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The Role of Learning in Olfactory Sensitivity

Monroe P. Friedman
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To the Graduate Council:

I am submitting herewith a dissertation written by Monroe P. Friedman entitled "The Role of Learning in Olfactory Sensitivity." I have examined the final electronic copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Psychology.

William O. Jenkins, Major Professor

We have read this dissertation and recommend its acceptance:

Ernest Furchtgott, Clifford H. Swenson, William E. Cole, Madeline D. Kneberg

Accepted for the Council:

Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

August 14, 1959

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Major Professor

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Madeline Kneberg

William E. Cole

Clifford H. Swensen Jr.

Ernest Furchtgott

Accepted for the Council:

Dale Hastings

Dean of the Graduate School

THE ROLE OF LEARNING IN OLFACTORY SENSITIVITY

A THESIS

Submitted to
The Graduate Council
of
The University of Tennessee
in
Partial Fulfillment of the Requirements
for the degree of
Doctor of Philosophy

by

Monroe P. Friedman

August, 1959

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To my wife, Rita, a special note of thanks is due for her patience, understanding, and encouragement over the past three years. This dissertation is dedicated to her.

Monroe P. Friedman

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CHAPTER I

INTRODUCTION

In recent years the psychological literature has reflected an increasing interest in the role of learning in perception. On the theoretical level, this interest is expressed principally by the considerable attention given to two current attempts to account for perceptual learning (Gibson & Gibson, 1955a; Postman, 1955). On the empirical level, the problems of industry and the military have generated a multitude of investigations in this area. These problems range in diversity from the training of military personnel in the identification of aircraft to the training of tasters in the food industry.

The remainder of this chapter will be devoted to a critical analysis of the theoretical formulations of perceptual learning and to a review of the empirical findings relevant to the present experiment.

Theoretical Background

The current theoretical controversy in perceptual learning originated with an analysis of the theoretical state of perceptual learning by Gibson and Gibson (1955a) and a statement of their own position. After briefly reviewing the pertinent theoretical literature on perception, these authors conclude that all existing perceptual theories have as a basic assumption the notion that a discrepancy exists between sensation and perception. Because these theories are characterized by this assumed discrepancy they are considered by Gibson and Gibson to represent a general type of "enrichment theory" of perception. The principal feature of the "enrichment theory" is its emphasis upon the progressively decreasing correspondence between perception and stimulation.

As an alternative to the "enrichment theory" Gibson and Gibson suggest a "specificity theory" of perceptual learning. In sharp contrast to the enrichment theory, the specificity theory has as its basic tenet the concept of a progressively, greater correspondence between perception and stimulation with learning. The authors state: "Perceptual learning, then, consists of responding to variables of physical stimulation not previously responded to" (Gibson & Gibson, 1955a, p. 34). To clarify their position, the writers cite the example of two men who differ radically in the number of identifying responses they emit when presented with a variety of wines to taste. The difference is accounted for in terms of the Gibsons' theory: i.e., the more sensitive taster has learned to discriminate more of the variables of physical stimulation.

The theoretical position of Gibson and Gibson did not remain unchallenged for long. Postman (1955) attacked the theory on several grounds. First of all, he contends that the enrichment hypothesis to which Gibson and Gibson object, does not represent the present associationistic position but an older and less sophisticated form of this approach, i.e., Titchener's context theory. According to Postman, the major difficulties with this historical position was its emphasis upon a distinction between sensation and perception, and the implication that perception decreases in correspondence with sensation as a function of experience. Gibson and Gibson have focused their attention on these aforementioned weaknesses.

Postman points out that modern associationism avoids the difficulties of the Titchener theory. The present stimulus-response formulation eliminates the distinction between sensation and perception, and consequently the Gibsons' interpretation of association theory as an enrichment theory is incorrect. As to the second difficulty of the Titchnerian thesis, Postman believes, that the question of direction of change in psychophysical correspondence in perceptual learning can only be answered experimentally.

A second Postman criticism of the specificity hypothesis is its purely descriptive nature. No mechanism of perceptual learning is postulated or implied. Gibson and Gibson restrict themselves completely to the descriptive statement that perceptual learning consists of responding to variables of stimulation not previously responded to. Postman believes that the associationists with their postulated process of stimulus-response association offer a substantially more complete formulation.

Having pointed out that the specificity position only qualifies as a descriptive generalization, Postman analyzes it on this level. In this analysis he attempts to demonstrate limitations of the Gibsons' position with reference to the perception of signs and symbols. Both sign and symbol perception are associative phenomena almost by definition. Both involve association of a sign or symbol with its representative object or event. Because of its inability to account for the perception of signs and symbols, the specificity hypothesis is considered by Postman to have limited generality.

In a reply to Postman, Gibson and Gibson (1955b) state that their specificity formulation is not a theory but the possible first step in the development of a theory. Consequently the explanatory value of their approach remains to be seen. They believe that their formulation will direct attention to phenomena which are unexplained by present theory.

In answer to Postman's criticism of the Gibsons' failure to postulate a mechanism of perceptual learning, the writers reply that the present hypothesis is concerned primarily with the question of what is learned in perceptual learning. They believe an understanding of the nature of perceptual learning is necessary before any specific mechanisms or processes can be hypothesized.

