THE EFFECT OF TONE ON TACHISTOSCOPIC WORD RECOGNITION

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SCOPE AND CONTENTS:

Three experiments investigated auditory-visual interaction and the role of a visual fixation point in tachistoscopic word recognition. The results showed that when a 60 db. or 90 db. tone preceded the presentation of the word by two, four or eight seconds, different effects on the recognition threshold were obtained only for the two second interval. In this case the 90 db. group had significantly higher thresholds than did the 60 db. group.

Other results showed that a 60 db. tone facilitated recognition to the same extent as a fixation point. It was concluded that a tone of moderate intensity and occurring a brief interval before the presentation of the word facilitates word recognition, whereas a more intense tone produces a disruptive effect.

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CHAPTER I

Introduction

This thesis presents three experiments concerned with the effect on tachistoscopic word recognition of the intensity of an auditory "ready" signal, and of signal-word presentation interval. The experiments had their origin in an interest in the questions of auditory-visual interaction in tachistoscopic word recognition and in the role of a visual fixation point in this situation.

With regard to the role of a visual fixation point in word recognition, Hay (1963) has recently shown that provision of a precise fixation point in the pre-exposure field results in a significant decrease in word recognition thresholds when compared with the condition of a completely homogeneous pre-exposure field. There would appear to be at least two possible interpretations of the nature of this facilitative effect. First, the fixation point may locate the place where the word will subsequently appear, something which the subject otherwise learns only gradually and which constitutes part of the well known practice effect in this task. Second, it may be that the subject learns quickly the place where the word will appear and that the fixation point simply enables him to retain fixation in the right place throughout the interval preceding the presentation of the word.

If the second interpretation is correct then the presentation of an auditory "ready" signal shortly before the presentation of the word should facilitate recognition since it would be expected that the subject could retain fixation over a short interval. If the first interpretation is correct then little facilitative effect should be demonstrated since the auditory signal cannot aid the subject in finding the correct place to look. This assumes that the tone has no effect on recognition other than as a cue. This assumption is fully discussed in the final chapter.

The first experiment reported was designed to study the effects of two intensities of tone, which preceded the tachistoscopic presentation of words by different intervals, on the recognition thresholds of words, and on the practice effect. If it could be shown that the threshold decreased with a decreasing tone-word presentation interval, this would provide presumptive evidence that the function of a visual fixation point is to enable the subject to retain fixation in the right place during the interval prior to the presentation of the word. The argument here is that with long intervals precise fixation is less likely to be maintained than with a short interval. Two intensities of tone were employed in order to detect any effects of auditory-visual interaction.

The second and third experiments were also designed to provide data relevant to the role of a visual fixation point. In the second experiment, the recognition performance of groups provided variously with a 90 db. tone of one second duration and an onset of two seconds prior to the presentation of the word, a visual fixation point, or both, were compared with each other and with that of a control group which received neither the tone nor the visual fixation point.

Since the effect of tone was not demonstrated in this experiment, and a 60 db. tone under identical conditions was shown to be significantly more facilitative than a 90 db. tone in the first experiment, a third experiment was performed. This experiment replicated the second but a 60 db. tone replaced the 90 db. tone.

In the next chapter of this thesis, the literature relevant to the problem of these experiments is reviewed. In subsequent chapters, the method used in the experiments and the results obtained are described and the significance of the results is discussed.

CHAPTER II

History

There is now an extensive literature on tachistoscopic word recognition. For the most part, investigations have been concerned with the effects on the threshold of properties of the words themselves, (e.g. frequency, recency, length, connotative meaning), and the effects of certain subject variables, (e.g. needs, values, experimentally induced set). There has, in addition, been limited experimentation on the effect on the threshold of such task variables as practice, and the provision of a precise fixation point in the pre-exposure field. Since this work, apart from that on fixation, is relevant to the experiments described in this thesis only as general background, a brief and selective review is given below. Further, since the experimental manipulations involve the presentation of auditory signals of different intensities at different intervals before the presentation of the words, questions of auditory-visual interaction, and of the effect of the length of the foreperiod, are raised. The somewhat scanty literature on these topics is also reviewed below.

The Effects of Word and Subject Variables

A review of the literature on word recognition shows considerable experimental interest in the period 1885-1928, and a renewed interest beginning around 1948. During the intervening years there are very few experiments reported. The early work has been summarized by Woodworth (1938, pp.737 f.f.). Of interest are the findings that the span for words presented tachistoscopically exceeded the letter span (Cattell, 1885; Erdmann and Dodge, 1898) and that information in reading was obtained wholly during the fixation pauses of the eyes, and not during the actual eye movement (Erdmann and Dodge, 1898). Another interesting phenomenon was reported by Wagner (1918). He demonstrated that letters near the beginning and end of a series are more easily recognized tachistoscopically than middle letters.

From 1928 to 1948, there were a few isolated experiments reported. Woodrow (1938) exposed two letters simultaneously at equal distances to the right and left of a visual fixation point and found a gradual decline of correct recognition as the distance from the fixation point was increased. He also found that letters close together cause more mutual interference than those widely separated. During the same period, the effects of intensive practice in a tachistoscopic situation were observed in two other studies. In both, intensive practice was reported to enlarge considerably the reading span for words (Weber, 1942; Renshaw, 1945).

In 1948, Postman, Bruner and McGinnies published an experiment in which they showed that subjects had lower recognition thresholds for words related to their dominant value area, as measured by the Allport-Vernon Study of Values, compared with words related to non-dominant value areas. In interpreting this finding, they proposed two mechanisms; perceptual sensitization to account for the lower thresholds of words related to the dominant value area and perceptual defence to account for the higher thresholds of unrelated words. Further evidence for a mechanism of perceptual defence was provided by McGinnies (1949). He showed that "taboo" words presented tachistoscopically had higher recognition thresholds than "neutral" words. In addition, he obtained greater GSR deflections when "taboo" words were shown at durations too short for the subjects to be able to recognize the words. Finally, on the basis that the subjects' incorrect guesses prior to correct recognition became less and less similar to the actual stimulus word, McGinnies concluded that there was an active tendency on the part of the subjects to avoid recognition of the "taboo" words.

These two experiments are important not only for the results obtained but also because of the interest they stimulated in the problem of determinants of word-recognition thresholds. Broadly speaking, subsequent experimentation proceeded along two lines. One was concerned with the analysis of the effect on the threshold of such word variables as frequency, length, recency, and connotative meaning, and the other with the effects of the subject's motivational state, personality characteristics and experimentally induced sets. Consideration is now given to this second line of research.

A number of investigators have found significant correlations between independent personality ratings and recognition thresholds (Eriksen, 1951, 1952; Lazarus, Eriksen and Fonda, 1951). Using pictures which represented individuals gratifying the needs of aggression, succorance and homosexuality, Eriksen (1951) found a direct relationship between these socially unacceptable needs and recognition thresholds. Ratings of defensiveness toward sexual or aggressive areas were used successfully to predict individual differences in visual duration thresholds for stimuli representing these areas. (Lazarus, Eriksen and Fonda, 1951).

The question of whether hunger acts as a determinant of perceptual selectivity for food-related stimuli has received some experimental attention in non-tachistoscopic situations (e.g. Sanford, 1936, 1937; Levine, Chein and Murphy, 1942; McClelland and Atkinson, 1948). McClelland and Atkinson (1948) projected blank slides on a screen to three groups of subjects who had not eaten for one-two; four-five; or sixteen-eighteen hours. The subjects were instructed to report what they "saw" on the screen and their reactions were categorized into food and non-food responses. Analyzing the types of food responses elicited, McClelland and Atkinson discovered that instrumental responses (e.g. knife, fork, etc.) increased as a result of food deprivation, but that goal-object responses did not.

The results of this experiment were interpreted as evidence that hunger results in a selective perceptual sensitivity to food objects. Presumably, hunger might be expected to have a similar effect on tachistoscopic word recognition thresholds. However, the question arises in this experiment whether these effects are attributable to motivational variables, in some way sensitizing the perceptual system to certain classes of stimuli, or to the induction of a set which differentially affects the probability of the verbal responses. The effects of set on response probability have been studied tachistoscopically. (Fulkerson, 1957). By varying the ratio of "taboo" to "non-taboo" words at the beginning of a list of stimulus words presented for tachistoscopic recognition, he established different degrees of expectation or set that taboo words would occur later in the stimulus list. Fulkerson found that when the proportion of "taboo" words in the list was high, their mean recognition thresholds were low, and vice versa. Differences in performance have also been shown to depend on the nature of the instructions given to the subject prior to tachistoscopic word recognition. (Postman, Bronson and Gropper, 1953; Freeman, 1954). There is evidence then that experimentally induced sets do affect word recognition in a tachistoscopic situation. Moreover, Postman (1953, p.88) has argued that the factor of "set" was neither adequately controlled nor evaluated in some experiments which are cited as demonstrating motivational selectivity on perceptual responses. It may well be, as Postman concludes that, "There is little evidence for direct sensitizing effects of motivational conditions on perception". (Postman, 1953, p.99). At any rate, it would appear that the effects on perception of a subject's motivational states and personality characteristics is an unsettled question.

While the experiments by Postman, Bruner and McGinnies (1948) and McGinnies (1949) were interpreted as evidence for the sensitizing effects of motivation on perception, these experiments did not control for an important stimulus variable, the frequency of the stimulus words. This leads us to a consideration of the first line of experimentation mentioned above, that is, the effect on recognition thresholds of stimulus variables.

