic trials. The analysis shows that the only significant effect is that of trials. The failure to obtain a significant interaction effect shows that, within the limits of our experiment, no group reduced reaction time more than any other group despite the fact that they had different amounts of practice. This is probably due to the fact that, as Woodworth and Schlosberg (1954, p. 35) point out, the practice effect is not large in the simple RT experiment. Blank (1934) gave subjects 60 trials per day for nine days and only decreased simple RT from 200 msecs. on the first day to 180 msecs. by the ninth day. Blank's data also show that, as in many other tasks, the major part of the performance improvement takes place in the early trials.

Recognition Thresholds

Table VI presents the analysis of variance done on the mean thresholds in milliseconds for the first two tachistoscopic stimuli presented to each group. It will be recalled that the amount of RT training was varied for each group before these stimuli were presented. Table VI shows that, as in our previous experiments the effect of serial position is a highly significant one. Also significant was the effect of amount of RT training. Figure 4 is a plot of these data with the scores for the two tachistoscopic stimuli averaged for each group. This finding shows that training in the RT situation produced positive transfer to the tachistoscopic situation. Figure 4 seems to suggest that the effect is stronger than our analysis indicates, since group four (89.2 RT trials followed by four tachistoscopic stimuli) is clearly out of line with the general downward trend of the data points. We feel that the divergence of this point is due to unfortunate subject sampling (this experiment is based on only ten subjects per group) rather than constituting a genuine reversal.

Table VII shows an analysis of variance done on the threshold values for the first four tachistoscopic stimuli of each group, but leaving out the last group since only two trials of tachistoscopic testing were given this group. The important thing to note here is that the treatment effect of amount of prior training has disappeared. Two explanations of this are possible. First, perhaps two tachistoscopic trials are all that is necessary to compensate for the prior RT training a subject has not received. Second, a small effect may exist, but our N is not large enough to give it statistical significance. However, on the basis of this experiment alone, the only conclusion that is warranted is that prior training with the tone cue in a RT situation transfer positively to a tachistoscopic situation. However, such training seems not as powerful as direct tachistoscopic practice leading one to conclude that factors in addition to the tone cue contribute to the practice decrement.

Table V

Analysis of Variance for Five Groups Receiving
Different Amounts of Reaction Time Trials

Source	df	M.S.	F.	P.
Between Ss	49			
Amount RT practice (RT)	4	3,391.44	1.62	N.S.
Error (b)	45	2,099.50		
Within Ss	50			
Serial Position (S.P.)	1	41,534.44	92.7	< .001
S.P. x RT	4	607.47	1.36	N.S.
Error (w)	45	448.13		
Total	99			

Table VI

Analysis of Variance for the First
Two Tachistoscopic Stimuli

Source	df	M.S.	F.	P.
Between Ss	59			
Amount RT practice (RT)	5	6,830.63	2.35	<.05
Error (b)	54	2,859.26		
Within Ss	60			
Serial Position (S.P.)	1	21,333.40	37.2	<.001
S.P. x RT	5	141.32	< 1	
Error (w)	54	573.52		
Total	119			

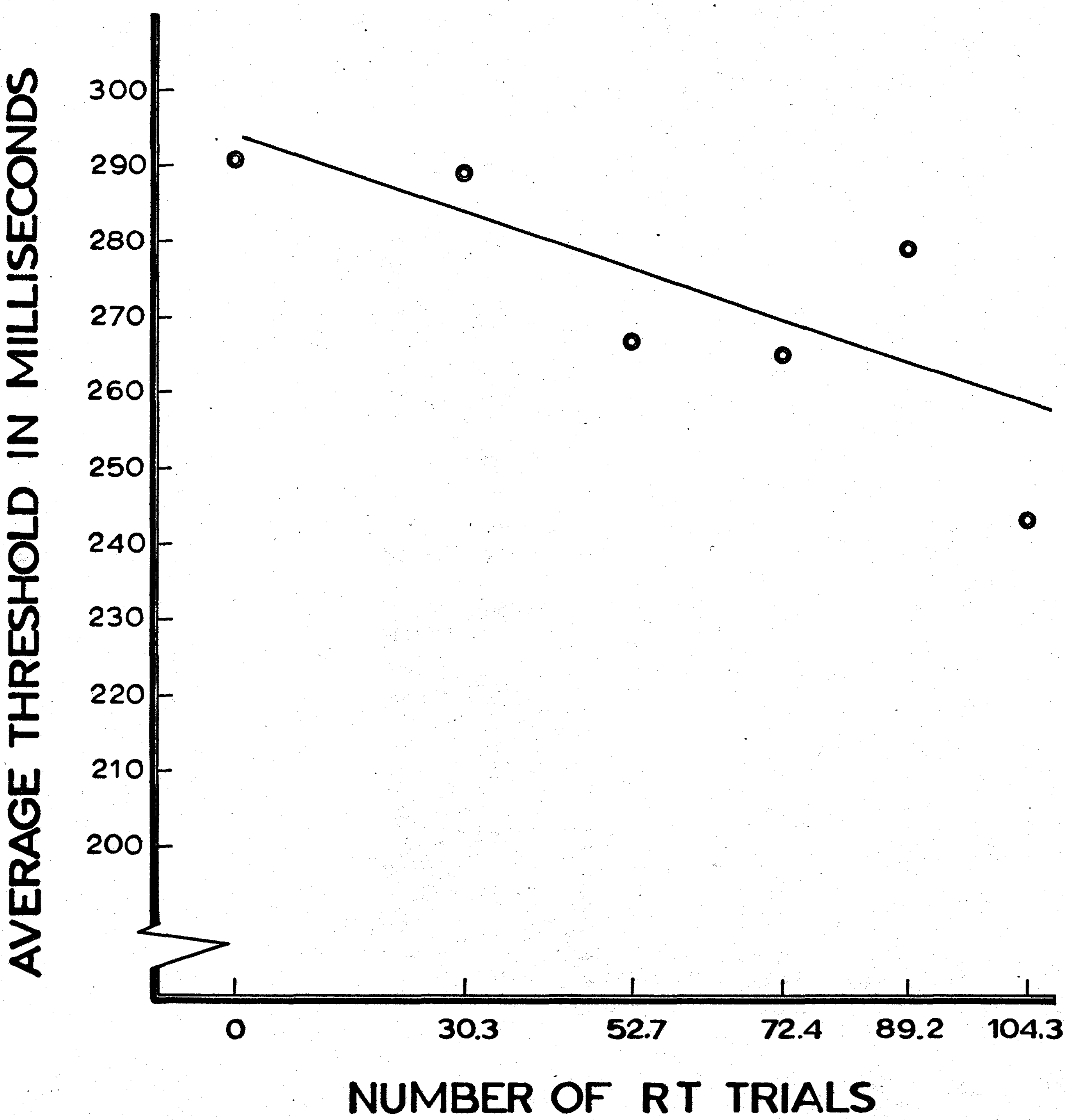

Figure 4: Average tachistoscopic thresholds for six groups receiving different amounts of reaction time training. Each point represents the average thresholds for the first two tachistoscopic stimuli, presented to each group.

Table VII

Analysis of Variance for the First
Four Tachistoscopic Stimuli

Source	df	M.S.	F.	P.
Between Ss	49			
Amount RT practice (RT)	4	5,048.00	1.04	N.S.
Error (b)	45	4,867.11		
Within Ss	150			
Serial Position (S.P.)	3	34,062.67	71.94	$<.001$
S.P. x RT	12	349.33	<1	
Error (w)	135	473.48		
Total	199			

CHAPTER V

DISCUSSION

The results of the three experiments just reported are consistent in showing the facilitative effect on tachistoscopic recognition of an auditory cue occurring a short interval before the exposure of the stimulus. Experiment I replicates the results of earlier experiments (Munoz, 1963) in showing both that the initial thresholds increase as the tone-stimulus presentation interval increases, and that the practice decrement interacts with the length of the interval. We found, as did Munoz, that performance improves less rapidly with longer as compared with shorter intervals. Experiment I extends Munoz's findings in examining a larger range of intervals and in including a group in which the length of the tone-stimulus presentation interval was randomly varied. The performance of this random group was better than expected and is therefore of some special interest and is the subject of further comment below.

In Experiment I and in Munoz's experiment the effects of the tone-stimulus presentation interval are confounded with the inter-stimulus presentation interval. That is, when the tone-stimulus presentation interval is eight seconds, the interval between successive presentations of the stimulus is longer than when the tone-stimulus presentation interval is two seconds. This procedural difference may have some consequences for the subjects' performance if recognition builds up over successive presentations and his report following a given presentation depends upon both what he saw on that exposure and what he recalls from previous exposures. The longer the inter-stimulus presentation interval the greater the opportunity for him to forget letters previously recognized. Experiment II was addressed to this problem. When the tone-stimulus presentation interval was varied and the inter-stimulus interval held constant, the tone-stimulus interval was shown still to have a large effect. Comparison of two groups in that experiment in which the tone-stimulus interval was constant at two seconds and the inter-stimulus interval was randomly varied or was fixed at fifteen seconds showed that the final performance of the fifteen second group was poorer. This finding is suggestive of factors in addition to the tone-stimulus presentation interval which affect the subjects performance in the tachistoscopic situation and these are commented on more fully below.