Gibson and Gibson are critical of the emphasis on change in response in the associationistic definition of perceptual learning. They argue that perceptual learning should be concerned with changes in effective stimulation. They contend that the basic problem of perceptual learning is how certain variables of physical stimulation come to function as cues.

A further point of disagreement is revealed in the Gibsons' objection to Postman's assertion that the question of direction of change in correspondence between perception and stimulation is an experimental one. If change in response is the sole criterion of perceptual learning without regard to the verdicality, or physical correspondence, of the response, then a progressive decrease in veridicality should be considered learning by Postman.

This last statement of Gibson and Gibson indicates one of the major problems of any theory of perceptual learning, i.e., a criterion of perceptual learning. As Gibson and Gibson have stated, the question of the nature of perceptual learning is basic to further theorization. Upon examining the criteria of perceptual learning postulated by the two theorists one notes an obvious difference in the relative importance of the roles assigned to the stimulus and the response. The Gibson and Gibson position is almost completely concerned with the stimulus side of the stimulus-response sequence while Postman expresses his criterion of perceptual learning solely in terms of changes in response.

Wohlwill (1958), in a penetrating analysis of the theoretical problem of perceptual learning, contends that a more clearly specified criterion of perceptual learning is necessary by both positions before an evaluation of the two approaches can be made. In particular, he states that the specific stimulus-response relationship to be learned is a crucial factor in determining the explanatory power of the two formulations. The author suggests a criterion for perceptual learning which he believes will distinguish between learning based upon perceptual functions and that based upon response association. Wohlwill's principal purpose in the formulation of this criterion is the exclusion from consideration of situations which necessarily involve new stimulus-response associations since in such situations, changes on the response side are not indicative of changes on the perceptual side. The consequence of this approach of Wohlwill is a criterion of perceptual learning which includes only the use of responses which have previously been associated with a given class of stimuli. Therefore, in a given learning situation, if the stimulus to be discriminated is a member of the given class of stimuli the response to it will reflect perceptual change. The author states:

> Perceptual learning might thus be regarded as the development of a transfer of a previously learned set of responses to a new set of stimuli, the possibility for this transfer inhering in the physical characteristics of the stimuli (Wohlwill, 1958, p. 440).

By this definition Wohlwill succeeds in eliminating certain types of learning situations from the province of perceptual learning. One apparent exclusion is the learning or signs and symbols since the responses to be learned in this setting were not previously established to the given stimulus class.

Wohlwill believes that his proposed criterion is useful in that it clearly separates two alternative theoretical positions concerning the nature of percpetual learning. Either the transfer of previously learned responses to the present stimulus occurs, as permitted by the situation, or the response is established through association with any discriminable aspect of stimulus through differential reinforcement. The Gibson and Gibson formulation, according to Wohlwill should be classed with the first alternative which looks upon perceptual learning as essentially a generalization phenomenon. The Postman position with its emphasis on an associationistic basis for perceptual learning belongs under the second alternative.

Wohlwill proceeds to analyze a variety of perceptual learning situations in the light of the two alternative positions. Of particular interest is his analysis of judgments of quantitative relationships. In judgments of complex quantitative relationships such as relative distance, Wohlwill believes the stimuli are sufficiently complex in nature to allow for a Gibson and Gibson interpretation of this type of learning. There are a multitude of dimensions of variation inherent in the stimulus to permit the subject to progressively elaborate and respond accordingly. If this learning occurred in the absence of external reinforcement, the Postman position would hardly be applicable since the associational position assumes some reinforcing agent. However, if reinforcement is present, the Postman position is clearly relevant. In this case, learning would consist of the association of the correct responses with any discriminable aspect of the stimulus. Wohlwill offers an experimentally testable implication of this thesis; i.e., according to Postman, there should be no difference in the ease of the establishment of learning based upon increasingly nonverdical responses and increasingly veridical ones. The Gibson and Gibson position would predict, according to Wohlwill, differential learning in favor of the increasing veridical judgments.

Judgments of relative distance illustrates a relatively complex example of judgments of quantitative relationships. Certainly, many relatively simpler problems exist in judgments of this type. It seems necessary to examine these judgments to see if they are qualitatively different from the more complex cases of judgments of quantitative relationships. Wohlwill believes that the answer depends upon the complexity of the dimension of physical stimulation under consideration in the context of the total judgmental situation. When a one-to-one correspondence exists between the psychological and the physical dimension of stimulation, no opportunity is provided for the specificity learning postulated by the Gibson and Gibson formulation. Wohlwill suggests the loudness of pure tones as an example of this one-to-one correspondence. However, even in this supposedly simple dimension of stimulation, problems arise. It is well known that changes in the physical intensity of sound are characterized by changes in the two psychological dimensions of pitch and loudness. A more appropriate modality, and the one selected in the present paper, seems to be olfaction. There are several reasons for this selection. The sense of smell is perhaps one of the most physiologically primitive of the human senses. Consequently, one would expect the possible psychological dimensions of olfaction to be limited by the relative primitiveness of the olfactory mechanism. Another reason is that no well-established psychological dimensions of olfaction exist in the comtemporary psychological literature such as in vision and audition. While this statement implies that the psychological dimension of olfaction is as dimensionally simple as the corresponding physical one, a word of caution must be mentioned. The fact that the visual and auditory modalities are characterized by a number of established psychological dimensions as compared to olfaction may be accounted for, perhaps more parsimoniously, in terms of the tremendous difference in the quantity of research performed in these areas. For practical reasons, vision and audition have received more attention than the other sense modalities.