The hypothesis that an individual is likely to read material relevant to his dominant value area, and therefore see words relevant to that area more frequently than individuals with a different value orientation, was offered by Solomon and Howes (1951) as an alternative explanation of the Postman et al (1948) results. Further, Howes and Solomon (1950) correctly pointed out that in the McGinnies (1949) experiment there was no control for the variable of word frequency and that reference to the Thorndike-Lorge Word Count (1944) showed that the "taboo" words employed by McGinnies had a lower frequency of usage than "neutral" words.

In rebuttal, however, McGinnies (1950) stated that the correlation between frequency and speed of recognition "does not constitute other than circumstantial evidence for the assumption that the higher thresholds of the "taboo" words were determined by their infrequency of occurrence. If --- the elevated duration thresholds for these words were a function of their affective connotation, the net regression effect would be the same". (1950, p.237). McGinnies admitted that his interpretations could be invalidated by experimental data, but never by ad hoc theories. It was clear that the need persisted for experimental evidence to determine what stimulus variables, if any, did have an effect on recognition thresholds.

Numerous studies have demonstrated that visual duration thresholds are inversely related to the written frequency of words (e.g. Howes and Solomon, 1951; Solomon and Postman, 1952; Newbigging, 1961a; Newbigging and Hay, 1962; Doehring, 1962). In an experiment in which subjects were required to read and pronounce nonsense words from one to twenty-five times prior to the presentation of these words tachistoscopically, Solomon and Postman (1952) found that the recognition thresholds of the words varied inversely with the number of times the subject read and pronounced them prior to tachistoscopic presentation. Similar results were reported by King-Ellison and Jenkins (1954).

The significance of the studies concerned with the effect of written word frequency on the threshold is that they demonstrate that this stimulus variable is a powerful determinant of recognition thresholds and that it accounts, in large part, for the effect on thresholds which some investigators had attributed to other variables such as motivational states and personality characteristics.

Varying connotative meaning in terms of word value, several attempts have been made to ascertain whether selective sensitivity to words from different value areas, originally proposed by Postman, Bruner and McGinnies (1948), can be reduced to differences in the frequency of usage of such words (e.g. Postman and Schneider, 1951; Solomon and Howes, 1951; Brown and Adams, 1954; Johnson, Thomson and Frincke, 1960).

Solomon and Howes (1951), and Postman and Schneider (1951) attempted to determine the relation of word value and speed of recognition when frequency is controlled and partialled out in the analysis of the results. Both studies yielded substantially the same results: (1) Frequent words have lower visual duration thresholds than infrequent words; (2) a significant positive relation exists between value rank and speed of recognition for infrequent stimulus words only. This interaction between frequency and value has also been reported by other investigators (e.g. Johnson, Thomson and Frincke, 1960).

Connotative meaning has also been studied in terms of "goodness" or "badness" as defined by rating on the good-bad scale of the Semantic Differential. Holding frequency constant, several investigators have reported that "good" words are recognized at significantly lower thresholds than matched "bad" words (Newton, 1955; Johnson, Thomson and Frincke, 1960; Newbigging, 1961b). However, some experiments have not shown an influence of "goodness" on visual duration thresholds. Taylor (1958) and Doehring (1962), for example, both demonstrated the usual significant effect of frequency, but were unable to show a relation between word "goodness" or "badness" and recognition thresholds.

From a consideration of the evidence presented here, it may safely be concluded that the effects of frequency on recognition thresholds have been well established. The experiments concerned with connotative meaning, however, have produced less consistent results. Nevertheless, Postman following a review of the role of word frequency concludes: "Experiments in which such controls (holding frequency constant) have been observed, have produced evidence that frequency cannot by any means account for the total of all the observed facts of perceptual selectivity". (1953, p.81).

Other variables which have been demonstrated to have an effect on the threshold include word recency and length. Postman and Solomon (1950) found that the recency of word usage is significantly correlated with duration thresholds when frequency is controlled; the more recently a word has been experienced, the lower its recognition threshold. They note, however, that the variables of recency and frequency are typically not independent; the more often a word occurs, the more likely it will occur more recently than other words.

A number of investigators have demonstrated an effect of word length on the threshold with long words having higher thresholds than short words. (McGinnies, Comer and Lacey, 1952; Melville, 1957; Newbigging, 1961a;

Newbigging and Hay, 1962). In addition, word length and frequency have been found to interact significantly, with the effect of word length being greatest for infrequent words. It would appear that these results contradict Howes and Solomon's (1951) contention that the factor of word length has no significant bearing on visual duration thresholds.

From this admittedly sketchy review, it would appear safe to conclude that word frequency is a powerful determinant of tachistoscopic word recognition. The effects of word length and recency also seem well established with that of connotative meaning being less certain. Attention is now turned to the relatively little investigated variables of practice and pre-exposure fixation.

Practice Effects

Although it is generally known that word recognition thresholds decrease as a function of practice and most experimenters precede presentation of an experimental list with a few practice words, there are relatively few experiments in which the practice effect has been analyzed for an extended series of words. Howes and Solomon (1951) plotted thresholds for sixty words showing that about three-fourths of the practice effect occurred in the first quarter of the list, although the curve was still dropping at the sixtieth word. Even in this experiment, however, probability of recognition depends on the location of the stimulus objects relative to the fixation point (Mishkin and Forgays, 1952; Heron, 1957; Kimura, 1959). This suggests that the provision of a precise fixation point directly below the middle of a stimulus word might effectively facilitate word recognition because the subject's task of anticipating the location of a stimulus is greatly facilitated. Whether the main function of a precise fixation point is to provide the exact location of stimuli remains unanswered.

A look at a representative sample of experimental investigations dealing with presentation of material tachistoscopically will reveal that pre-exposure fields range from a homogeneous field to one having many different types of fixation aids (e.g. Howes and Solomon, 1951; Goldiamond and Hawkins, 1958; Taylor, 1958; Newbigging, 1961a, 1961b). This would indicate that the role of fixation in determining visual duration thresholds has been completely overlooked by most investigators working in this area.

Recently, however, Hay (1963) reported two experiments which are directly concerned with this problem. In the first experiment, she pretrained four groups and studied the effects of transfer on word recognition thresholds. Positive transfer occurred to a similar degree for the three experimental groups who received either a series of high frequency words, low frequency words, or digits, but no transfer occurred for the control group who received exposures to blank white cards. Hay interprets these results in terms of the presence or absence of stimuli and comes to the conclusion that one of the important variables in word recognition thresholds is learning where to fixate immediately prior to presentation of the stimulus. Her argument is that since all of the pretraining stimuli were presented in the same place as the test stimuli, equal opportunities were provided for subjects to learn where to fixate. Also, all pretraining and test stimuli required left to right scanning for their identification. She suggests that learning where to fixate and improved efficiency in scanning constitute two aspects of a general tachistoscopic skill which transfers from the recognition of one type of stimulus material to the recognition of another.

This conclusion led to a second experiment by Hay (1963). Two groups were presented with different pre-exposure fields. One group was trained with a precise fixation point placed in the pre-exposure field so that when the stimulus word was presented, the middle letter of the word fell directly above the point fixated. The pre-exposure field for the second group was a blank white card. The group presented with a precise fixation point had significantly lower initial recognition thresholds. For Hay, the presentation of a precise fixation point in the pre-exposure field eliminates the necessity for subjects to learn where to fixate and accounts for the initially lower thresholds of this group.

To summarize this section, very little direct investigation has been carried out on the problem of fixation. The facilitative effect of a precise fixation point on recognition thresholds has been amply shown (Hay, 1963), but the problem of interpretation of this effect still remains.

Foreperiod Effects

In this section, some experimental evidence is presented which illustrates the effects of warning signal-stimulus presentation intervals on the responses to auditory and visual stimuli. Reaction time (RT) studies are discussed with particular emphasis on the length of foreperiod required to produce optimum reaction time. Following this discussion, several experiments which investigate the effects of foreperiod on sensory thresholds are presented.

A review of RT studies (Teichner, 1954) has revealed that the use of a preparatory signal yielded faster reaction times than the omission of such a signal; therefore, most experiments employ some sort of ready signal to obtain optimum performance. If a subject is not "set" to respond when a stimulus is presented, his reaction time will be very slow. On the other hand, if the subject must wait for a considerable length of time after being ready to respond, RT again will be slow or a false "start" will have occurred. Therefore, it may reasonably be argued that RT will be dependent upon the degree to which the subject is ready or "set" to respond. Considered from this viewpoint, then, RT becomes quite relevant to any discussion concerning the effects of the length of foreperiod on responses to various stimuli. The results of some of the experiments discussed here clearly indicate that RT is a function of the absolute length of the foreperiods employed, very long intervals being unfavorable. Subsequently, the question of optimum interval to produce the quickest reaction has arisen (e.g. Woodrow, 1914, 1916; Freeman, 1937, 1938; Lansing, Schwartz and Lindsley, 1956).

Breitweiser (1911) found definite individual differences in the length of the optimum foreperiod and reported a range of optima between 1-4 seconds. Conflicting results, however, were obtained by Telford (1931). Taking repeated measurements of twenty-nine subjects, he found that the average RT increased systematically from an optimum of one second to at least four seconds. It must be emphasized here that different RTs have been shown to occur depending on whether the interval is varied or not for each subject (Woodrow, 1914; 1916). In Telford's experiment, the intervals were randomly presented to each subject.

Woodrow's studies (1914; 1916) would seem to indicate that a two second foreperiod is optimum, with an optimal length of 2-4 seconds. In spite of some apparent acceptance of this figure (2 seconds), there is a question as to the significance of these results since the data were obtained from a total of only three subjects. Freeman and Kendall (1940) estimated that if the standard error of the means of Woodrow's data were of the same order as those obtained in their study, there would be no significant difference between the 2 and 8 second intervals and Teichner (1954) has argued that Woodrow's obtained optimum actually may be best expressed as a range between 2-8 seconds.