Although the finding in Experiment I that the random group performed better than expected, and the finding in Experiment II that the inter-stimulus interval had some effect on the subjects' performances late in practice, constitute important effects which must be taken into account in interpreting the practice decrement observed, it is nonetheless true that the tone-stimulus interval is the single most powerful variable we have studied. Because of this Experiment III was performed to see if the interval effect had trans-situational generality. The outcome of that experiment did indeed show that practice with a fixed tone-stimulus interval in a reaction time task transferred to a tachistoscopic task in which that interval was preserved. The amount of transfer was, with one reversal, a direct function of the amount of practice in the reaction time task. Although this is so, the absolute amount of transfer is relatively small and the data also show that the benefit from reaction time training, while regularly related to the amount of that training, is rapidly made up for by tachistoscopic training itself. Thus, the effects of prior reaction time training are no longer evident by tachistoscopic items three and four.

In the balance of this section some of the more minor findings of the experiments are discussed following which these and the major findings concerned with the tone-stimulus interval are considered in relation to a theoretical explanation of the practice decrement.

We shall discuss five fairly specific problems which arose from the experimental data. The first problem is, why did the random group in Experiment I show an unexpectedly large practice decrement? Why, in Experiment I did we find a difference between the two second tone offset-sequence presentation group and the four second group when Munoz (1963) did not? Why, in Experiment II did lengthening the inter-stimulus interval result in higher thresholds late in practice rather than throughout practice? Why, in the same experiment, was there no interaction of treatment x trials between the 2-15 and 8-15 groups when our previous experiment and Munoz (1963) both found such an interaction? Finally, why was there any transfer in Experiment III and given transfer, why not 100% transfer?

In the Results Section of Experiment I, it was pointed out that the practice decrement of the random group could not be attributed to differential use of the short intervals contained in the random interval schedule. Another possible interpretation is that while a tone cue contributes somewhat to learning other factors are involved. One can add to this a conclusion that the tone cue in the case of the random group did not contribute to lowering thresholds at all. However, this second conclusion must be rejected because Newbigging (1965, p. 319) presents data which clearly shows a no-tone situation to produce higher thresholds than an eight second tone-letter-sequence interval. In our experiment the random group had lower thresholds than the eight second group. Therefore, one must conclude that a cue presented at random intervals does play some role. Let us concede for the moment that other factors play a role in the practice decrement and see how much information the subject could possibly get from the random interval presentation. After a number of presentations his behaviour could be predicated on the following premises: (1) the sequence will flash no later than eight seconds after the tone goes off (2) the average length of the interval is slightly over four seconds (3) a long series of long intervals is likely to be followed by a short interval presentation and vice versa (4) as the time increases after the tone goes off, the chances increase that the sequence will flash. Naturally, the subject will not have as precise an appreciation of the contingencies as this suggests, but as the number of trials increase, it is not unlikely that some of these contingencies influence his behaviour. The practice decrement that this group shows then is a function of the information which the tone cue gives about "when" the stimulus will be exposed.

Our next concern is our finding that the two second and four second interval groups in Experiment I were significantly different, while in the Munoz (1963) experiment, they were not different. The only procedural differences between the two experiments was in the stimulus items presented. It will be recalled that our twelve stimuli were meaningless seven letter sequences. Munoz used nine letter words having a frequency of 1/3.6 million. Each experimental session consisted of the presentation of eighteen such words. This leads us to suspect that the task in our experiment was harder for the subject. This conclusion is teneable because thresholds in Munoz's experiment were lower than those in our experiment. Our evidence to support this conclusion is that meaningfulness has been shown to reduce thresholds, so that words in his experiment should be more easily identified than our seven letter sequences. So, it seems reasonable to conclude that Munoz's test was not difficult enough to distinguish between the two and four second conditions.

Experiment II showed that lengthening the inter-stimulus interval resulted in the practice decrement reaching an asymptote more quickly hence, thresholds in the later trials for the 2-15 groups were higher than those of the 2-R group, while on the beginning trials no difference existed. We should note at this point that the experimental groups were composed of only ten subjects each so that any conclusions drawn must be regarded as tentative. We have tendered the explanation that lengthening the inter-stimulus interval results in higher thresholds because over a lengthened period the subject will forget more of what he has already established about the sequence. But this does not explain why the effect shows up in the later trials.

Let us make three assumptions which if valid would explain this. First, we know that early in practice the subject is going to take many exposures (for instance, the 2-15 group took an average of 15.1 exposures before reaching threshold) before he identifies the sequences. So let us assume that the consequences of forgetting a letter are not as crucial in early practice as in late, simply because the subject is going to get more chances to rectify this error early in practice than later.

The second assumption is that because he is becoming better at the task by stimulus ten, for instance, he is gaining more information per exposure. This, of course, means that he has more to forget in the inter-stimulus interval.

A final assumption is that proactive inhibition is building up over trials. By stimulus ten the subject has said 63 (9x7) letters at least. The total is actually higher since each subject typically makes mistakes which subsequent exposures correct and he repeats himself often.

The reader will have noted that our second assumption is exactly opposite to the one Newbigging and Hay (1962) made. They assumed that the amount of information gained on the identifying exposure remained constant across trials. Our assumption states that on any exposure the subject is more capable of gaining information on stimulus ten than on stimulus one. Which assumption is correct is a matter for further experimental study.

By showing that lengthening the inter-stimulus interval an asymptote of performance is reached more quickly, we supply an explanation why no interaction of treatment x trials was observed between the 2-15 and the 8-15 groups in Experiment II. The interaction found in Experiment I is a result of the eight second group reaching asymptote more quickly than the two second group, because of the relatively longer inter-stimulus interval of the eight second group. By keeping these two the same for both groups the interaction was eliminated so we may conclude that the amount of learning exhibited in any group is a function of the inter-stimulus interval.

Experiment III provides evidence for the facilitation of the practice effect by a tone cue. It seems apparent from this experiment that training in knowing when a stimulus will appear is one of the important tasks the subject faces in the tachistoscopic situation. But the experiment proves one of two things: either the RT training does not produce all the attentional responses that are produced by the tone in the tachistoscopic situation, or other skills which mediate practice are trained in addition to tone-induced ones. Both of these possibilities may be true. The RT situation is an extremely simple one when compared to tachistoscopic training.

The reader will have noted that in discussing these five problems arising from the results that a shift in emphasis has occurred. We have stressed the importance of the development of attentional responses less than Munoz (1963) and Newbigging (1965) have done. This is because we believe an alternative explanation of the effects of tone cues is possible. We believe an important task facing the subject in the tachistoscopic situation is the gradual learning of exactly when the stimulus will be exposed so that he may be maximally attentive at that instant.

The evidence we shall present for such a position is drawn from time estimation studies. Such evidence cań only be suggestive since the experimental procedures used in such studies are quite unlike our procedures, although we are assuming the position that the basic problem (how long is a given interval) is the same in both tasks.

The argument is that two things are learned about the tone-stimulus interval. First, the subject is told only that the tone will sound "shortly" before the stimulus is exposed. We propose that during the first tachistoscopically presented item, which typically involves between five and twenty-five stimulus exposures, the subject's responses come to reflect the fact that the interval is of constant duration. Secondly, we propose that as the number of exposures increases the subject's ability to be maximally attentive at the instant the stimulus is exposed increases because his estimate of the time interval between cue and stimulus improves.

There is some evidence which suggests that a subjects ability to estimate short time intervals can be improved. One method of testing this is the method of reproduction. A stimulus is presented (called the initial stimulus), then an interval occurs, and then another stimulus is presented (called the terminal stimulus). The subject is required to reproduce the length of this interval. Woodworth (1930) using a one second interval found that the threshold (standard deviation from the mean) for such an interval was 8.6%. Hawickhorst (1934) with training reduced this threshold to 3.6%. Renshaw (1932) reduced this to 1.2% but his subjects required 159 days of practice to reach this level.

The properties of the initial and terminal stimuli of the interval to-be-estimated have been shown to affect the accuracy of the subject's estimate. Fraisse (1963) discusses some German experiments which show that the more intense the initial stimulus, the shorter the interval seems. The effect becomes less marked as the interval is lengthened. In our experiment the initial stimulus is the tone and the sequence exposure may be considered as the terminal stimulus. If the above finding is applied to our experimental situation, the prediction is generated that thresholds should be affected by varying the intensity of the tone cue (initial stimulus). Increasing the intensity of the tone should result in the ensuing interval being judged shorter. But if the actual physical length of the interval remains fixed increasing the intensity of the tone cue should result in less accurate estimations. The effect on thresholds of varying the intensity of the tone cue should decrease as the tone-stimulus interval is lengthened. Munoz (1963) supplies data that conforms with this prediction. He tested subjects in tachistoscopic recognition using three intervals of two, four, and eight seconds and two tone intensities, sixty db. and ninety db. He found that the tone intensities produced much the same thresholds when the four and eight second intervals were used. But thresholds for the ninety db. tone were significantly higher than thresholds found with the sixty db. tone when a two second interval was used. This supports, then, the prediction made from time estimation experiments.