Notwithstanding the above-mentioned criticism, olfaction remains as an ideal modality for the investigation of perceptual learning at a relatively simple level. Although the results of an exploratory investigation of the role of learning in olfaction will not necessarily support the Postman position or negate the Gibson and Gibson position since the assumption of a one-to-one correspondence between the psychological and physical dimensions may be erroneous, the findings should shed considerable light on the nature of perceptual learning.

Empirical Background

As Gibson (1953) has indicated in an extensive review of the empirical literature in perceptual learning, little evidence relating perceptual judgments to learning exists in the current textbooks of psychology. However, some recent trends in perceptual theory such as the formulations of Hebb, Ames and Cantril, and Gibson and Gibson have somewhat changed this unproductive state. Other influences are the practical problems of industry and the military which have generated a multitude of research in this area.

As in any new area of investigation the first questions to be asked are, of necessity, basic in nature. In particular, the question of the existence of improvement of perceptual judgments with practice, must be answered. And secondly, if there is evidence for improvement of these judgments, what factors influence them?

Of particular interest to the present thesis is the evidence for improvement of perceptual acuity and sensitivity by practice and the role of the following factors in perceptual learning: amount of practice, distribution of practice, and knowledge of results. The review of this evidence, which follows, will be in great part, a summary of the rather exhaustive review of Gibson (1953).

Improvement of Perceptual Acuity and Sensitivity

The effects of practice on acuity have been investigated principally in the area of vision. Optometrists have made numerous claims that prescribed training will aid in the correction of visual anomalies such as astigmatism and nearsightedness. Woods, however, according to Gibson, reported no change in the condition of 103 myopic patients tested before and after training. Although Gibson cites a study by Morgan as evidence that the treatment must be varied depending on the particular anomaly, the influence of training on the correction of visual anomalies remains questionable.

Considerable positive evidence has been found for the effect of practice on foveal visual acuity. Sanford (1888) in an early experiment using letters as test objects, and more recently Wilcox (1936) using parallel bars, reported large increments in acuity as a result of practice. Bruce and Low (1951) add generality to these findings with a report of an increase in acuity after training with aircraft photographs, presented tachistoscopicly. Two rather isolated studies, Dobrowolsky and Gaine (Gibson, 1953), and Low (1946) demonstrated that practice affects peripheral visual acuity positively too, with a considerable increase in sensitivity in the latter investigation.

In cutaneous sensitivity, Gibson cites a number of early studies, such as Dresslar, Mukherjee, Solomons, Tawney, and Volkman indicating the effectiveness of practice in lowering the two-point threshold on the skin. An early study in audition by Brown (Gibson, 1953) demonstrated that practice raised the upper threshold for discrimination of tones. Harriman and MacLeod (1953) found a significant increase in sensitivity to salt in rats as a result of practice. In this study the rats were deprived of water and reinforced with electric shock. In general, these investigations demonstrate an increase in sensitivity as a result of practice in a number of diverse sense modalities. In most instances the stimulus presented to the subject represented a composite of a number of psychological dimensions of stimulation. In the two-point limen, for example, the subjects were exposed to warmth, cold, and perhaps pain stimulation. No investigations of the effects of practice on olfactory sensitivity were found in the literature.

Amount of Practice

That practice affects improvement in perceptual judgments is perhaps evident from the above discussion. However, still to be ascertained is the function which relates these two variables. Gibson notes that few of the experiments relating to this topic have measured the effects of practice at sufficient points to accurately describe a function. However, that frequency of practice is an effective variable, has been shown in a number of diverse investigations (Bevan & Zener, 1952; Crosland, Taylor & Newsom, 1929; Fehrer, 1935; Gough, 1922; Howes & Solomon, 1951; Seward, 1931; Tresselt, 1947), and Fernberger (1916) has found evidence that early practice is more effective than later in improvement in lifting weights. Of these studies, learning curves were plotted by Seward, Howes and Solomon, and Bevan and Zener. In general, these investigators found a gradual continuous rise in their measures of improvement although there was little agreement on the direction of the acceleration of the learning curves. This lack of agreement of direction may reflect the differences in the tasks employed.

Distribution of Practice

Although the effects of distribution of practice have been investigated in a huge number of diverse learning situations relatively little work has been done in perceptual learning. Gibson cites only one study (Lewis, 1908) which has investigated this parameter. Lewis found that distributed practice on alternate days accelerated the rate of decrease of the Muller-Lyer illusion.