Turning to the effects of foreperiod on thresholds, shorter intervals have been found to produce lower thresholds (Newhall, 1923; Howarth and Treisman, 1958; Treisman and Howarth, 1959). Two experiments (Howarth and Treisman, 1958; Treisman and Howarth, 1959) demonstrated that phosphene and auditory thresholds, as determined by the descending method of limits, increased monotonically as the interval between warning signal and threshold stimulus increased from 1 to 9 seconds. The warning signals were either a light flash on the tachistoscope or an electric bell.

In another threshold experiment, however, Child and Wendt (1936) presented a visual stimulus at five different time-intervals before the auditory stimuli. The greatest increase of frequency of tone reports occurred when the light preceded the tone by half a second. Smaller increases were shown when light preceded the tone by one second or followed it by half a second, and no increase was obtained when light preceded the tone by two seconds.

The conflicting results reported in some of the above-mentioned studies would suggest that the question of optimal range of intervals or an optimum foreperiod is dependent upon the experimental conditions under which the effects of foreperiod are studied.

Sensory Interaction

Since the experiments to follow are concerned with auditory-visual interaction, the present discussion will be focussed on this area of research. More specifically, the effects of auditory stimulation on some of the different visual processes will be discussed first, followed by a report on the effects of visual stimulation on auditory sensitivity.

The bulk of research on sensory interaction has been performed by Russian investigators and is available in a review article by London (1954). Due to apparent ambiguities in communication, the Russian findings, reported below, must be treated as second-hand and necessarily incomplete in detail. Consequently, more detailed attention will be given to those American studies which have obtained some evidence for sensory interaction.

Pronounced effects, as a result of auditory stimulation, have been demonstrated on the peripheral sensitivity of the visual organ. What has been considered a somewhat surprising discovery is the demonstration by some Soviet investigators that central sensitivity of the dark-adapted eye to blue-green colors is increased by a constant background of auditory stimulation, whereas to orange-red, it is decreased. At the same time other hues remain unaffected (London, 1954, p.534). Not only were these effects demonstrated over a considerable range of loudness but Kravkov (London, 1954, p.534) also ascertained that the degree of effect varied directly with the intensity and duration of the auditory stimulus.

Urbantschitsch (Ryan, 1940, p.663) performed a wide range of exploratory experiments on intersensory relations and found that auditory stimulation with a tuning fork increased color sensitivity - high tones were more effective than low tones. According to Ryan (1940), however, the reliability of these results is highly doubtful, for Urbantschitsch did not report any clear statement of the conditions or instructions used.

The possibility of a differential effect of tones on various colors was also shown by Zietz (Ryan, 1940, p.669). He demonstrated that when red was exposed tachistoscopically with a tone of 200 d.v. it tended to violet;

with a tone of 500 d.v. it seemed brighter, turning yellow. Contradictory results, however, were obtained by Serrat and Karwoski (1936). Using a sound of 410 d.v., no significant effect upon color thresholds of 506 mu and 710 mu were discovered. Here again, the reliability of these results is questioned because no statistical analysis of the data was provided and only three subjects were employed in the first experiment and two subjects in the second.

Inhibition, facilitation and distortion of the perception of apparent movement have been demonstrated as well (Ryan, 1940; Gilbert, 1939). From these results, Gilbert (1941) concludes that a mild stimulus facilitates apparent movement, while an intense stimulus inhibits it.

The phenomenon of critical flicker frequency (c.f.f.) has been studied by Kravkov (London, 1954, p.536) in the Soviet Union. He has reported that the effects of auditory stimulation depend on the monochromatic nature of the light used. Thus, c.f.f. is reduced for green light (520 mu) and raised for orange-red light (630 mu) during the time of auditory stimulation. Employing white light as the primary stimulus, c.f.f. was heightened for central vision and lowered for peripheral vision. Von Schiller (Ryan, 1940, p.670) and Ogilvie (1956) have also discovered auditory effects on c.f.f. Ogilvie (1956) investigated c.f.f. (1) in the absence of noise, (2) in the presence of continuous noise, (3) with auditory flutter (interrupted noise) in-phase with visual flicker, (4) with auditory flutter out-of-phase with c.f.f. The results showed that c.f.f. is not changed by continuous noise but is significantly increased by interrupted noise. Further, c.f.f. was higher in the presence of in-phase than out-of-phase auditory flutter.

The claim has also been made that auditory stimulation influences visual acuity. Experiments by Kravkov (London, 1954, p.536) reportedly show that if the stimuli to be distinguished are black forms on a white ground, acuity is increased, but acuity decreases if white forms on a black ground are used. Hartmann (1933), however, repeated Kravkov's experiments and discovered slight increases in acuity under both conditions. Consequently, Hartmann concluded that an auxiliary stimulus increases acuity independently of the nature of the test objects, a conclusion directly opposite to that of Kravkov.

Some Russian researchers have shown that auditory stimulation increases electrical sensitivity and produces changes in visual contrast effects (London, 1954, p.537). Hochberg and Brooks (1958) were able to raise brightness contrast thresholds by presenting an annoying stimulus on a tape recorder and pairing it with geometrical figures.

Although most research has employed light as the primary stimulus, a number of studies have been undertaken with sound the primary, and light the accessory, stimulation. For example, some Russian studies have demonstrated increased auditory sensitivity with the presence of visual stimulation, while absence of visual stimulation produces a decrease in auditory sensitivity. Furthermore, illumination of a white room with green light increases auditory sensitivity, but with red light it is decreased (London, 1954, p.538).

There have also been a few American studies concerned with the effects of visual stimuli on auditory thresholds and sensitivity (e.g. Hartmann, 1934; Child and Wendt, 1936; Thompson, Voss and Brogden, 1958; Gulick and Smith, 1959). Bright general illumination increased scores for the Seashore records for pitch and intensity discrimination, according to Hartmann (1934). Somewhat similar effects were obtained by Thompson, Voss and Brogden (1958). They studied the effects of various intensities of simultaneous illumination on the detection for a 1,000 cycle tone. The effect of light on auditory acuity is one of facilitation but it can occur only when light intensity is at supra-threshold levels. On the other hand, Gulick and Smith (1959) were unable to obtain evidence that visual stimulation from a homogeneous field affects auditory acuity. This lack of consistency in results is considered by Thompson, Voss and Brogden (1958) to be the outstanding feature of the research in this area.

Despite the inconsistency of some of the results of studies varying auditory-visual interaction, most studies reveal that audio-visual interaction effects do occur. A final note: it should be recognized that since almost all of the experiments, both Russian and American, employ an accessory stimulus which occurs simultaneously with the primary stimulus, the experiments to be reported on in this thesis are not totally analogous to most auditory-visual studies. Nonetheless, it would appear reasonable to assume from the available evidence that facilitative effects will occur when an auditory "ready" signal is presented sometime before the exposure of a stimulus-word.

CHAPTER III

Experiments

This thesis reports three separate experiments, each of which will be individually described. Since the same basic apparatus and procedure were used in all three, they will be described in detail only for Experiment 1. Differences in detail will be described in the Method section of each experiment.

Experiment I

Method

Subjects: 36 male and 36 female students from University Summer School were randomly selected as Ss. Their ages ranged from 19 to 32 with a mean age of 24.7 years.

Design: The 72 subjects were assigned randomly to one of six treatment groups, with the restriction that there be six males and six females in each group. The design was a Lindquist Type III (Lindquist, 1953) with tone intensity (60 db. or 90 db.) and tone onset-word presentation interval (2, 4, or 8 seconds) constituting the between subject comparisons, and serial position of words the within subjects main effect.

Apparatus: A list of eighteen words was selected from the Thorndike-Lorge (1944) general count. The list was made up of nine-letter words having a frequency of occurrence of 1/3.6 million. Each word was typed in elite capital letters on a 9" x 12" plain white card. The words were presented for recognition in a standard Gerbrands tachistoscope; the pre-exposure field for all six groups of Ss consisted of a blank milk-glass screen.

Earphones were placed on the S's head at the beginning of the experimental session and remained on until the end of the session. A standard tone generator manufactured by Ashman Electronics was used to feed an 880 cps. tone of 60 db. or 90 db. via the earphones to each subject. The duration of the tone was constant at one second and its onset preceded the presentation of a word by 2, 4 or 8 seconds for the subjects in the different groups.

All components of the timing circuit, which was activated by pressing a key, were enclosed in soundproof boxes in an attempt to eliminate any regularly occurring auditory cues except for the tone. A constant background noise level of approximately 45 db. was maintained by means of an air ventilation system in the experimental room.

Procedure: Each S was run individually for one session lasting from a half to one hour. The subjects were instructed as follows:

"I am going to present some words to you one at a time. The words I shall show you will appear on the screen directly in front of you. Each word will be presented for a very short period of time and you may not be able to tell what the word is at first. However, after each presentation I want you to tell me everything you think you see. Remember, even if you do not recognize the word I still want you to tell me what you think you see. Each word will be presented to you several times until you have correctly recognized it. I will inform you when you are correct and then I will show you another word. You will hear a tone before each presentation of a word. Now place the earphones on your head and we shall be ready to start. Are there any questions?"

If there were questions, the relevant parts of the instructions were re-read.

The list of words was presented in a different random order to each S. The method of ascending limits was used. The first exposure of each word was 50 milliseconds and successive exposures were increased by 10 milliseconds until correct recognition occurred. E recorded all responses on a score sheet opposite the appropriate exposure duration time. The exposure duration for each correct response constituted the threshold data.