Another time estimation experiment supplies results which are suggestive of ours. Doehring (1961) in an investigation of time intervals of a few seconds identifies a factor of consistency. This refers not to the average accuracy of the subjects responses, but to the range in which the subject's judgments fall. Doehring showed that the consistency of judgments decreases as the interval is increased as might be expected. The important point for our purposes, however, is that around intervals of four seconds inconsistency begins to increase rapidly. For intervals below four seconds the consistency decrease as interval increases is much less than for intervals about four seconds. This then suggests that if a time estimation notion applies in our experiment, bigger threshold differences should occur between the eight and four second intervals, than between the two and four second intervals. This is supported by our data. It will also be recalled that while Munoz (1963) did not find differences between the two and four second intervals, he did find a difference between the thresholds for the four second and eight second interval conditions.

But a time estimation type of formulation has certain defects. First, the practice decrement found in tachistoscopic recognition is large and in the case of our experiment the largest part of learning took place in the first six trials. It seems unlikely the improvements in time estimation are large enough to mediate as much practice decrement as we found. It will be recalled, moreover, that the shortest intervals show the greatest amount of practice decrement. This seems to conflict with a time estimation hypothesis, since because the long intervals are estimated less accurately than short intervals, there is more improvement possible in the estimation of long intervals than in the estimation of short intervals.

However, we believe these objections can be overcome by considering some other features of the tachistoscopic situation which could contribute to the threshold decrement.

Hay (1963) and Munoz (1963) have both shown that establishing a fixation point lowers thresholds. It seems likely then that when the subject is not provided with a fixation point he gradually comes to localize the place where the stimulus will appear. We have noted that many subjects ask why the stimulus is appearing in different places, which seems to indicate that they were trying to establish a fixed location. Heron (1957) found that when letters were presented both to the right and left of a fixation point that letters to the left are more readily recognized. This he concluded was the result of two types of eye-movements: one was a sweep to the left to the beginning of a word and the second a sweep to the right. Hay (p. 94) stated that a fixation point might allow the subject to eliminate the first of these movements, since the subject would have a good idea of where the stimulus is to appear.

Let us suppose that in addition to establishing a fixation point the subject develops other attentional responses which also serve to reduce thresholds. Now consider these as observing responses in a discrimination situation as outlined by Wyckoff (1952). These observing (attentional) responses may be defined as any response of the subject which exposes him to a relevant dimension of the stimulus. Wyckoff regards the discrimination situation as dependent on the development of observing responses. Briefly, he suggests that observing responses increase in frequency as they are reinforced by the making of a correct discrimination, and as the frequency of correct observing responses increases due to this source of reinforcement, the level of discrimination attained increases. It is our contention that learning is not as great in the case of long intervals as compared to short intervals because, since the long interval is not as accurately estimated as the short interval, observing (attentional) responses in the long interval situation do not receive the same level of reinforcement as responses in the short interval situation.

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APPENDIX A

ORDER OF INTERVALS

FOR

RANDOM GROUP

IN

EXPERIMENT I

EXPERIMENT I

Order of intervals in seconds used for the random group. Read down column.

COLUMNS

1	2	3	4	5	6	7	8	9	10	11	12
1.2	6.0	6.0	3.2	7.6	.4	1.2	4.8	7.6	5.2	6.4	1.6
2.0	5.6	6.0	4.0	1.2	4.0	5.2	5.6	6.0	3.2	4.0	.4
5.6	2.8	6.4	1.2	4.0	4.8	8.0	1.2	.8	1.2	4.0	2.0
7.2	6.8	2.8	3.6	4.4	5.6	2.0	6.8	7.2	5.2	7.2	8.0
6.8	4.4	2.4	6.8	7.2	7.6	6.0	5.2	3.2	4.0	5.6	2.0
4.4	5.6	2.4	5.2	.4	1.6	5.2	5.2	3.2	4.8	4.8	7.6
1.2	6.4	4.8	3.2	7.6	4.4	.4	1.6	6.4	1.2	5.2	8.0
5.2	8.0	.8	1.6	7.2	7.2	2.4	8.0	1.6	4.4	6.0	6.0
3.6	5.6	.4	4.4	.4	3.2	.8	7.2	.4	2.8	3.6	5.2
6.4	6.4	2.8	2.4	5.2	6.8	5.6	.8	6.0	3.6	.4	6.0
2.8	3.6	2.0	1.2	4.8	1.6	.8	4.4	2.4	2.8	2.4	6.0
1.2	4.4	8.0	4.0	.4	1.6	2.4	7.2	1.2	2.8	4.8	6.0
.4	6.8	8.0	1.2	8.0	2.4	6.8	6.4	6.8	6.0	1.2	5.6
4.4	6.0	3.2	6.8	7.6	4.0	6.8	4.4	3.6	.4	4.4	6.8
6.8	1.6	3.2	2.0	2.4	2.8	7.6	7.6	6.4	.8	4.0	4.8
3.6	1.6	5.6	.8	8.0	3.2	4.8	4.0	4.4	6.8	4.0	4.8
6.8	6.0	1.2	4.0	7.2	8.0	3.6	3.2	1.2	3.6	4.8	1.2
5.2	5.2	2.0	6.0	4.0	1.2	7.2	7.6	3.2	2.0	6.4	2.8
4.8	.8	4.4	4.8	2.0	8.0	4.8	2.4	.8	1.6	6.0	2.4
.4	.8	2.8	1.6	7.2	2.0	6.8	4.8	2.8	5.6	6.0	4.4
6.8	1.2	7.2	5.6	5.6	5.2	2.0	7.6	6.8	7.2	2.0	2.8
3.6	6.4	3.6	4.4	4.8	.8	1.2	3.6	2.4	6.8	6.0	2.0
2.0	6.4	3.2	.8	8.0	.8	2.8	6.8	4.8	2.0	.8	.8
.4	1.6	5.2	6.8	7.6	2.0	1.6	6.0	3.2	2.4	5.6	3.6
4.4	4.8	2.0	3.6	4.4	.8	6.4	1.2	1.2	2.4	3.2	.8

APPENDIX B

RAW DATA

FOR

EXPERIMENT I

Experiment I

Group 1 - Recognition Thresholds in hundredths of a second for the group with a .5 second tone offset-sequence presentation interval

Serial Position

Subjects	1	2	3	4	5	6	7	8	9	10	11	12
1	21	30	23	24	17	20	25	22	20	20	19	17
2	47	31	30	28	25	27	26	23	30	48	40	42
3	24	18	20	16	16	16	16	21	18	16	17	16
4	27	24	20	20	19	26	24	28	23	22	17	20
5	31	19	25	20	22	22	22	16	16	16	18	17
6	25	26	24	30	18	17	19	19	24	18	20	22
7	24	33	25	23	20	19	21	18	17	20	21	18
8	41	38	39	40	20	27	25	37	19	18	30	23
9	33	29	26	28	29	22	24	24	20	25	22	22
10	28	26	25	23	32	22	20	21	23	18	18	21
11	31	18	24	47	34	25	22	20	19	19	35	21
12	36	31	33	28	26	33	23	26	27	23	24	25
13	37	24	22	47	26	27	19	24	18	21	20	22
14	31	26	24	19	19	19	23	20	17	24	22	20
15	43	23	20	27	21	22	31	22	23	24	27	22
16	34	33	30	22	25	28	32	23	20	29	30	18
17	26	26	25	19	20	18	20	22	19	17	16	18
18	23	24	24	28	28	18	27	28	25	24	23	27
19	21	19	16	17	16	16	16	19	17	17	17	18
20	27	29	21	20	19	21	21	19	22	21	21	22

Experiment I

Group 2 - Recognition Thresholds in hundredths of a second for the group with a 1 second tone offset-sequence presentation interval

Serial Position

Subjects	1	2	3	4	5	6	7	8	9	10	11	12
1	27	23	17	22	23	22	20	17	18	18	23	18
2	30	29	39	32	20	21	30	17	23	32	32	18
3	25	21	29	18	31	23	18	28	31	30	18	24
4	40	36	27	17	25	23	24	26	21	27	28	24
5	25	17	34	25	28	18	21	29	22	28	33	24
6	32	37	34	39	35	38	31	48	33	42	34	39
7	27	26	32	19	31	22	21	26	19	17	16	24
8	36	54	37	28	17	21	20	49	18	18	39	21
9	30	31	35	27	27	28	21	20	23	26	23	25
10	32	31	26	23	25	20	25	19	25	25	23	21
11	30	25	22	19	19	23	18	20	22	19	21	18
12	18	20	23	24	16	25	22	26	23	17	20	16
13	31	33	22	25	19	23	17	16	16	17	16	16
14	29	42	28	19	23	24	18	35	22	31	21	25
15	35	26	43	35	24	21	18	21	28	18	19	17
16	38	22	38	28	28	29	24	26	27	22	24	24
17	24	20	29	20	21	20	19	24	28	22	23	23
18	32	29	31	40	29	19	28	22	31	25	23	24
19	35	26	34	18	17	17	23	24	21	18	21	18
20	36	34	33	35	22	20	26	21	23	21	22	23