Knowledge of Results

A number of studies have found evidence for perceptual learning without any apparent knowledge of results. These studies are characterized by the omission of external reinforcement. However, the experimental situation provides the S with some "internal" reinforcement and consequently it seems extremely difficult to experimentally test the effects of practice on perceptual judgment without reinforcement of some kind. For example, in the writer's experience, in absolute threshold determinations in olfaction and gustation without external knowledge of results, Ss have reported definite recognition of the stimulant under investigation and this recognition was substantiated by their results.

As a consequence of this discussion the following three types of perceptual learning emerge: perceptual learning with both internal and external reinforcement, perceptual learning with only internal reinforcement, and perceptual learning with only external reinforcement. As mentioned above, the third type may be extremely difficult, if not impossible, to demonstrate empirically.

In her review of perceptual learning without external reinforcement, Gibson cites several studies of the two-point threshold by Dresslar, Mukherjee, Tawney, and Volkman, which have demonstrated learning without reinforcement by E. The reviewer points out that the method of limits employed in these studies provides the S with definite anchoring concepts of "oneness" and "twoness." Her point is substantiated by a study by Hoisington (1917) who used the method of constant stimuli and found no decrement in the two-point limen.

Gibson cites several studies which she believes provide no opportunity for internal reinforcement. Fernberger (1916) and Urban (Gibson, 1953) found improvement in comparisons of lifted weights with no external reinforcement. Fehrer (1935) and Seward (1931) reported improvement in the identification of letters under "impoverished" conditions of stimulation. Fehrer presented her stimuli tachistoscopicly and Seward, under dim illumination. Contrary to Gibson's statement that these studies present no opportunity for selfreinforcement, it appears to the present writer in all four instances an argument could be offered in favor of the possibility of internal reinforcement. For example, in the learning of the identification of letters under dim illumination it seems possible that the S will identify one part of the letter early in the learning process and gradually build upon this until sufficient information is made available for identification purposes. After having identified one part of the letter the successive presentations will be reinforcing.

Of the experiments which contrast practice with and without external knowledge of results, all show a definite superiority of the external knowledge condition. The classic experiments in this area have been performed by Thorndike (1932), who produced evidence for a variety of absolute judgments. The studies by Minturn and Reese, and Taubman on absolute judgment of numbers and Solomon's investigation on the two-point limen are further evidence cited by Gibson. Other evidence is an investigation of favor discrimination by Pfaffman and Schlosberg (1953) in which they found that knowledge of the results improved performance of experienced and inexperienced Ss in easy and difficult discriminations.

Summary of the Empirical Literature

In general, evidence exists for improvement in perceptual judgments by practice for a wide range of perceptual phenomena. In acuity, improvement is noted in central and peripheral vision, and the two-point threshold. Increases in sensitivity are seen in audition and gustation. The stimuli employed in these range in complexity from aircraft silhouettes (Low, 1946) to salt solutions (Harriman and MacLeod, 1953). The frequency of practice has proved to be a significant variable in a number of diverse investigations with some agreement on the properties of the function relating amount of practice and degree of improvement. On the basis of the one study testing the effects of massed versus spaced practice trials, distribution of practice affects improvement in performance. More research directed at uncovering the effects of this variable is obviously needed in a variety of perceptual learning settings. The role of knowledge of results in perceptual learning is a complex one. External knowledge of results gives improved performance in a variety of situations but the effects of internal reinforcement are not clear.

Purpose of the Present Study

The purpose of the present study is twofold in nature. The first of these aims is primarily theoretical. One useful approach in science has been to concentrate on the determination of the laws of simple phenomena for the purpose of accounting for more complex ones. The present experiment is typical of this approach. By investigating the role of learning in the relatively primitive olfactory modality, certain more complex theoretical problems may be clarified. In particular, the present experiment is relevant to the previously discussed theoretical controversy between the specificity position of Gibson and Gibson and the associationist position of Postman.

On the empirical level, the present experiment, by investigating the role of learning in olfactory sensitivity, represents an attempt to supplement the paucity of literature concerning the olfactory sense and its relation to important psychological variables.

CHAPTER II

METHOD AND PROCEDURE

Experimental Design

Two experiments were performed, the second being a partial replication of the first. Both experiments had the same design but differed in the number of levels involved in the treatment variables. Experiment I employed a three by three by eight factorial design for repeated measurements. The two treatment variables were trials per session and days between sessions and eight threshold determinations were taken for each S. The geometric representation of this design is shown in Figure 1. Three Ss were used in each of the nine resulting cells making a total of twenty-seven for Experiment I.

Because of the practical difficulties of scheduling Ss for this experiment which extended, in some cases, over a period of four weeks, no matching was employed. In fact, since each S selected his schedule on the basis of his availability, E employed no systematic basis for the selection and assignment of Ss to conditions.