Results

Average thresholds in milliseconds for each of the three intervals of time and two intensities of tone are plotted as a function of serial position in Figure 1. These data were subjected to an analysis of variance, a summary of which is presented in Table I.

Of the main effects, only that for serial position was significant. There is, then, a significant decrement in the threshold as a function of the serial position of words and this finding confirms the already well established practice effect in recognition threshold determinations. The main effects of intensity and interval were not significant when tested against the mean square error term of the intensity x interval interaction.[1]

It may also be observed from Table I that the interval x intensity and the serial position x interval interactions are both significant while that for serial position x intensity is not. The significant serial position x interval interaction is presented in Figure 2. It is quite evident that while the decrement over serial position for words is the same for both the 2 and 4-second interval groups, the decrement for the 8-second interval group is more gradual.

The significant interval x intensity interaction

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[1] Since the interval x intensity interaction was significant, the main effects of interval and intensity were tested against the mean square of the interval x intensity interaction.

Table I

Analysis of Variance of Threshold Data from the Six Experimental Groups

Source	df	M.S.	F.	P.
Between Ss	71			
Interval	2	1,706.85	1.05	N.S.
Intensity	1	249.04	< 1	-
Interval x Intensity	2	1,622.43	3.19	<.05
Error (b)	66	509.41		
Within Ss	360			
Serial Position (S.P.)	5	1,680.85	24.40	<.001
S.P. x Interval	10	145.36	2.11	<.05
S.P. x Intensity	5	72.59	1.05	N.S.
S.P. x Interval x Intensity	10	81.46	1.18	N.S.
Error (w)	330	68.88		
Total	431			

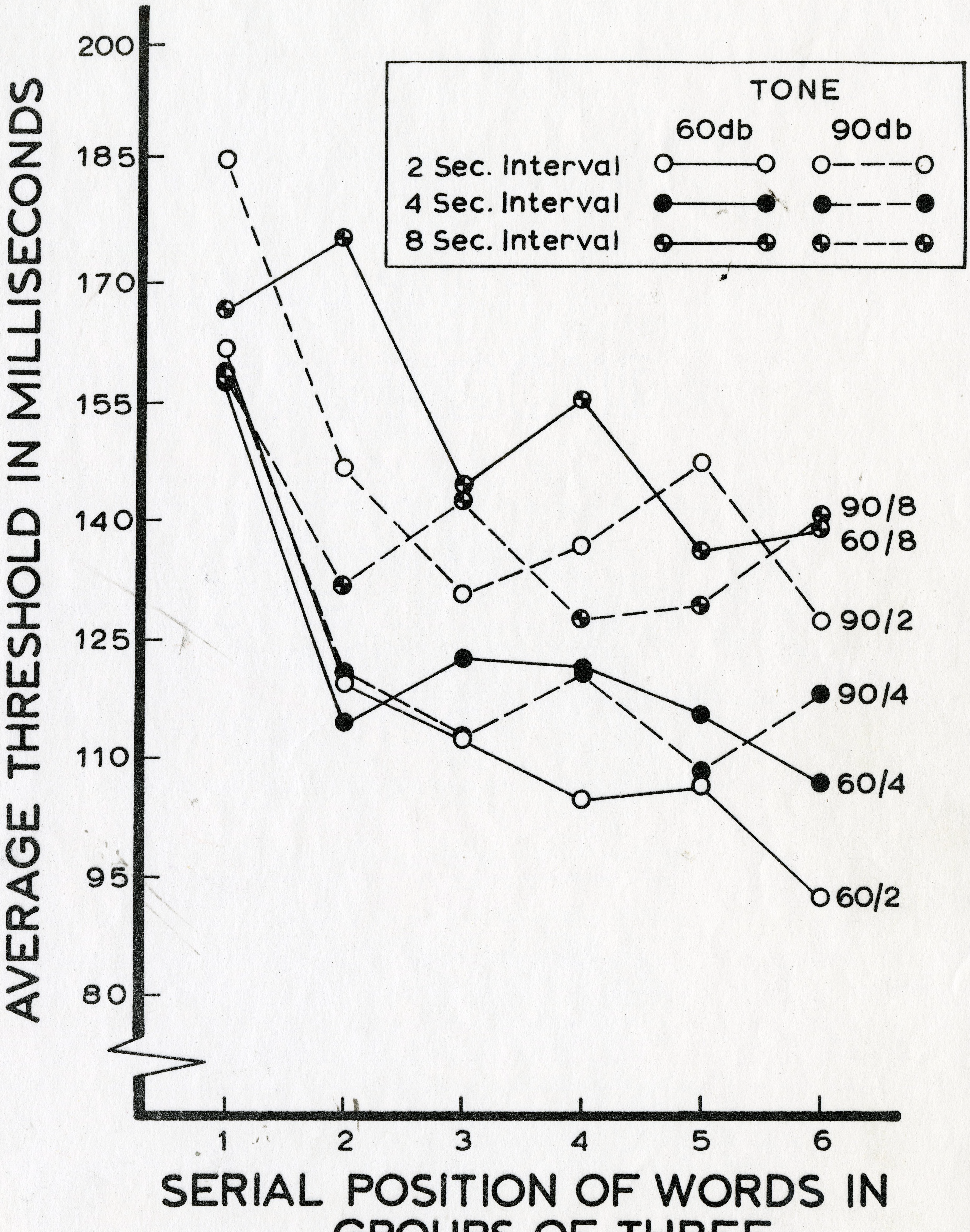

Figure 1: Average threshold in milliseconds plotted as a function of serial position of words for groups receiving three different tone onset-word presentation intervals in combination with two different tone intensities.

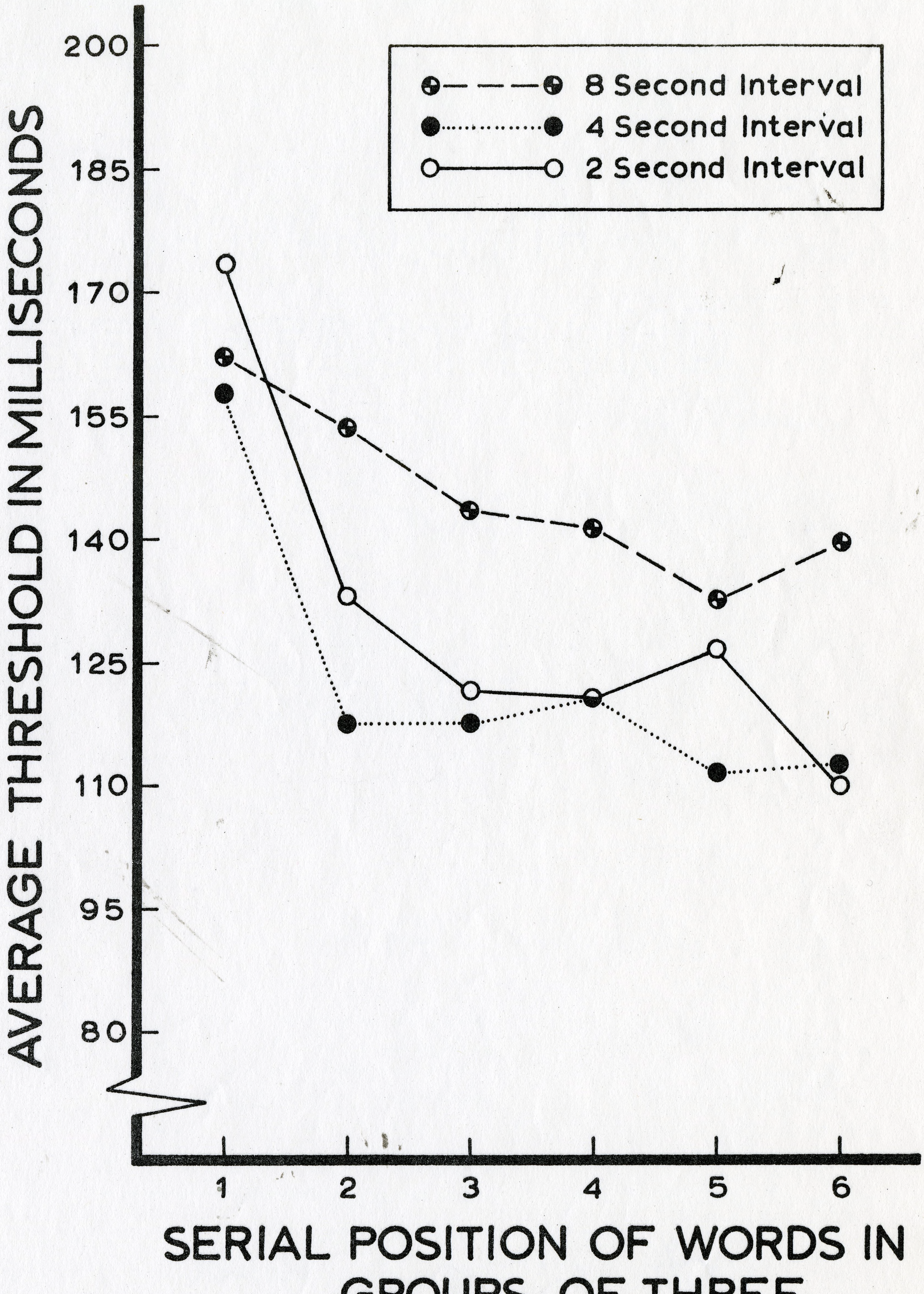

Figure 2: Average threshold in milliseconds plotted as a function of serial position of words for groups receiving three different tone onset-word presentation intervals.

is depicted in Figure 3. Duncan's (1955) New Multiple Range test was administered to the treatment means to determine which of the group means differed significantly. The test showed that the means for the 60 db. and 90 db. tones were significantly different at the 2-second interval. Further, the means for the 60 db. tone at 2 and 4 seconds were significantly different from the 60 db. mean at 8 seconds.