Experiment I

Group 3 - Recognition Thresholds in hundredths of a second for the group with a 1.5 second tone offset-sequence presentation interval

	Serial Position											
Subjects	1	2	3	4	5	6	7	8	9	10	11	12
1	21	20	23	17	18	19	26	30	19	17	19	19
2	40	29	28	27	28	22	19	25	25	28	17	21
3	35	39	38	17	29	21	25	39	18	33	25	25
4	31	25	17	25	19	19	28	23	25	18	20	21
5	27	23	28	30	16	19	16	16	35	16	16	17
6	31	27	27	23	22	23	20	16	17	17	16	16
7	31	29	28	25	21	26	20	26	19	21	22	18
8	30	43	35	34	36	30	33	26	30	29	31	24
9	23	26	20	29	23	26	20	20	19	27	19	20
10	43	32	28	26	22	22	20	23	19	19	20	21
11	32	27	21	24	22	16	16	16	16	22	24	19
12	27	24	35	26	21	22	23	24	19	22	21	21
13	25	25	27	20	22	18	28	20	20	25	17	20
14	35	35	24	24	22	25	18	27	20	22	23	25
15	29	23	24	51	30	29	18	16	17	19	21	17
16	28	25	25	19	22	22	30	21	19	29	23	23
17	25	29	23	23	21	18	19	26	19	18	32	24
18	37	35	28	20	25	16	22	21	26	17	26	20
19	19	21	19	18	17	16	17	16	17	16	16	16
20	29	21	19	18	24	18	33	23	20	25	20	19

Experiment I

Group 4 - Recognition Thresholds in hundredths of a second for the group with a 2 second tone offset-sequence presentation interval

Serial Position

Subjects	1	2	3	4	5	6	7	8	9	10	11	12
1	37	37	18	23	19	20	24	29	19	20	21	19
2	23	29	18	17	17	16	18	21	23	16	16	17
3	31	18	17	20	26	25	18	21	17	18	21	17
4	33	37	23	27	22	21	16	16	20	18	16	18
5	32	24	19	28	30	20	21	21	19	23	18	20
6	37	29	26	27	26	25	23	25	21	25	22	22
7	33	30	30	26	23	22	26	20	21	19	16	20
8	29	29	32	25	24	25	24	19	22	17	19	16
9	34	27	34	20	22	20	23	21	24	17	20	21
10	32	30	31	24	23	23	20	17	21	18	20	19
11	75	51	51	40	32	40	43	39	31	48	27	32
12	25	32	21	35	17	23	23	22	21	24	16	16
13	51	31	30	35	41	27	24	29	23	25	20	18
14	28	17	22	16	24	22	16	16	17	20	18	16
15	24	18	19	23	19	20	18	20	16	17	22	28
16	33	24	22	19	35	20	23	24	26	21	22	20
17	37	30	23	25	22	23	24	19	25	23	20	21
18	32	25	21	23	17	25	21	22	23	16	16	24
19	27	27	23	21	19	21	22	20	20	18	18	20
20	35	25	21	23	22	20	23	20	19	20	21	19

Experiment I

Group 5 - Recognition Thresholds in hundredths of a second for the group with a 4 second tone offset-sequence presentation interval

Serial Position

Subjects	1	2	3	4	5	6	7	8	9	10	11	12
1	31	29	32	25	31	37	30	24	29	21	26	27
2	38	30	29	27	27	35	31	39	33	27	35	33
3	46	49	41	37	33	25	30	36	29	23	27	27
4	41	35	30	25	35	30	31	23	33	25	27	26
5	19	28	18	18	16	16	21	19	21	18	20	19
6	31	35	27	21	25	25	25	23	27	22	26	24
7	25	31	19	27	17	28	20	23	21	23	19	19
8	34	28	45	35	41	43	35	41	30	26	29	26
9	35	24	49	41	37	31	40	29	26	23	25	25
10	36	33	27	35	30	35	26	28	28	31	27	27
11	30	31	27	30	34	24	25	20	22	21	21	20
12	23	30	21	19	20	22	18	18	28	16	19	16
13	35	27	27	31	46	27	27	26	30	23	25	28
14	30	27	25	26	25	24	23	24	24	23	23	23
15	26	24	27	19	21	23	20	21	19	19	17	18
16	31	33	30	27	31	34	31	29	29	28	29	30
17	32	31	22	35	31	19	25	28	24	22	21	21
18	34	30	57	34	31	29	32	31	37	30	33	33
19	28	25	26	27	24	23	29	22	23	25	23	22
20	21	27	19	17	16	18	18	18	17	16	20	21

Experiment I

Group 6 - Recognition Thresholds in hundredths of a second for the group with a 6 second tone offset-sequence presentation interval

Serial Position

Subjects	1	2	3	4	5	6	7	8	9	10	11	12
1	40	33	35	31	25	29	27	23	26	25	23	24
2	39	30	20	27	23	23	23	27	21	22	22	20
3	38	32	22	25	23	20	28	21	19	23	19	20
4	34	34	27	32	23	32	26	29	26	22	25	27
5	42	30	26	31	29	27	21	23	24	25	25	25
6	47	37	35	32	41	30	35	33	31	33	29	34
7	29	35	34	48	46	37	31	40	31	29	35	30
8	34	32	27	41	37	30	32	27	31	33	25	29
9	30	29	30	31	32	32	29	30	31	28	27	29
10	36	32	29	37	39	34	30	31	28	32	30	32
11	40	34	26	34	30	30	23	30	28	24	27	23
12	32	30	32	30	23	27	17	18	27	23	25	21
13	40	43	31	29	35	27	30	23	25	25	26	23
14	35	33	29	27	36	27	26	25	21	27	25	24
15	44	36	29	40	32	37	33	26	29	35	33	30
16	38	31	27	19	27	17	20	31	17	20	23	19
17	35	26	29	37	40	24	18	22	23	19	21	19
18	32	34	37	26	30	28	25	21	26	25	22	24
19	35	36	38	30	29	30	25	26	29	27	28	28
20	29	33	33	21	20	25	27	31	23	26	28	23

Experiment I

Group 7 - Recognition Thresholds in hundredths of a second for the group with an 8 second tone offset-sequence presentation interval

Serial Position

Subjects	1	2	3	4	5	6	7	8	9	10	11	12
1	75	70	71	63	69	72	59	63	70	70	63	65
2	51	56	52	50	47	46	50	52	51	49	41	49
3	37	30	32	30	34	29	31	35	28	31	32	28
4	41	45	37	37	40	35	37	34	33	43	30	42
5	31	27	28	46	35	42	32	33	40	37	30	35
6	42	41	45	37	39	41	42	35	36	40	37	42
7	38	29	41	35	34	39	42	31	33	39	35	30
8	36	34	35	39	36	40	35	33	36	37	33	34
9	41	39	39	42	40	39	39	40	37	38	37	37
10	43	45	41	41	41	38	40	39	43	40	38	36
11	33	30	30	43	43	36	33	32	34	31	30	31
12	28	36	31	30	27	27	26	24	23	28	24	27
13	35	33	32	29	28	27	24	30	29	30	27	26
14	29	29	22	22	21	19	24	23	20	19	21	22
15	31	25	25	24	17	22	23	18	19	19	20	18
16	32	29	32	21	39	29	24	23	26	22	25	23
17	40	39	21	22	17	30	26	25	23	25	22	24
18	44	39	34	36	29	34	32	35	30	32	34	34
19	31	42	28	29	21	25	21	19	18	19	20	18
20	50	41	45	43	48	41	46	45	49	41	43	43

Experiment I

Group 8 - Recognition Thresholds in hundredths of a second for the group with a random tone offset-sequence presentation interval

Serial Position

Subjects	1	2	3	4	5	6	7	8	9	10	11	12
1	33	29	31	18	28	22	22	33	20	23	21	24
2	35	45	31	36	31	33	29	28	32	36	32	33
3	19	23	21	18	18	16	17	16	16	16	16	17
4	22	32	17	18	30	32	33	21	29	24	18	16
5	44	36	35	32	29	37	33	38	36	32	35	32
6	25	27	26	23	25	27	18	26	25	22	18	19
7	37	30	32	22	23	21	22	22	23	21	20	22
8	23	30	21	21	24	24	21	22	26	29	22	20
9	44	36	31	29	44	29	28	34	17	33	30	30
10	32	32	34	29	33	25	33	29	24	31	25	19
11	31	31	26	24	26	22	27	27	30	24	32	16
12	39	31	34	18	31	35	30	34	28	27	29	32
13	32	38	17	24	29	33	25	26	35	31	43	20
14	33	26	36	30	31	23	38	31	19	31	26	18
15	25	29	27	26	23	27	21	26	30	27	26	28
16	38	24	28	32	27	30	26	26	31	29	28	29
17	36	29	28	27	24	25	26	23	26	25	26	34
18	27	32	30	40	33	28	28	30	33	30	31	36
19	33	29	31	36	37	27	30	28	28	25	31	35
20	32	30	25	27	25	22	20	20	20	20	16	34

APPENDIX C

RAW DATA

FOR

EXPERIMENT II

Experiment II

Group 1 - Recognition Thresholds in hundredths of a second for the group with an 8 second tone offset-sequence presentation interval and a 15 second exposure-exposure interval