The experimental design for Experiment II was identical with that of Experiment I except that only two levels for each treatment variable were employed. Again each of the cells contained three Ss and with four cells there was

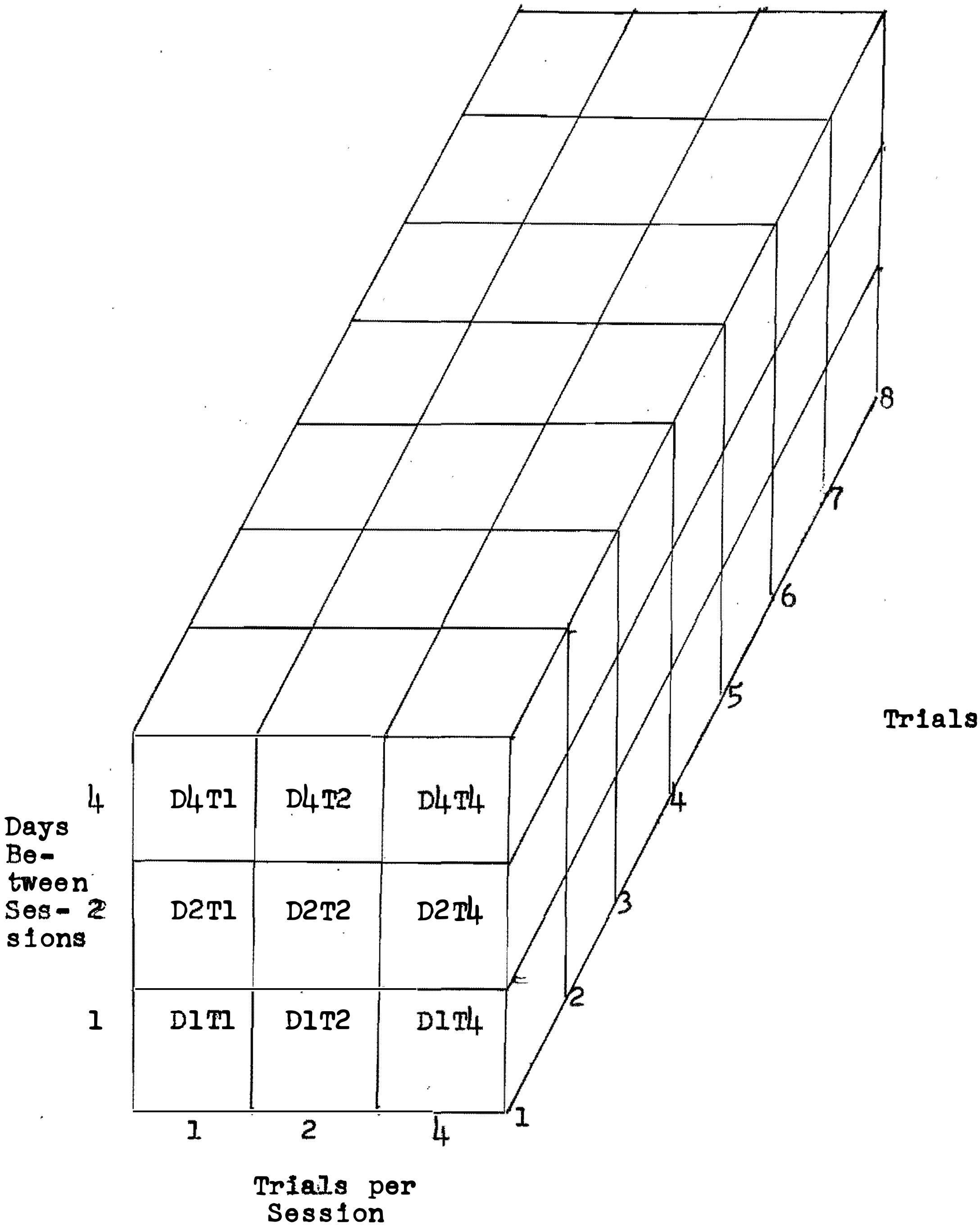

Figure 1. Geometric representation of design for Experiment I.

a total of twelve S in the replication. The design for Experiment II is represented geometrically in Figure 2.

Subjects

The Ss were thirty-nine male undergraduate students from the University of Tennessee. They ranged in age from eighteen to twenty-seven and were all volunteers from an introductory course in psychology. In their classroom work no mention had been made of the problem under investigation or of related problems. None of the Ss had had previous experience with olfactory threshold determination in the psychological laboratory.

Procedure

All data was collected in an air-conditioned room. Temperature ranged from seventy-two to seventy-four degrees Fahrenheit. S was seated comfortably and presented with four grooved wooden blocks each of which held a 10X75 mm cork-stoppered pyrex test tube. Three of the test tubes contained ethylene glycol only while the fourth contained the odorant, iso-amyl acetate in ethylene glycol as the solvent.

A forced-choice method of limits proposed by Jones (1956) was used for all threshold determinations. S was instructed to sniff all tubes and to identify the tube which smelled different from the others. To avoid contamination