It would appear that the 60 db. tone simply acts as a cue for the presentation of the word which, within the range of intervals tested, has its maximum facilitative effect when its onset is two seconds prior to the presentation of the word. The 90 db. tone, on the other hand, apparently has a disruptive effect on word recognition at the two second interval. This effect seems to dissipate rapidly after the termination of the tone and at the four-second interval the 90 db. tone is as effective a cue as the 60 db. tone.

Experiment II

Method

<u>Subjects:</u> Ss were 24 males and 24 female students from University Summer School. They ranged in age from 19 to 32, with an average age of 25.6 years.

<u>Design:</u> The forty-eight Ss were randomly assigned to one of four experimental groups with the restriction that

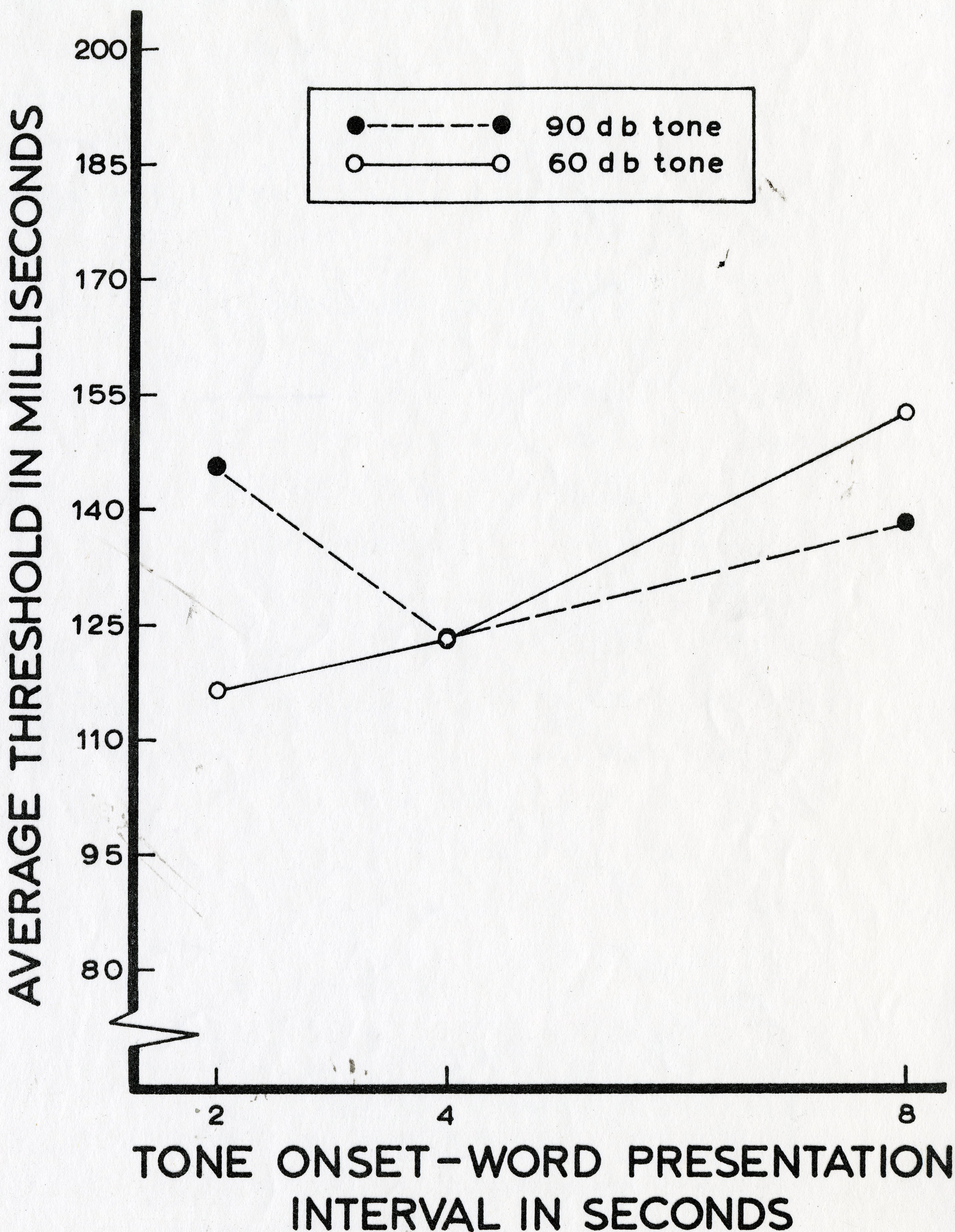

Figure 3: Average threshold in milliseconds plotted as a function of tone onset-word presentation interval for groups receiving two different tone intensities.

there be six males and six females in each group. Another Lindquist Type III design was employed in which the between subject comparisons were fixation vs. no fixation, and 90 db. tone vs. no tone. Serial position was the within subjects main effect.

Apparatus: The apparatus was identical to that used in Experiment I except that the pre-exposure field for two groups consisted of a precise fixation point in the form of a small dot that appeared directly below the position which the middle letter of each stimulus-word would occupy in the exposure field. The pre-exposure field for the no-fixation groups was a blank milk-glass screen.

Procedure: The procedure of Experiment I was used in this experiment with altered instructions. Subjects presented with a fixation point in the pre-exposure field were instructed that the words to be shown would appear directly above the fixation point. Further, although only two of the four groups received tone during the experiment, all Ss wore the earphones. No mention of tone was made in the instructions given to those subjects not receiving a tone.

Results

The average thresholds in milliseconds for the four groups plotted as a function of serial position of words are presented in Figure 4. A summary of the analysis of variance of these data is given in Table II.

Table II

Summary of Analysis of Variance of the Data from the Three Experimental Groups and the One Control Group

Source	df	M.S.	F.	P.
Between Ss	47			
Tone	1	353.34	< 1	-
Fixation	1	8,635.17	16.38	< .001
Tone x Fixation	1	41.25	< 1	-
Error (b)	44	538.33		
Within Ss	240			
Serial Position (S.P.)	5	776.20	7.87	< .001
S.P. x Tone	5	66.51	< 1	-
S.P. x Fixation	5	185.63	1.88	N.S.
S.P. x Tone x Fixation	5	43.71	< 1	-
Error (w)	220	98.67		
Total	287			

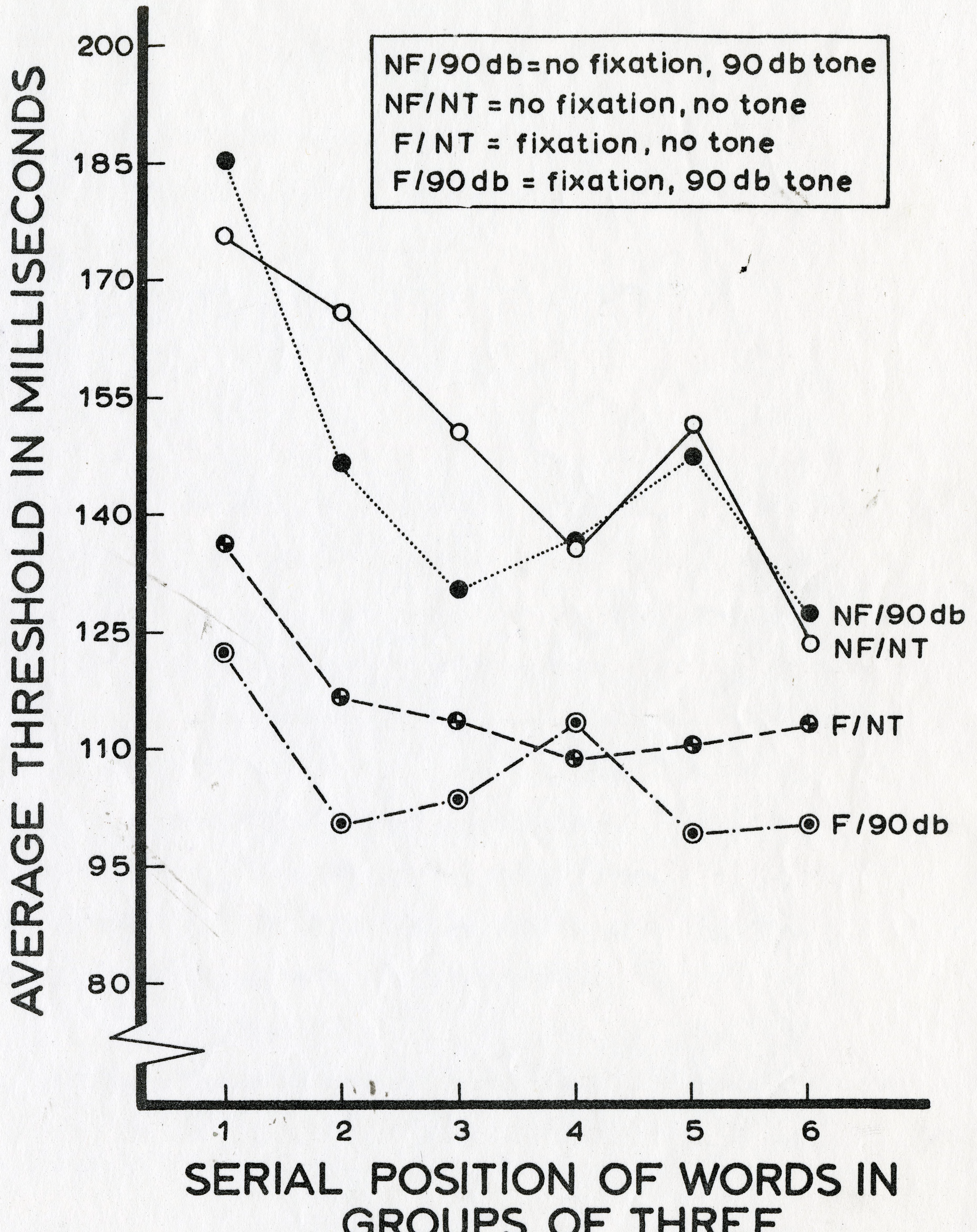

Figure 4: Average threshold in milliseconds plotted as a function of serial position of words for the one control group and three experimental groups.