Serial Position

Subjects	1	2	3	4	5	6	7	8	9	10	11	12
1	35	30	32	31	30	27	28	29	27	27	30	28
2	32	34	33	29	28	28	23	25	25	23	21	24
3	41	40	37	38	38	43	41	37	46	40	42	37
4	38	38	34	33	34	32	37	33	34	31	32	33
5	29	26	29	23	25	22	24	23	24	24	20	22
6	37	37	37	35	32	31	31	32	29	28	31	29
7	39	37	40	39	36	34	33	36	33	35	35	34
8	43	40	41	41	39	41	40	37	39	38	36	37
9	35	35	30	33	31	32	32	29	28	31	30	29
10	33	36	39	32	30	29	26	25	25	26	21	27

Experiment II

Group 2 - Recognition Thresholds in hundredths of a second for the group with a 2 second tone offset-sequence presentation interval and a 15 second exposure-exposure interval

Serial Position

Subjects	1	2	3	4	5	6	7	8	9	10	11	12
1	25	20	30	16	29	28	18	21	24	25	21	28
2	33	31	28	29	21	24	23	28	22	21	25	28
3	35	27	33	22	21	21	24	24	31	24	23	21
4	32	21	20	19	26	24	17	29	22	18	17	16
5	33	31	30	29	28	22	23	22	23	22	24	20
6	37	34	32	30	30	29	26	27	31	29	27	26
7	34	35	27	38	21	25	23	19	23	27	29	26
8	22	21	18	19	16	17	20	17	17	17	17	17
9	35	35	31	23	28	27	29	24	24	25	23	23
10	34	22	27	26	31	24	26	23	29	24	25	24

Experiment II

Group 3 - Recognition Thresholds in hundredths of a second for the group with a 2 second tone offset-sequence presentation interval and a 10 second exposure-exposure interval

Serial Position

Subjects	1	2	3	4	5	6	7	8	9	10	11	12
1	32	29	27	23	21	17	19	19	18	19	17	17
2	34	35	31	30	27	28	26	23	27	22	20	21
3	26	23	24	21	20	22	19	21	16	18	21	20
4	24	24	23	20	21	20	18	19	20	17	19	21
5	29	25	26	26	27	23	24	22	26	27	21	23
6	36	33	32	31	29	30	27	27	25	28	24	23
7	34	30	29	31	27	29	26	26	23	25	21	21
8	30	27	22	24	24	27	25	24	22	16	19	18
9	28	24	25	20	23	20	21	23	20	19	20	17
10	29	31	25	21	24	18	22	17	18	18	18	16

Experiment II

Group 4 - Recognition Thresholds in hundredths of a second for the group with a 2 second tone offset-sequence presentation interval and a random exposure-exposure interval

	Serial Position											
Subjects	1	2	3	4	5	6	7	8	9	10	11	12
1	29	27	23	30	16	22	26	23	21	22	20	23
2	31	32	36	38	30	28	32	27	27	26	27	26
3	35	31	30	28	26	22	16	16	17	16	16	17
4	27	24	23	21	20	23	19	19	18	18	17	17
5	24	19	22	19	18	18	16	18	20	17	19	19
6	30	29	26	26	22	23	21	19	17	17	17	16
7	32	28	27	24	29	22	17	18	19	16	19	18
8	29	30	24	26	27	24	18	23	22	21	24	20
9	28	25	22	21	24	23	22	26	24	16	18	16
10	26	20	20	16	19	17	16	19	17	16	17	16

APPENDIX D

RAW DATA

FOR

EXPERIMENT III

Experiment III

Group 1 - Recognition Thresholds in hundredths of a second for the group receiving the equivalent of 2 tachistoscopic trials on the RT apparatus, then 10 tachistoscopic trials

Serial Position

Subjects	RT	1	2	3	4	5	6	7	8	9	10
1	33	30	30	26	24	23	20	22	18	18	18
2	41	27	25	29	22	28	29	33	27	24	25
3	21	25	29	26	22	23	16	17	22	19	18
4	20	41	28	32	32	29	30	25	23	23	21
5	26	39	33	27	28	25	29	27	27	24	24
6	41	31	20	22	20	21	23	17	21	18	20
7	36	26	33	23	17	19	17	16	18	17	19
8	29	22	19	17	21	19	17	17	17	16	17
9	24	32	27	27	26	22	23	23	24	25	22
10	32	33	30	22	27	25	24	25	20	19	20

The number under RT represents the number of reaction time trials the given subject received

Experiment III

Group 2 - Recognition Thresholds in hundredths of a second for the group receiving the equivalent of 4 tachistoscopic trials on the RT apparatus, then 8 tachistoscopic trials

		Serial Position							
Subjects	RT	1	2	3	4	5	6	7	8
1	55	24	24	23	20	19	20	16	17
2	74	31	29	28	25	17	24	22	22
3	38	26	23	21	21	19	23	19	18
4	35	27	26	25	23	22	21	20	21
5	48	25	21	22	19	17	18	16	16
6	71	27	25	25	26	20	21	23	21
7	68	26	20	23	22	24	23	20	19
8	47	30	31	24	28	26	28	27	28
9	41	34	30	28	28	28	25	25	23
10	50	28	27	24	23	23	20	24	20

The number under RT represents the number of reaction time trials the given subject received

Experiment III

Group 3 - Recognition Thresholds in hundredths of a second for the group receiving the equivalent of 6 tachistoscopic trials on the RT apparatus, then 6 tachistoscopic trials

		Serial Position					
Subjects	RT	1	2	3	4	5	6
1	65	23	19	20	17	21	19
2	101	32	25	24	21	22	25
3	52	26	25	22	22	19	20
4	48	30	26	24	23	27	24
5	70	33	29	26	27	25	26
6	102	29	24	25	23	22	22
7	96	30	28	23	23	21	17
8	70	29	27	26	21	20	22
9	56	24	24	20	19	21	20
10	64	27	23	23	24	23	18

The number under RT represents the number of reaction time trials the given subject received

Experiment III

Group 4 - Recognition Thresholds in hundredths of a second for the group receiving the equivalent of 8 tachistoscopic trials on the RT apparatus, then 4 tachistoscopic trials

		Serial Position			
Subjects	RT	1	2	3	4
1	75	25	23	17	19
2	122	41	32	29	28
3	64	26	20	21	18
4	57	29	32	25	22
5	88	25	22	21	19
6	128	27	26	22	21
7	120	34	30	28	29
8	91	26	30	22	17
9	72	33	31	28	27
10	75	25	22	22	20

The number under RT represents the number of reaction time trials the given subject received

Experiment III

Group 5 - Recognition Thresholds in hundredths of a second for the group receiving the equivalent of 10 tachistoscopic trials on the RT apparatus, then 2 tachistoscopic trials

		Serial Position	
Subjects	RT	1	2
1	84	20	19
2	143	26	21
3	70	23	20
4	73	25	23
5	113	31	25
6	153	22	19
7	140	30	27
8	101	23	23
9	83	28	26
10	83	29	25

The number under RT represents the number of reaction time trials the given subject received

Experiment III

Group 1 - Reaction times in milliseconds for the group receiving the equivalent of 2 tachistoscopic trials on the RT apparatus. Each subject is here numbered as where the appropriate tachistoscopic data (Experiment III, Group 1) is found

Serial Position

Subject 1 Trials	1	2	3	4	5	6	7	8	9	10
1-10	249	252	228	239	221	259	233	259	251	279
11-20	279	253	228	252	279	217	227	218	198	183
21-30	233	219	211	242	225	201	200	203	216	76
31-33	228	219	193							
Subject 2										
1-10	325	316	441	351	358	295	417	296	475	277
11-20	236	381	251	269	244	212	276	356	270	222
21-30	268	263	327	267	298	250	261	392	294	258
31-40	378	299	262	352	251	308	254	231	267	238
41	229									
Subject 3										
1-10	317	299	250	221	290	261	224	239	318	351
11-20	275	276	270	272	252	226	252	224	284	234
21	225									
Subject 4										
1-10	253	306	209	249	234	267	231	244	243	235
11-20	250	225	234	217	225	221	227	216	209	233

Experiment III

Group 1 - Reaction times in milliseconds for the group receiving the equivalent of 2 tachistoscopic trials on the RT apparatus. Each subject is here numbered as where the appropriate tachistoscopic data (Experiment III, Group 1) is found

Serial Position

Trials Subject 5	1	2	3	4	5	6	7	8	9	10
1-10	293	483	599	333	318	506	360	550	597	309
11-20	237	251	311	360	351	334	352	361	311	354
21-26	365	377	326	311	301	308				
Subject 6										
1-10	241	213	243	211	197	234	252	191	280	185
11-20	202	182	229	227	208	244	184	199	194	201
21-30	255	208	209	214	227	211	226	201	368	236
31-40	218	207	261	218	209	218	194	158	235	185
41	211									
Subject 7										
1-10	430	284	252	251	226	318	291	225	209	233
11-20	244	261	232	228	230	221	214	232	218	225
21-30	193	217	201	218	208	234	219	203	198	194
31-36	236	221	189	206	209	198				
Subject 8										
1-10	227	232	233	234	223	267	262	234	239	259
11-20	233	274	306	293	229	251	292	285	330	151
21-29	257	280	286	289	273	277	242	225	169	