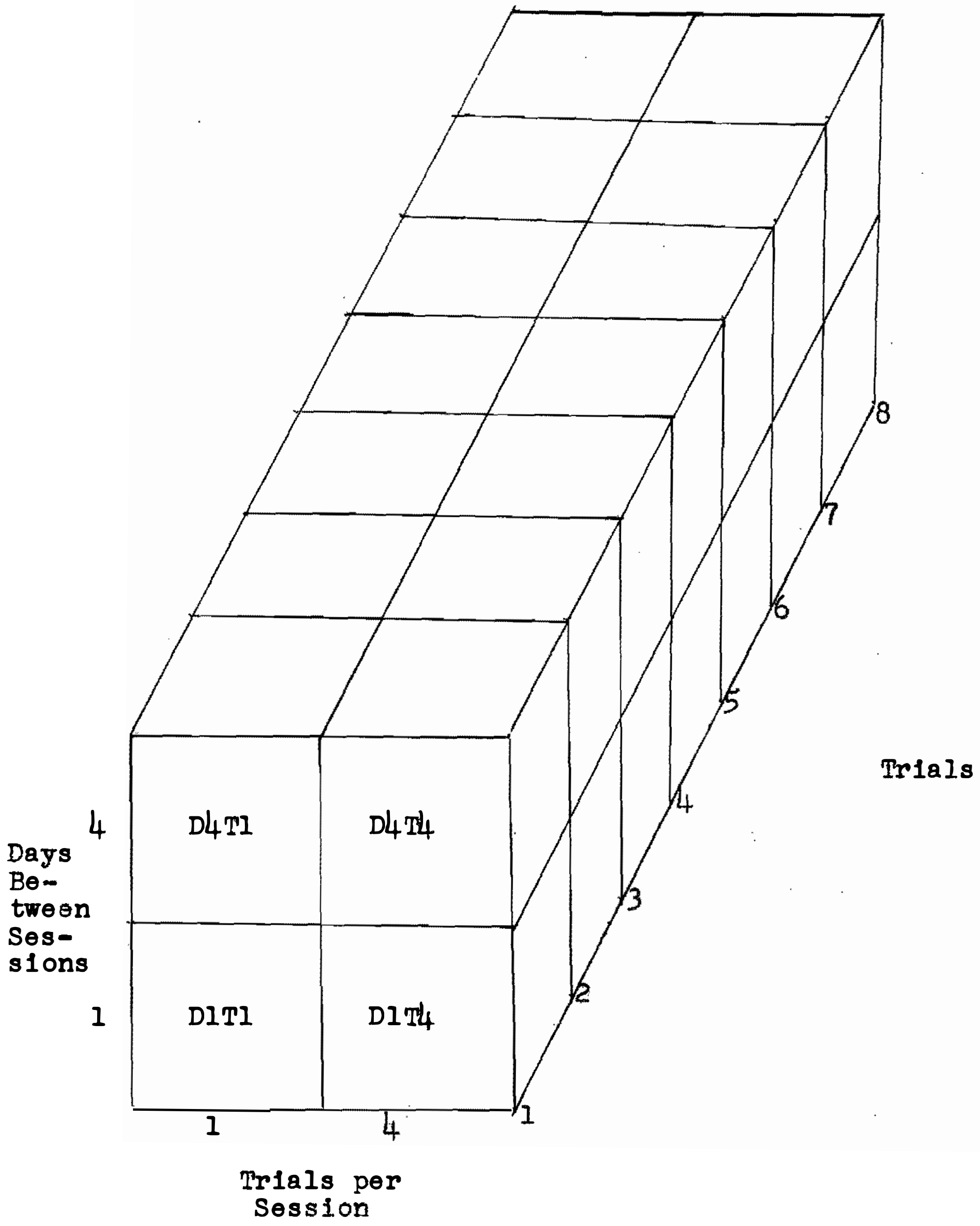

Figure 2. Geometric representation of design for Experiment II.

from adaptation effects only the ascending series of the method of limits was employed and each trial consisted of two such series. The level at which S correctly identified the odorant twice in succession was taken as the threshold value for that series. The threshold value for a given trial was the mean of the threshold values for the two series making up the trial. The testing time for each trial was approximately twelve minutes and three minutes of rest were given between trials for Ss exposed to more than one trial a session.

All Ss received knowledge of results. They were told "right" for a correct choice and "wrong" for an incorrect one. In the case of an incorrect response no further knowledge was provided by E so S was not informed which one of the remaining three tubes contained the stimulant.

To control for diurnal effects, each S was tested at the same time of day for all his sessions. The possible contaminating effects of smoking were partially controlled by instructing each S to refrain from smoking for at least an hour before each session.

The odorants were prepared by successive dilution of iso-amyl acetate in ethylene glycol. The highest concentration, Tube No. 15, contained .01M iso-amyl acetate, the next tube, No. 14, contained .005M, Tube No. 13, .0025M and so on down to Tube No. 1 which contained $6.5X10^{-7}$M iso-amyl acetate.

Statistics

Because the primary interest in this study was in the number of S showing the effects of the experimental variables, the major emphasis in the analysis of the data was placed upon consistency rather than magnitude of changes. Consequently the Chi square technique was frequently employed. In the determination of the effects of magnitude and direction of change, an analysis of trends proposed by Grant (1956), was used for both experiments.

Since there was no basis for predicting the direction of the effects of the test variables, two-sided tests for significance were used in all analyses.

CHAPTER III

RESULTS

Since this study consisted of two experiments, the second a partial replication of the first, two separate analyses were performed. In each replication the two independent variables, trials per session, and days between sessions, were also analyzed separately. An attempt was made to analyze communalities and differences between the two experiments on each of these variables.