As shown in Table II the main effects of fixation and serial position are both significant. The main effect of tone, however, and none of the interactions reach significance.[2]

The main effect of serial position simply reconfirms the practice effect on word recognition thresholds. The finding that the provision of a precise fixation point in the pre-exposure field significantly facilitates tachistoscopic word recognition was expected on the basis of a study by Hay (1963).

It is quite obvious that a 90 db. tone of one second duration, whose onset precedes the presentation of the word by two seconds, does not facilitate performance when compared to the condition where there is neither a tone nor a visual fixation point. As the previous experiment suggests, and as the next experiment tends to confirm, this is probably because its cue value is masked by its disruptive effect. On the other hand, the similarity of the curves for the fixation group and the fixation plus 90 db. tone group suggests that the disruptive effect of the tone is overcome by the presence of a visual fixation point.

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[2] Since there was no significant tone x fixation interaction, it was pooled with the between Ss error term to form the mean square error term against which the main effects of tone and fixation were tested.

Experiment III

Method

Subjects: Ss were 24 male and 24 female students enrolled in the Introductory Psychology course. They ranged in age from 19 to 31 with an average of 24.0.

Design: The design was an exact replication of Experiment II except that the 90 db. tone was replaced by one of 60 db. Again, four groups of twelve subjects were used in a Lindquist Type III design. The between subject comparisons were fixation vs. no fixation, and 60 db. tone vs. no tone; while serial position was the within subjects main effect.

Apparatus: The apparatus was exactly the same as in Experiment II.

Procedure: The procedure of Experiment II was employed in this experiment.

Results

Figure 5 depicts the average threshold data in milliseconds as a function of serial position of words for all four groups. An analysis of variance of the data is summarized in Table III and shows that the main effects of fixation, tone and serial position are all significant. None of the interactions is significant.[3]

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[3] Again, as there was no significant tone x fixation interaction, it was pooled with the between Ss error term to form the mean square error term against which the main effects of tone and fixation were tested.

Table III

Analysis of Variance of the Data from the
Three Experimental Groups and the One Control Group

Source	df	M.S.	F.	P.
Between Ss	47			
Tone	1	12,064.22	34.09	$<.001$
Fixation	1	3,444.50	9.73	$<.005$
Tone x Fixation	1	415.68	1.18	N.S.
Error (b)	44	352.45		
Within Ss.	240			
Serial Position (S.P.)	5	894.01	16.90	$<.001$
S.P. x Tone	5	54.47	1.03	N.S.
S.P. x Fixation	5	59.92	1.13	N.S.
S.P. x Tone x Fixation	5	55.55	1.05	N.S.
Error (w)	220	52.90		
Total	287			

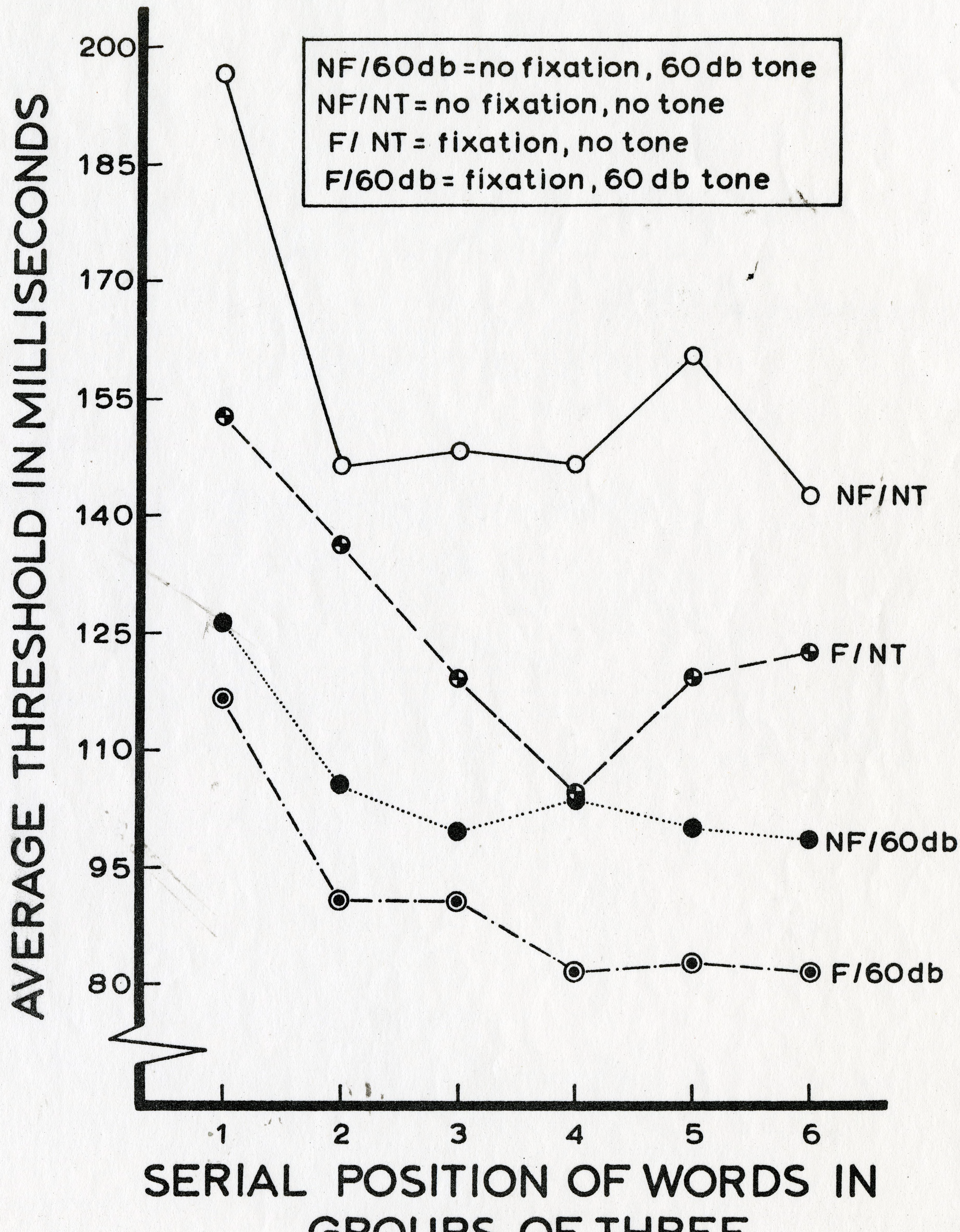

Figure 5: Average threshold in milliseconds plotted as a function of serial position of words for the one control group and three experimental groups.

The significant effects of fixation and serial position simply confirm the findings of the previous experiments. Of greater interest is the demonstrated facilitative effect of the 60 db. tone. It should be noted that the group with this tone alone tends to perform slightly better than the group with only a visual fixation point. Moreover, the best performance is obtained when fixation and 60 db. tone are combined, suggesting that the facilitative effects of the two cues tend to summate.

CHAPTER IV

Discussion

As stated in the Introduction to this thesis, the experiments reported were undertaken because of an interest in the nature of the facilitative effect of a visual fixation point on tachistoscopic word recognition. It was suggested that the fixation point may serve to locate for the subject the place where the stimulus word is to be presented, something he otherwise learns only gradually; or it may, alternatively, simply enable him to retain fixation in the right place during the interval which precedes the presentation of the word. The results of the experiments, particularly Experiment III, show that the location of the right place is not a necessary condition for the facilitation of word recognition. In Experiment III it was found that a 60 db. tone occurring two seconds before the presentation of the word resulted in somewhat lower thresholds than did a visual fixation point used alone. This finding suggests that the tone acts simply as a "ready" signal, and enables the subject to fixate when the word will appear, facilitating recognition in this way.

The results of Experiment I are generally supportive of this interpretation. Considering only those groups which received the 60 db. tone 2, 4 or 8 seconds prior to the presentation of the word, it is clear that thresholds are a monotonically increasing function of interval. If the tone serves only as a cue, this finding may be readily interpreted. The longer the interval between the tone and the presentation of the word, the less likely it is that the subject will retain fixation in the right place. The higher threshold for the longer intervals simply reflects the subject's inability to retain fixation. This finding is consistent with studies of reaction time and sensory thresholds in which the interval between the "ready" signal and the presentation of the stimulus has been varied (e.g. Teichner, 1954; Howarth and Treisman, 1958; Treisman and Howarth, 1959).

The finding in Experiment I that a 90 db. tone occurring two seconds before the presentation of the word results in significantly higher thresholds than a 60 db. tone under the same conditions somewhat complicates the issue. Evidently, this tone combines a disruptive effect with its value as a cue. This disruptive effect apparently dissipates rapidly since the thresholds of the 60 and 90 db. groups do not differ when the interval is lengthened to four or eight seconds.

The results of Experiment II generally confirm those of Experiment I as far as the disruptive effects of a 90 db. tone are concerned. In this experiment, the performance of the group with the 90 db. tone alone was practically identical to that of the group which had neither a visual fixation point nor an auditory "ready" signal. Further, the group that had a 90 db. tone combined with a visual fixation point performed at the same level as a group with a visual fixation point alone. This suggests that the presence of the fixation point tends to overcome the disruptive effects of the tone.