Experiment III

Group 1 - Reaction times in milliseconds for the group receiving the equivalent of 2 tachistoscopic trials on the RT apparatus. Each subject is here numbered as where the appropriate tachistoscopic data (Experiment III, Group 1) is found

Serial Position

Trials Subject 9	1	2	3	4	5	6	7	8	9	10
1-10	717	508	311	317	308	309	285	291	267	299
11-20	227	250	259	299	257	262	276	243	243	234
21-24	225	207	205	242						
Subject 10										
1-10	444	324	284	260	237	262	256	251	227	252
11-20	231	215	254	221	225	223	239	233	241	233
21-30	234	227	208	213	227	210	256	249	239	219
31-32	215	224								

Experiment III

Group 2 - Reaction times in milliseconds for the group receiving the equivalent of 4 tachistoscopic trials on the RT apparatus. Each subject is here numbered as where the appropriate tachistoscopic data (Experiment III, Group 2) is found

Serial Position

Trials Subject 1	1	2	3	4	5	6	7	8	9	10
1-10	351	236	209	213	207	225	252	282	156	361
11-20	210	217	268	268	272	281	221	242	219	225
21-30	255	214	226	236	261	209	235	217	234	203
31-40	194	236	221	243	207	225	239	236	225	236
41-50	231	221	247	224	223	256	239	215	231	238
51-55	200	210	220	192	275					
Subject 2										
1-10	248	237	263	221	240	239	217	237	248	231
11-20	238	242	232	276	208	203	222	218	271	234
21-30	265	207	203	215	211	238	236	217	235	218
31-40	224	229	222	234	266	203	217	220	231	242
41-50	225	212	200	211	235	217	222	225	210	214
51-60	225	215	224	231	230	225	231	207	241	217
61-70	226	218	274	210	222	238	214	228	230	236
71-74	200	226	204	210						
Subject 3										
1-10	237	268	274	261	239	258	209	210	234	237
11-20	229	215	200	213	224	233	218	229	214	235
21-30	197	211	233	208	222	216	224	202	190	212
31-38	201	238	189	220	223	191	205	217		

Experiment III

Group 2 - Reaction times in milliseconds for the group receiving the equivalent of 4 tachistoscopic trials on the RT apparatus. Each subject is here numbered as where the appropriate tachistoscopic data (Experiment III, Group 2) is found

Serial Position

Trials Subject 4	1	2	3	4	5	6	7	8	9	10
1-10	237	317	252	316	250	351	221	261	277	253
11-20	270	251	217	226	212	198	234	270	183	217
21-30	225	227	267	242	201	220	239	217	228	230
31-35	218	206	234	214	216					
Subject 5										
1-10	328	270	255	237	249	222	234	216	268	230
11-20	221	208	235	271	250	218	226	237	214	225
21-30	209	210	228	269	274	202	231	215	224	231
31-40	218	300	248	232	213	205	226	238	223	224
41-48	210	223	243	190	215	193	216	224		
Subject 6										
1-10	241	363	278	220	230	251	249	168	241	230
11-20	233	218	246	220	260	236	218	243	217	241
21-30	201	220	225	225	233	218	244	243	202	211
31-40	234	239	230	196	222	247	274	233	219	241
41-50	236	214	230	225	208	228	241	211	210	201
51-60	204	231	228	223	267	209	202	235	227	200
61-70	223	238	192	239	208	219	241	224	228	209
71	186									

Experiment III

Group 2 - Reaction times in milliseconds for the group receiving the equivalent of 4 tachistoscopic trials on the RT apparatus. Each subject is here numbered as where the appropriate tachistoscopic data (Experiment III, Group 2) is found

Serial Position

Trials Subject 7	1	2	3	4	5	6	7	8	9	10
1-10	250	238	265	233	208	271	263	260	249	238
11-20	234	233	218	263	250	244	215	234	237	224
21-30	251	227	210	239	215	220	243	231	217	229
31-40	234	232	243	240	216	247	226	230	249	246
41-50	231	245	216	209	228	253	242	238	230	217
51-60	193	262	225	231	220	214	226	234	229	228
61-68	253	216	233	244	214	226	216	224		

Subject 8										
1-10	401	584	351	551	376	544	474	434	391	321
11-20	314	333	305	338	318	285	476	397	279	459
21-30	264	285	291	267	275	252	292	286	250	269
31-40	266	260	296	276	265	283	293	392	273	258
41-47	234	243	251	310	395	259	295			

Subject 9										
1-10	626	426	278	308	308	548	317	259	392	309
11-20	273	261	277	242	375	336	217	231	260	327
21-30	222	279	268	194	265	307	260	327	227	201
31-40	223	193	201	234	220	277	359	278	286	270
41	280									

Experiment III

Group 2 - Reaction times in milliseconds for the group receiving the equivalent of 4 tachistoscopic trials on the RT apparatus. Each subject is here numbered as where the appropriate tachistoscopic data (Experiment III, Group 2) is found

Serial Position

Trials Subject 10	1	2	3	4	5	6	7	8	9	10
1-10	268	257	226	233	239	222	215	234	241	236
11-20	249	235	228	234	242	216	233	245	240	213
21-30	221	214	210	238	211	230	217	220	229	202
31-40	210	215	230	231	206	200	223	190	213	241
41-50	206	237	200	212	180	228	196	225	204	217

Experiment III

Group 3 - Reaction times in milliseconds for the group receiving the equivalent of 6 tachistoscopic trials on the RT apparatus. Each subject is here numbered as where the appropriate tachistoscopic data (Experiment III, Group 3) is found

Serial Position

Trials Subject 1	1	2	3	4	5	6	7	8	9	10
1-10	300	261	283	257	279	270	256	278	187	215
11-20	254	158	199	217	233	223	218	205	256	239
21-30	238	217	249	235	229	201	228	214	253	284
31-40	230	216	193	200	216	227	238	214	229	204
41-50	229	202	216	228	207	234	273	222	200	190
51-60	213	224	261	210	223	194	231	248	196	223
61-65	233	214	201	225	191					

Subject 2										
1-10	341	297	290	267	238	264	229	247	254	221
11-20	237	228	304	241	218	258	245	238	278	269
21-30	272	202	218	255	220	250	229	252	264	204
31-40	231	237	255	221	268	239	214	256	229	266
41-50	234	240	236	210	232	229	275	244	238	217
51-60	265	222	218	257	230	206	213	237	219	240
61-70	209	217	235	261	238	224	224	237	230	221
71-80	229	271	234	206	215	228	219	253	226	238
81-90	213	229	225	217	236	218	226	233	239	208
91-100	215	206	243	246	249	203	215	256	233	190
101	227									

Experiment III

Group 3 - Reaction times in milliseconds for the group receiving the equivalent of 6 tachistoscopic trials on the RT apparatus. Each subject is here numbered as where the appropriate tachistoscopic data (Experiment III, Group 3) is found

Serial Position

Trials Subject 3	1	2	3	4	5	6	7	8	9	10
1-10	327	258	240	239	261	230	227	232	251	243
11-20	229	203	217	213	222	204	198	235	263	204
21-30	216	232	244	210	226	239	205	211	226	237
31-40	235	199	204	218	232	255	201	304	202	195
41-50	183	238	216	240	203	227	190	212	238	219
51	204									

Subject 4										
1-10	268	232	255	274	220	242	251	208	236	225
11-20	257	199	232	201	225	217	132	347	196	185
21-30	220	197	174	209	230	199	222	279	236	203
31-40	198	183	221	193	208	206	183	232	205	223
41-48	210	218	194	230	188	176	224	183		

Subject 5										
1-10	276	282	225	240	254	278	239	216	230	226
11-20	211	239	244	263	215	221	236	252	207	249
21-30	208	233	248	224	198	202	235	249	223	265
31-40	240	254	226	285	261	207	218	232	228	203
41-50	224	237	241	253	200	215	228	236	257	200
51-60	217	241	195	182	229	247	196	208	237	224
61-70	251	220	204	183	236	242	230	213	251	222

Experiment III

Group 3 - Reaction times in milliseconds for the group receiving the equivalent of 6 tachistoscopic trials on the RT apparatus. Each subject is here numbered as where the appropriate tachistoscopic data (Experiment III, Group 3) is found

Serial Position

Trials Subject 6	1	2	3	4	5	6	7	8	9	10
1-10	266	261	243	235	248	270	226	232	267	226
11-20	273	230	225	228	231	249	257	203	229	217
21-30	259	223	248	254	213	226	249	230	224	215
31-40	209	256	221	248	233	214	197	261	239	225
41-50	236	241	208	252	230	195	249	222	235	216
51-60	249	203	204	215	230	209	196	254	238	221
61-70	192	278	231	234	245	256	224	210	221	218
71-80	205	213	201	234	247	233	222	227	215	238
81-90	191	235	213	228	220	218	202	194	226	230
91-100	232	226	243	197	220	236	267	302	247	254
101-102	212	210								
Subject 7										
1-10	342	263	274	307	290	276	244	252	226	243
11-20	267	210	224	262	278	215	236	240	277	223
21-30	228	243	259	210	238	209	241	259	223	209
31-40	222	214	247	253	267	195	276	220	237	206
41-50	195	242	221	186	243	226	262	229	214	239
51-60	190	265	238	220	213	269	241	258	205	263
61-70	241	256	234	222	205	260	278	224	230	208
71-80	191	237	242	278	261	243	226	281	206	192