Experiment I

<u>The Effects of Trials per Session</u>

The effects of number of trials per session upon sensitivity were analyzed parametricly and non-parametricly. An analysis of trends (Grant, 1956) was employed as the parametric technique as seen in Table I. However certain assumptions of this technique may have been violated. Among these is the assumption of equal error variances for each group of the same trial. Table II indicates the ranges and means for each group at each trial. Since the range is a crude index of variability, an examination of the behavior of the group ranges from trial to trial may reflect some light on the homogeneity of the error variances for each trial. A cursory look at this data indicates heterogeneity of the ranges for some trials. For Trial 2 the ranges of Group D4T1 and Group D4T2 differ by a factor of sixteen. For Trial 5 the factor is seven for the comparison of the ranges of Group D4T1 and Group D1T2. These differences in group ranges for the same trial may well indicate a violation of the homogeneity of variance assumption. A further problem is that these wide differences in range hold for some trials and not for others. Consequently any transformation of the data would have differential effects on variability. In light of this probable violation, caution must be exercised in the interpretation of the results of the trend analysis.

As indicated in Table I, the over-all trend was significant at the .01 level. Mathematically this means that the slope of the curve representing mean values for each trial deviated significantly from zero, or behaviorally speaking, the <u>S</u>s showed significant changes in sensitivity from Trial 1 to Trial 8. The fact that the linear component of the over-all trend was highly significant indicates that the threshold changes from Trial 1 to Trial 8 were gradual, and in the direction of increased sensitivity.

The moderately high significance of the differences between group trends indicates that the trends of the mean threshold values from Trial 1 to Trial 8 differed significantly for the nine groups. The fact that the trials per session component of the differences between group trends differed in quadratic form is somewhat evident from Figure

TABLE I

SUMMARY OF ANALYSIS OF TRENDS OF CODED THRESHOLD VALUES FOR EXPERIMENT I

Source of Variation	df	Mean Square	F
A. Over-all Trend	7	20.7989	7.37**
1. Linear	1	131.7304	18.44**
2. Quadratic	1	5.2284	1.81
3. Cubic	1	5.7813	1.53
4. Quartic	1	0.0471	0.02
5. Higher Order	3		
B. Between Group Means	8	12.6536	0.30
a. Trials	2	36.2917	0.87
b. Days	2	6.0035	0.14
c. Interaction	4	4.1597	0.10
C. Between Group Trends	56	4.1728	1.48*
1. Linear	8	11.6355	1.63
a. Trials	2	3.8031	0.53
b. Days	2	2.4796	0.35
c. Interaction	4	20.1297	2.82
2. Quadratic	8	4.1149	1.42
a. Trials	2	8.7575	3.03*
b. Days	2	3.1195	1.08
c. Interaction	4	2.2914	0.80
3. Cubic	8	5.1819	1.37
a. Trials	2	6.9713	1.85
b. Days	2	1.4660	0.39
c. Interaction	4	6.1452	1.63
4. Quartic	8	1.8263	0.82
a. Trials	2	0.3480	0.16
b. Days	2	5.3251	2.40
c. Interaction	4	0.8161	0.37
5. Higher Order	24		
D. Between Individual Means	18	41.8252	14.82**
E. Between Individual Trends	126	2.8213	
1. Linear	18	7.1423	
2. Quadratic	18	2.8906	
3. Cubic	18	3.7728	
4. Quartic	18	2.2187	
5. Higher Order	54		
Total	215		

* Significant at 5% confidence level
** Significant at 1% confidence level

TABLE II

MEANS AND RANGES OF THE CODED THRESHOLD VALUES ACROSS TRIALS BY GROUP IN EXPERIMENT I

Group		Trial 1	2	3	4	5	6	7	8
D1T1	Mean	8.2	8.2	6.5	3.2	3.3	3.8	2.7	3.2
	Range	8.0	8.0	9.5	1.5	3.0	1.5	3.0	4.5
D2T1	Mean	4.4	3.3	4.2	3.5	3.5	3.3	3.5	3.2
	Range	4.0	4.5	5.0	4.0	1.5	2.0	3.0	5.0
D4T1	Mean	7.2	4.3	4.5	3.8	4.8	4.8	4.5	5.3
	Range	2.0	0.5	0	1.5	1.0	3.0	3.0	2.5
D1T2	Mean	5.3	5.8	5.3	5.7	6.3	7.2	5.3	5.7
	Range	5.5	10.5	10.0	9.0	7.0	8.5	5.0	8.5
D2T2	Mean	7.0	7.5	7.7	7.8	4.7	3.3	4.0	3.8
	Range	6.5	5.5	7.5	5.5	4.0	1.5	4.5	2.0
D4T2	Mean	6.0	5.8	4.5	5.8	5.8	6.3	4.7	4.8
	Range	4.0	8.0	3.5	7.5	4.5	6.0	3.0	7.0
D1T4	Mean	6.5	6.7	5.7	3.5	3.2	3.2	3.7	4.0
	Range	6.5	8.0	7.5	4.0	2.5	3.5	2.5	3.5
D2T4	Mean	4.8	5.2	5.3	3.5	5.0	3.2	3.2	3.8
	Range	7.5	10.0	9.5	5.0	1.0	2.0	3.0	4.5
D4T4	Mean	5.5	5.5	6.7	7.0	2.5	3.2	3.2	3.5
	Range	1.5	2.0	4.0	2.0	2.0	3.0	2.0	3.0
Grand Mean		6.1	5.8	5.6	4.9	4.4	4.3	3.7	4.1