This finding of a disruptive effect of a fairly intense tone raises the whole question of auditory-visual interaction and suggests that the 60 db. tone too, may have effects other than as a cue. While it may facilitate recognition to the same extent as a visual fixation point, the mechanism involved may be quite different than suggested above. The present experiments provide no evidence that this is the case but it must nevertheless be considered as a possibility.

The experiments do, however, provide clear evidence that the 90 db. tone combines a disruptive effect with its cue value. Whether this disruptive effect is central or peripheral remains unclear. A possible peripheral interpretation worth noting derives from a study by Krauskopf and Coleman (1956). They showed that 137 db. white noise presented binaurally increases the high frequency tremor movements of the eye and it may be that the apparent disruptive effect of an intense tone observed in these experiments is simply a blurring of vision resulting from such increased movement. The finding in Experiment II that the disruptive effect of the 90 db. tone on word recognition was overcome by the provision of a visual fixation point is consistent with this interpretation. It could be argued that the presence of a visual fixation point serves to reduce the amount of eye movement induced by an intense tone. While technically difficult, this possibility might be directly investigated by recording the eye movements of each subject while he was performing in the visual recognition situation.

On the other hand, there is the possibility that the facilitative and disruptive effect of tone may be central in origin. Hebb (1955), for example, has theorized that every stimulus initiates two types of sensory processes. One of these processes consists of nervous impulses being sent directly to specific cortical areas, thereby providing a basis for a discriminative response. Simultaneously, a second process is originated whereby impulses are transmitted diffusely via the reticular activating system (a mechanism first postulated by Moruzzi and Magoun, 1949) to all parts of the cortex; these impulses serve the function of keeping the cortex active or aroused. Therefore, Hebb concludes, every stimulus possesses both a cue and an arousal function.

Moreover, it has been suggested that an inverted U-shaped relation exists between the level of arousal and performance, the greater the deviation in either direction from the optimum arousal level, the greater the decrease in performance (e.g. Freeman, 1940; Hebb, 1955; Bindra, 1959, pp. 246-247). Conceivably, then, the disruptive effect of a 90 db. tone demonstrated in both Experiments I and II could be attributed to "over-arousal" of the cortex, resulting in a decrease in performance; while the facilitative effect of a 60 db. tone shown in Experiments I and III could be considered due to near "optimum-arousal" of the cortex, resulting in an improvement in performance.

Clearly, further empirical observation is required before an adequate theoretical interpretation of the mechanism mediating the facilitative and disruptive effects of tone is to be proposed. The final paragraph below describes some possible lines of investigation which may be profitable in this respect.

Since the effect on word recognition of tone was demonstrated to be dependent upon both its intensity and the interval between its onset and the presentation of the word, systematic parametric studies in which intensity as well as interval are varied over a wide range of values might demonstrate the nature of this effect more clearly. Other parameters worthy of consideration are the duration of tone and the complexity of the recognition task, neither

SUMMARY

Three experiments were performed to investigate the question of auditory-visual interaction in tachistoscopic word recognition and the role of a visual fixation point in this situation.

The first experiment was concerned with the effects on word recognition thresholds of 880 cps tones of 60 db. and 90 db., which preceded the tachistoscopic presentation of words by intervals of 2, 4 or 8 seconds. Seventy-two subjects were randomly assigned to six groups of twelve subjects each. Each group recognized the same list of eighteen low frequency words under one of six conditions of interval and tone intensity. The results indicated a significant interval x intensity interaction where performance was better for the 60 db. group than the 90 db. group, when tone onset preceded word-presentation by two seconds. The two tones did not have different effects for the 4 and 8 second intervals. The two second interval was optimum for the 60 db. tone with performance for the eight second interval being significantly worse.

The second and third experiments investigated the relative effectiveness in facilitating word recognition of a precise visual fixation point and an 880 cps, 60 or 90

db. tone whose onset preceded the presentation of the word by two seconds. In the second experiment, four groups of twelve subjects were tested under one of the following conditions: no fixation, no tone; fixation, no tone; no fixation, 90 db. tone; fixation, 90 db. tone. Exactly the same design was employed in the third experiment, except that a 60 db. tone replaced one of 90 db. All subjects were shown the same list of low frequency words used in the first experiment. In both experiments, the visual fixation point was shown to have a significant facilitative effect on word recognition. A facilitative effect on word recognition of a 60 db. tone was demonstrated in the third experiment but no such effect was shown in the second experiment by the 90 db. tone. It was also found that an experimental group with a 60 db. tone alone performed slightly better than a control group with only a visual fixation point.

These findings were interpreted as evidence that a tone of moderate intensity, occurring a brief interval before word-presentation, facilitates word recognition to an extent equal to that of a fixation point. If the tone is intense enough, however, it possesses a disruptive effect which dissipates rapidly. The nature of these effects was discussed and suggestions for further research were advanced.

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APPENDIX A

RAW DATA FOR EXPERIMENT I

Experiment I

Group 1 - Recognition Thresholds in hundredths of a second for the group with 60 db. tone, 2 second tone onset-word presentation interval

Serial Position	Subjects 1	2	3	4	5	6	7	8	9	10	11	12
1	12	17	18	26	31	30	21	21	26	18	15	17
2	12	11	13	9	15	24	24	17	14	17	13	10
3	11	8	8	11	21	9	19	14	8	21	12	10
4	9	9	12	21	20	19	15	15	7	19	8	11
5	12	16	8	6	19	13	11	17	9	14	8	8
6	11	10	7	10	7	10	9	10	9	13	13	15
7	15	10	18	12	10	10	17	15	8	12	8	12
8	10	8	8	6	9	10	11	10	6	13	10	8
9	13	9	11	7	9	10	19	17	16	20	8	9
10	9	12	6	11	18	8	7	8	17	11	11	11
11	8	15	8	8	15	12	10	11	9	11	8	11
12	9	9	6	6	8	11	13	21	7	12	9	11
13	8	10	9	9	15	13	15	20	7	10	13	10
14	9	11	10	9	9	12	11	9	10	13	7	8
15	9	8	8	7	9	24	12	10	8	13	11	7
16	9	8	6	10	7	8	10	12	7	14	10	6
17	8	6	7	7	7	11	12	12	7	12	10	8
18	7	10	8	12	8	12	13	15	11	9	7	7

Experiment I

Group 2 - Recognition Thresholds in hundredths of a second for the group with 90 db. tone, 2 second tone onset-word presentation interval

Serial Position	Subjects 1	2	3	4	5	6	7	8	9	10	11	12
1	30	13	23	15	11	41	16	21	26	11	12	28
2	20	9	17	17	10	13	13	23	11	26	21	22
3	19	11	20	12	26	13	25	19	9	12	24	28
4	21	8	9	20	18	23	19	21	11	9	14	24

5	17	13	12	15	15	15	7	24	11	13	11	15
6	12	8	17	19	14	15	14	20	11	13	14	6
7	15	9	9	13	13	13	11	16	9	11	16	13
8	27	9	10	13	10	13	13	20	10	12	9	21
9	16	8	19	15	6	14	8	12	10	9	14	25
10	11	18	10	14	16	11	9	13	9	12	13	20
11	14	20	18	15	7	17	17	21	9	12	8	12
12	14	11	11	15	11	22	8	25	10	11	20	9
13	23	10	8	10	11	27	8	15	14	13	11	12
14	19	9	32	26	10	15	9	24	10	16	11	12
15	25	16	8	9	10	12	9	19	14	17	13	23
16	17	14	10	10	12	16	8	14	18	16	11	19
17	12	9	9	9	8	24	7	14	8	18	9	24
18	11	10	13	8	9	10	8	19	13	17	11	13

Experiment I

Group 3 - Recognition Thresholds in hundredths of a second for the group with 60 db. tone, 4 second tone onset-word presentation interval

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

Experiment I

Group 4 - Recognition Thresholds in hundredths of a second for the group with 90 db. tone, 4 second tone onset-word presentation interval

Serial Position	Subjects 1	2	3	4	5	6	7	8	9	10	11	12
1	25	11	13	25	19	27	12	8	15	17	14	19
2	17	24	25	10	15	25	14	23	18	25	8	8
3	9	11	19	11	17	10	9	12	12	16	11	17
4	8	28	16	15	16	24	10	8	11	7	8	10
5	13	10	13	8	14	15	7	9	8	11	10	12
6	10	8	27	7	11	20	9	8	9	11	10	14
7	8	8	10	10	13	10	7	8	10	9	8	11
8	9	11	13	15	13	27	9	17	15	8	8	9
9	13	6	10	20	17	18	7	9	11	9	8	11
10	11	10	14	19	20	10	28	8	13	10	7	15
11	8	8	9	10	15	21	13	9	10	8	10	14
12	8	10	11	12	20	20	14	7	7	8	10	7
13	10	9	17	9	13	14	8	9	11	10	9	13
14	15	9	12	9	14	24	6	8	9	10	10	18
15	7	7	10	7	10	10	16	16	6	7	9	8
16	9	9	18	11	5	11	19	7	8	9	13	8
17	8	11	14	9	12	16	25	10	11	11	13	12
18	17	10	21	8	21	14	8	12	11	9	6	9

Experiment I

Group 5 - Recognition Thresholds in hundredths of a second for the group with 60 db. tone, 8 second tone onset-word presentation interval

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

Experiment I

Group 6 - Recognition Thresholds in hundredths of a second for the group with 90 db. tone, 8 second tone onset-word presentation interval