Experiment III

Group 3 - Reaction times in milliseconds for the group receiving the equivalent of 6 tachistoscopic trials on the RT apparatus. Each subject is here numbered as where the appropriate tachistoscopic data (Experiment III, Group 3) is found

Serial Position

Trials Subject 7 (cont'd.)	1	2	3	4	5	6	7	8	9	10
81-90	230	252	226	214	201	246	191	235	218	222
91-96	267	235	248	212	276	225				
Subject 8										
1-10	332	315	287	253	266	271	247	302	255	271
11-20	237	224	255	272	229	246	233	248	270	249
21-30	271	248	214	252	229	220	267	238	221	287
31-40	229	232	258	263	239	226	230	249	224	268
41-50	254	220	236	215	263	287	292	258	223	244
51-60	210	239	265	241	236	220	218	234	207	253
61-70	251	246	232	255	264	226	220	245	253	211
Subject 9										
1-10	263	277	248	234	211	257	263	237	276	220
11-20	258	237	269	214	229	248	265	226	240	209
21-30	225	206	238	249	191	220	259	274	215	233
31-40	204	241	228	210	249	229	205	198	286	149
41-50	236	221	214	230	229	233	245	218	227	200
51-56	204	271	243	216	205	223				

Experiment III

Group 3 - Reaction times in milliseconds for the group receiving the equivalent of 6 tachistoscopic trials on the RT apparatus. Each subject is here numbered as where the appropriate tachistoscopic data (Experiment III, Group 3) is found

Serial Position

Trials Subject 10	1	2	3	4	5	6	7	8	9	10
1-10	292	325	217	321	268	282	260	238	191	245
11-20	201	218	250	228	253	234	226	243	210	229
21-30	243	257	269	220	214	236	221	202	240	219
31-40	198	214	271	224	247	209	232	216	228	212
41-50	227	265	220	209	213	230	222	217	195	184
51-60	267	241	216	265	222	238	236	243	207	203
61-64	210	289	203	226						

Experiment III

Group 4 - Reaction times in milliseconds for the group receiving the equivalent of 8 tachistoscopic trials on the RT apparatus. Each subject is here numbered as where the appropriate tachistoscopic data (Experiment III, Group 4) is found

Serial Position

Trials

Subject 1	1	2	3	4	5	6	7	8	9	10
1-10	313	272	257	240	235	265	256	281	258	226
11-20	233	262	225	210	206	234	191	258	213	225
21-30	280	257	231	228	212	234	209	264	200	193
31-40	227	181	234	216	241	237	224	209	252	198
41-50	230	217	255	244	229	210	197	161	274	239
51-60	212	226	240	209	195	253	222	247	209	198
61-70	241	243	205	196	221	243	192	272	258	216
71-75	241	188	203	228	210					

Subject 2										
1-10	346	321	300	279	283	265	223	278	246	282
11-20	292	259	243	267	270	275	234	258	216	222
21-30	231	262	256	274	225	249	272	224	255	234
31-40	287	244	225	212	256	216	238	214	273	250
41-50	269	274	253	225	221	232	216	268	242	239
51-60	231	266	278	241	230	249	223	260	228	234
61-70	238	246	212	255	244	287	228	235	252	266
71-80	249	210	222	215	211	265	231	216	222	240
81-90	249	238	229	263	247	206	254	199	250	235
91-100	221	235	228	226	223	224	257	214	230	258

Experiment III

Group 4 - Reaction times in milliseconds for the group receiving the equivalent of 8 tachistoscopic trials on the RT apparatus. Each subject is here numbered as where the appropriate tachistoscopic data (Experiment III, Group 4) is found

Serial Position

Trials Subject 2 (cont'd.)	1	2	3	4	5	6	7	8	9	10
101-110	239	263	216	230	243	257	210	245	223	227
111-120	258	215	241	201	220	240	249	258	204	222
121-122	226	240								
Subject 3										
1-10	321	304	273	256	227	270	237	257	223	216
11-20	194	240	237	223	241	268	215	208	182	199
21-30	233	196	181	226	249	193	219	239	210	197
31-40	172	246	233	218	222	205	211	274	238	224
41-50	215	261	232	246	210	229	194	182	203	227
51-60	219	191	215	226	202	189	234	248	214	198
61-64	202	210	235	225						
Subject 4										
1-10	324	296	235	272	238	249	211	230	221	215
11-20	238	206	274	240	215	239	260	228	226	226
21-30	213	229	254	208	220	236	241	229	236	217
31-40	190	202	237	246	213	223	255	201	200	206
41-50	307	251	243	211	221	234	220	219	197	203
51-57	264	215	229	243	216	206	234			

Experiment III

Group 4 - Reaction times in milliseconds for the group receiving the equivalent of 8 tachistoscopic trials on the RT apparatus. Each subject is here numbered as where the appropriate tachistoscopic data (Experiment III, Group 4) is found

Serial Position

Trials Subject 5	1	2	3	4	5	6	7	8	9	10
1-10	265	244	201	273	251	228	236	202	259	264
11-20	229	232	201	262	234	222	200	192	238	248
21-30	229	238	217	221	253	201	228	234	245	249
31-40	233	215	226	207	230	221	248	236	206	215
41-50	204	229	238	221	215	264	215	229	232	241
51-60	265	207	231	192	194	208	231	217	211	209
61-70	232	246	201	200	222	236	249	237	204	211
71-80	228	213	229	274	243	209	191	206	234	261
81-88	237	228	176	239	210	223	242	207		

Subject 6

1-10	322	295	273	277	227	242	235	221	226	233
11-20	198	253	265	241	209	223	276	213	238	239
21-30	243	229	230	308	211	235	223	216	220	208
31-40	230	229	246	208	190	206	235	220	249	210
41-50	212	228	231	248	263	200	211	227	201	225
51-60	201	229	233	206	211	216	228	233	205	229
61-70	248	201	226	193	199	212	225	247	195	162
71-80	238	246	208	221	238	225	207	212	205	219
81-90	250	247	212	226	235	227	219	190	206	269

Experiment III

Group 4 - Reaction times in milliseconds for the group receiving the equivalent of 8 tachistoscopic trials on the RT apparatus. Each subject is here numbered as where the appropriate tachistoscopic data (Experiment III, Group 4) is found

Serial Position

Trials Subject 6 (cont'd.)	1	2	3	4	5	6	7	8	9	10
91-100	211	227	241	216	200	236	230	229	226	228
101-110	212	190	239	215	260	248	228	236	213	228
111-120	220	227	233	228	215	263	209	203	236	249
121-128	227	218	238	202	240	217	202	209		
Subject 7										
1-10	298	303	274	281	253	227	231	269	220	217
11-20	233	258	217	227	238	240	216	227	213	224
21-30	219	222	230	207	264	239	244	197	273	202
31-40	234	230	216	226	226	195	239	231	228	205
41-50	220	241	242	226	205	206	234	242	267	223
51-60	237	228	241	205	271	219	235	227	245	209
61-70	219	230	218	209	244	228	246	237	203	262
71-80	220	218	224	230	219	205	223	224	200	269
81-90	211	228	236	238	231	233	240	202	214	235
91-100	207	191	197	204	245	220	236	240	227	213
101-110	232	238	212	265	243	206	210	258	221	234
111-120	202	223	236	252	231	206	214	220	207	223

Experiment III

Group 4 - Reaction times in milliseconds for the group receiving the equivalent of 8 tachistoscopic trials on the RT apparatus. Each subject is here numbered as where the appropriate tachistoscopic data (Experiment III, Group 4) is found

Serial Position

Trials Subject 8	1	2	3	4	5	6	7	8	9	10
1-10	241	276	233	242	258	233	221	258	272	249
11-20	215	232	241	226	239	224	211	234	227	247
21-30	214	229	230	263	200	224	268	233	257	225
31-40	238	266	240	231	207	220	236	207	214	225
41-50	263	226	219	223	235	227	233	245	206	212
51-60	211	217	218	224	245	200	203	210	265	229
61-70	236	222	242	220	236	240	227	212	228	241
71-80	208	204	195	209	213	220	234	219	230	249
81-90	225	236	208	262	237	212	221	241	209	224
91	218									

Subject 9										
1-10	321	294	265	273	227	238	241	227	231	222
11-20	240	260	239	224	271	227	243	258	201	263
21-30	232	242	252	212	274	217	220	236	256	221
31-40	235	226	233	210	205	215	231	224	262	243
41-50	221	238	262	203	229	243	221	230	239	251
51-56	208	228	233	248	215	238				

Experiment III

Group 4 - Reaction times in milliseconds for the group receiving the equivalent of 8 tachistoscopic trials on the RT apparatus. Each subject is here numbered as where the appropriate tachistoscopic data (Experiment III, Group 4) is found