Serial Position	Subjects 1	2	3	4	5	6	7	8	9	10	11	12
1	23	9	27	22	35	19	23	15	23	9	8	12
2	13	9	11	21	19	16	13	24	10	16	10	9
3	14	7	20	13	14	14	9	20	23	21	8	10
4	15	7	17	14	26	12	19	7	11	7	14	9
5	18	6	24	10	11	16	13	6	11	17	10	16
6	21	14	10	13	16	9	13	16	9	18	13	7
7	13	8	25	19	15	26	20	25	19	12	6	8
8	13	7	20	16	11	11	12	10	11	14	9	10
9	15	8	22	12	12	9	9	19	17	31	6	14
10	17	13	17	13	10	13	20	7	12	12	6	9
11	9	8	27	11	11	11	19	8	8	26	6	13
12	10	14	20	9	16	15	11	9	14	19	9	8
13	10	14	21	11	10	9	13	20	12	16	12	13
14	18	8	15	14	12	8	15	13	17	18	8	8
15	15	6	23	12	8	12	16	13	9	17	8	12
16	11	7	15	18	12	17	12	12	9	31	6	13
17	8	8	32	20	12	12	13	6	8	21	8	10
18	14	9	27	9	16	32	15	8	13	24	7	11

APPENDIX B

RAW DATA FOR EXPERIMENT II

Experiment II

Group 1 - Recognition Thresholds in hundredths of a second for the group with no fixation, no tone

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

Experiment II

Group 2 - Recognition Thresholds in hundredths of a second for the group with fixation, no tone

Serial Position	Subjects 1	2	3	4	5	6	7	8	9	10	11	12
1	25	10	14	23	21	10	11	8	22	18	8	19
2	35	13	16	12	10	21	8	10	9	9	7	8
3	25	15	9	11	10	8	21	13	9	7	7	9
4	26	20	6	20	8	7	8	6	14	17	7	14
5	16	44	7	22	8	7	10	13	9	8	6	8
6	17	8	6	9	8	6	8	7	16	10	6	8
7	13	10	20	9	8	21	7	11	12	11	8	12
8	20	7	6	15	10	40	8	7	7	9	5	6
9	15	11	6	10	7	27	6	8	8	15	6	8
10	20	10	7	6	6	11	6	6	12	8	8	7
11	31	24	9	6	12	10	36	10	10	10	6	8
12	23	8	7	8	8	15	6	6	11	6	6	9
13	12	8	8	27	9	8	19	8	9	8	7	12
14	14	8	5	9	16	19	21	7	10	8	7	9
15	23	16	7	12	10	6	8	9	8	17	6	9
16	14	8	9	7	9	11	8	8	16	10	6	9
17	18	9	7	8	7	19	16	11	24	19	6	11
18	12	15	6	14	7	19	6	8	17	11	6	16

Experiment II

Group 3 - Recognition Thresholds in hundredths of a second for the group with no fixation, 90 db. tone

Serial Position	Subjects 1	2	3	4	5	6	7	8	9	10	11	12
1	30	13	23	15	11	41	16	21	26	11	12	28
2	20	9	17	17	10	13	13	23	11	26	21	22
3	19	11	20	12	26	13	25	19	9	12	24	28
4	21	8	9	20	18	23	19	21	11	9	14	24
5	17	13	12	15	15	15	7	24	11	13	11	15
6	12	8	17	19	14	15	14	20	11	13	14	6
7	15	9	9	13	13	13	11	16	9	11	16	13

8	27	9	10	13	10	13	13	20	10	12	9	21
9	16	8	19	15	6	14	8	12	10	9	14	25
10	11	18	10	14	16	11	9	13	9	12	13	20
11	14	20	18	15	7	17	17	21	9	12	8	12
12	14	11	11	15	11	22	8	25	10	11	20	9
13	23	10	8	10	11	27	8	15	14	13	11	12
14	19	9	32	26	10	15	9	24	10	16	11	12
15	25	16	8	9	10	12	9	19	14	17	13	23
16	17	14	10	10	12	16	8	14	18	16	11	19
17	12	9	9	9	8	24	7	14	8	18	9	24
18	11	10	13	8	9	10	8	19	13	17	11	13

Experiment II

Group 4 - Recognition Thresholds in hundredths of a second for the group with fixation, 90 db. tone

Serial Position	Subjects 1	2	3	4	5	6	7	8	9	10	11	12
1	10	8	10	14	12	19	10	12	25	27	7	22
2	7	6	8	15	9	18	10	23	10	14	10	13
3	10	8	9	15	11	8	8	16	10	11	8	9
4	8	6	22	10	12	8	23	11	15	7	8	11
5	6	6	11	10	7	8	9	7	12	10	9	7
6	7	8	10	12	7	8	13	8	10	13	14	9
7	8	6	14	11	13	10	8	9	17	7	6	16
8	7	8	8	13	8	12	14	9	10	7	18	10
9	8	6	8	15	9	10	17	9	12	11	9	10
10	9	7	16	13	9	8	27	11	14	8	7	8
11	17	6	17	11	9	7	12	11	8	12	14	19
12	7	6	10	9	20	13	10	9	8	10	18	8
13	7	7	11	16	9	11	10	7	13	14	13	8
14	10	5	13	14	8	9	10	10	9	8	13	9
15	8	9	9	10	9	8	7	11	10	13	10	9
16	7	5	11	13	12	8	8	8	12	10	9	12
17	10	5	10	14	8	7	10	7	11	10	12	10
18	10	5	10	8	30	7	7	10	10	11	10	15

APPENDIX C

RAW DATA FOR EXPERIMENT III

Experiment III

Group 1 - Recognition Thresholds in hundredths of a second for the group with no fixation, no tone

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

Experiment III

Group 2 - Recognition Thresholds in hundredths of a second for the group with fixation, no tone

Serial Position	Subjects 1	2	3	4	5	6	7	8	9	10	11	12
1	19	16	20	20	34	26	22	11	31	11	24	20
2	11	13	15	8	13	16	9	16	6	21	12	26
3	10	11	15	9	16	11	10	12	8	9	7	12
4	19	20	32	12	9	18	11	10	9	14	23	18
5	9	21	9	6	13	17	12	10	10	12	9	18
6	13	12	17	15	7	19	10	12	11	8	16	9
7	10	14	9	6	8	10	7	16	8	8	11	7
8	7	10	10	8	26	23	6	9	12	18	7	10
9	8	19	20	7	8	14	12	19	33	9	15	5
10	8	11	11	6	7	17	9	7	17	7	20	14
11	8	16	11	8	23	11	8	7	8	9	7	13
12	10	13	8	6	11	11	9	9	11	7	8	11
13	8	12	9	6	10	14	7	11	7	7	10	13
14	14	18	19	6	10	15	6	11	27	17	8	12
15	13	18	16	8	9	17	10	15	14	9	11	13
16	10	9	11	9	8	10	8	10	22	12	13	14
17	19	11	11	6	9	29	15	11	13	12	9	10
18	7	11	14	15	13	10	8	10	36	9	6	11

Experiment III

Group 3 - Recognition Thresholds in hundredths of a second for the group with no fixation, 60 db. tone

	Subjects											
Serial Position	1	2	3	4	5	6	7	8	9	10	11	12
1	19	35	10	16	17	10	13	14	22	9	9	11
2	15	15	7	8	15	8	13	13	23	8	14	8
3	15	11	9	7	8	8	16	9	9	10	11	10
4	13	14	10	10	11	13	16	12	12	6	13	8
5	8	18	8	12	9	8	12	13	12	8	9	6
6	8	7	9	8	14	8	17	16	12	7	8	6
7	8	15	8	6	7	8	11	13	12	12	11	6
8	8	21	10	8	7	9	9	10	9	10	9	7
9	10	17	11	9	8	7	20	8	12	7	10	6
10	7	12	8	12	8	7	9	20	10	8	11	8
11	10	16	10	12	8	8	15	16	11	9	8	7
12	13	12	9	8	10	8	20	11	10	7	9	6
13	8	7	11	10	10	12	11	13	8	8	9	8
14	7	10	13	7	14	8	9	12	9	7	12	9
15	6	7	11	9	10	10	29	13	10	9	9	5
16	9	10	9	7	8	6	17	10	10	6	11	8
17	9	8	15	11	12	7	8	8	8	6	13	6
18	6	13	13	9	10	11	14	22	11	9	9	6

Experiment III

Group 4 - Recognition Thresholds in hundredths of a second for the group with fixation, 60 db. tone

Subjects

Serial Position	1	2	3	4	5	6	7	8	9	10	11	12
1	10	9	16	38	27	7	12	10	12	11	5	20
2	12	8	15	7	19	8	23	12	10	8	7	9
3	11	8	10	9	7	7	10	9	6	13	6	9
4	10	7	8	8	15	8	12	7	10	9	8	21
5	8	8	11	8	7	15	8	10	8	7	7	12
6	8	7	9	7	8	8	10	9	8	8	7	6
7	9	7	19	9	7	11	8	6	10	12	7	7
8	8	7	14	12	9	10	8	8	7	10	7	8
9	12	6	9	14	8	10	8	9	7	11	6	7
10	11	7	9	8	12	8	8	7	6	7	6	6
11	7	7	7	10	9	8	10	11	6	7	7	7
12	8	8	13	8	7	8	8	9	7	10	6	10
13	9	8	7	9	6	7	9	11	10	9	8	6
14	7	7	12	9	8	11	12	7	8	8	6	7
15	8	6	6	8	9	8	10	9	8	10	6	9
16	7	6	10	9	7	9	12	9	6	7	7	7
17	7	7	14	8	17	6	12	8	8	9	7	6
18	8	8	8	7	7	8	11	7	6	7	6	5