Serial Position

Trials Subject 10	1	2	3	4	5	6	7	8	9	10
1-10	273	224	259	260	235	229	206	231	252	229
11-20	236	221	236	204	226	196	254	211	240	225
21-30	214	190	215	233	191	227	238	202	197	254
31-40	208	233	229	201	214	210	212	226	234	206
41-50	290	233	227	218	208	237	192	198	183	231
51-60	249	210	225	203	239	260	212	195	207	195
61-64	212	191	204	207						

Experiment III

Group 5 - Reaction times in milliseconds for the group receiving the equivalent of 10 tachistoscopic trials on the RT apparatus. Each subject is here numbered as where the appropriate tachistoscopic data (Experiment III, Group 5) is found

Serial Position

Trials Subject 1	1	2	3	4	5	6	7	8	9	10
1-10	259	230	241	252	225	229	218	207	235	220
11-20	241	206	209	217	216	210	238	241	260	235
21-30	215	211	186	174	92	249	226	235	217	210
31-40	211	202	212	191	238	200	210	241	196	196
41-50	232	217	210	196	207	228	200	218	229	233
51-60	194	209	206	197	189	218	198	224	199	212
61-70	215	203	203	169	241	232	217	194	265	204
71-80	206	208	198	193	216	214	228	204	209	183
81-84	198	190	204	217						
Subject 2										
1-10	301	255	243	268	292	237	254	293	268	225
11-20	237	234	243	265	298	222	232	268	201	283
21-30	277	279	255	242	311	293	258	259	216	237
31-40	234	249	235	225	209	257	234	262	301	253
41-50	228	239	253	262	291	253	237	224	200	219
51-60	255	237	243	235	220	236	239	237	215	241
61-70	207	224	213	215	238	247	226	272	290	191
71-80	210	231	222	209	238	208	261	222	243	232
81-90	240	217	211	225	234	241	217	198	233	261

Experiment III

Group 5 - Reaction times in milliseconds for the group receiving the equivalent of 10 tachistoscopic trials on the RT apparatus. Each subject is here numbered as where the appropriate tachistoscopic data (Experiment III, Group 5) is found

Serial Position

Trials Subject 2 (cont'd.)	1	2	3	4	5	6	7	8	9	10
91-100	218	230	212	200	191	76	293	261	194	263
101-110	237	227	216	230	191	192	260	213	241	204
111-120	237	206	232	233	241	249	270	219	269	218
121-130	210	203	204	261	272	210	215	263	264	219
131-140	200	202	234	214	229	194	249	230	261	259
141-143	255	194	239							
Subject 3										
1-10	383	269	251	230	249	251	168	238	228	233
11-20	218	205	220	225	227	218	207	200	241	262
21-30	51	183	170	201	202	225	251	225	244	258
31-40	244	211	218	230	248	277	244	263	219	218
41-50	199	215	236	234	230	234	228	186	241	210
51-60	231	219	228	216	228	267	234	216	235	178
61-70	219	223	228	213	239	208	241	213	215	209
Subject 4										
1-10	309	278	260	238	251	234	262	234	291	268
11-20	241	220	231	218	234	224	279	260	255	243
21-30	234	249	220	210	217	233	226	291	243	206

Experiment III

Group 5 - Reaction times in milliseconds for the group receiving the equivalent of 10 tachistoscopic trials on the RT apparatus. Each subject is here numbered as where the appropriate tachistoscopic data (Experiment III, Group 5) is found

Serial Position

Trials Subject 4 (cont'd.)	1	2	3	4	5	6	7	8	9	10
31-40	218	234	209	200	196	217	224	222	215	208
41-50	207	214	217	208	225	238	241	208	224	211
51-60	200	204	222	201	212	223	214	209	227	229
61-70	218	237	238	193	234	261	270	238	222	216
71-73	209	194	238							
Subject 5										
1-10	237	241	220	232	216	249	238	229	220	232
11-20	219	210	247	236	224	258	217	224	232	219
21-30	215	220	210	224	238	241	244	238	227	226
31-40	224	218	219	208	182	209	196	194	232	228
41-50	209	231	200	194	214	202	238	221	216	243
51-60	192	184	209	199	217	218	239	261	194	200
61-70	237	218	229	220	176	184	217	190	195	222
71-80	212	183	176	217	243	202	203	191	172	184
81-90	201	234	216	207	214	206	216	193	194	185
91-100	224	204	203	217	194	209	186	234	221	199
101-110	219	224	196	204	193	185	200	204	209	198
111-112	203	191								

Experiment III

Group 5 - Reaction times in milliseconds for the group receiving the equivalent of 10 tachistoscopic trials on the RT apparatus. Each subject is here numbered as where the appropriate tachistoscopic data (Experiment III, Group 5) is found

Serial Position

Trials Subject 6	1	2	3	4	5	6	7	8	9	10
1-10	315	298	303	265	262	217	235	542	302	263
11-20	263	294	275	271	243	268	251	254	231	263
21-30	255	261	243	249	238	216	214	183	300	218
31-40	251	285	258	227	268	352	275	434	220	228
41-50	217	230	255	243	231	228	210	218	261	243
51-60	234	217	271	237	210	191	201	233	200	217
61-70	190	231	233	217	218	228	301	241	237	215
71-80	225	234	261	217	217	265	241	233	201	313
81-90	261	280	242	248	201	202	249	260	217	231
91-100	164	270	200	222	219	238	234	251	209	209
101-110	237	251	207	209	216	220	206	253	249	206
111-120	220	191	180	236	200	209	225	215	226	231
121-130	212	191	230	180	263	212	237	216	238	240
131-140	226	222	241	231	260	236	212	190	215	216
141-150	241	256	234	206	210	241	232	224	202	210
151-153	226	206	210							

Subject 7										
1-10	331	264	237	268	257	243	240	286	261	219
11-20	238	247	265	232	202	219	226	295	273	270

Experiment III

Group 5 - Reaction times in milliseconds for the group receiving the equivalent of 10 tachistoscopic trials on the RT apparatus. Each subject is here numbered as where the appropriate tachistoscopic data (Experiment III, Group 5) is found

Serial Position

Trials Subject 7 (cont'd.)	1	2	3	4	5	6	7	8	9	10
21-30	250	239	241	232	268	237	251	217	200	262
31-40	252	240	217	228	249	251	230	237	265	235
41-50	291	243	217	202	200	236	217	232	256	272
51-60	260	239	215	227	234	262	204	215	232	224
61-70	225	216	238	262	227	234	200	215	214	229
71-80	237	253	224	217	239	214	217	233	214	234
81-90	225	234	202	204	251	257	217	232	269	191
91-100	238	241	240	218	261	230	231	220	222	210
101-110	237	220	215	226	291	273	204	191	237	215
111-120	214	229	200	232	240	221	224	215	237	234
121-130	284	215	203	190	225	216	237	230	234	214
131-140	224	220	217	209	205	206	241	238	241	211
Subject 8										
1-10	268	273	241	250	239	274	229	265	243	205
11-20	222	237	227	238	234	232	219	206	235	250
21-30	253	265	219	200	208	184	252	239	232	230
31-40	241	241	202	218	211	226	217	240	249	232
41-50	239	230	232	219	265	244	251	265	222	219
51-60	217	201	243	243	254	261	229	221	232	234

Experiment III

Group 5 - Reaction times in milliseconds for the group receiving the equivalent of 10 tachistoscopic trials on the RT apparatus. Each subject is here numbered as where the appropriate tachistoscopic data (Experiment III, Group 5) is found

Serial Position

Trials Subject 8 (cont'd.)	1	2	3	4	5	6	7	8	9	10
61-70	240	220	219	237	249	220	209	203	197	196
71-80	216	194	272	265	219	239	215	214	204	204
81-90	192	274	239	231	242	254	221	217	220	212
91-100	202	215	209	200	238	249	236	228	229	216
101	218									
Subject 9										
1-10	254	267	233	250	242	217	219	238	241	263
11-20	279	254	220	221	235	210	261	248	239	238
21-30	215	202	209	173	268	274	242	237	246	220
31-40	222	215	261	223	231	239	240	207	206	201
41-50	309	268	224	206	217	234	221	216	194	183
51-60	265	240	215	210	238	234	219	214	228	212
61-70	222	234	216	212	234	229	238	220	218	214
71-80	202	243	219	200	226	232	207	233	204	206
81-83	214	227	218							

Experiment III

Group 5 - Reaction times in milliseconds for the group receiving the equivalent of 10 tachistoscopic trials on the RT apparatus. Each subject is here numbered as where the appropriate tachistoscopic data (Experiment III, Group 5) is found

Serial Position

Trials Subject 10	1	2	3	4	5	6	7	8	9	10
1-10	276	254	240	239	216	209	214	228	263	227
11-20	230	224	236	258	234	271	209	215	223	223
21-30	204	239	240	228	196	183	191	214	231	217
31-40	234	208	203	193	187	174	231	242	228	216
41-50	197	234	215	228	226	216	209	199	183	205
51-60	226	214	237	191	183	194	201	238	217	218
61-70	233	238	215	226	232	218	201	194	188	207
71-80	200	208	210	200	197	190	198	231	228	223
81-83	224	229	198							