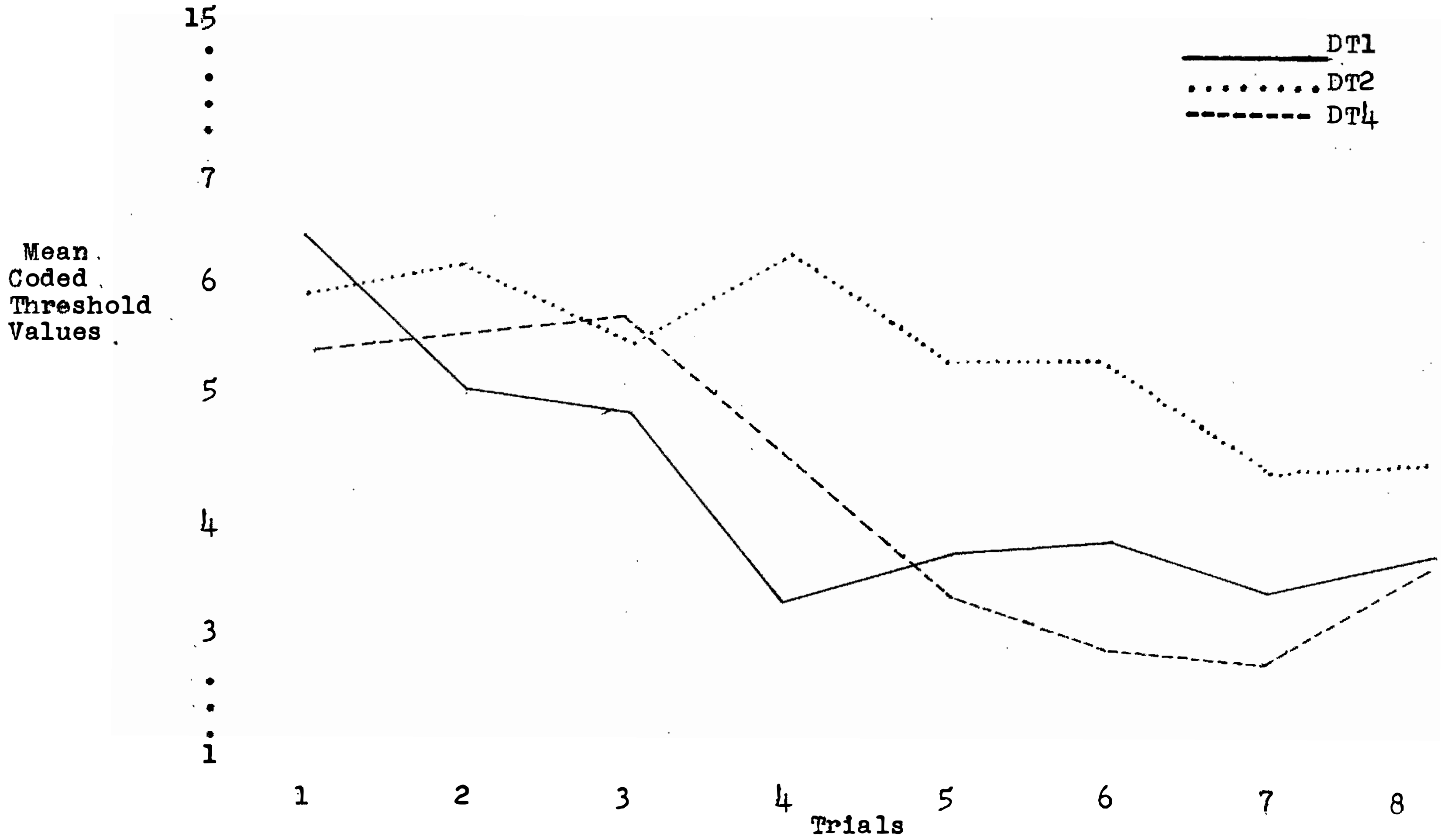

Figure 3. Mean coded threshold values across trials for one, two, and four trials per session in Experiment I.

3. Curve DT2 is in general, concave downward with an absolute maximum at Trial 4. In contrast curve DT1 is concave upward with an absolute minimum at the same trial. Psychologically, this finding indicates that the major portion of the learning occurred in the first few trials for some groups (Curve DT1) and in the last few for others (Curve DT2).

Of particular interest in respect to the reliability of the measures are the highly significant individual differences in average performance as shown by the significant F between individual means. These significant differences are usually found in the case of reliable measures of performance (Grant, 1956).

Of the other comparisons involving the variable of trials per session it is interesting to note the insignificant value for this component of the differences between group means. Since this result includes a comparison of the group means over all eight trials it is not surprising that no differentiation exists.

Examination of the consistency of the effects of the trials per session variable, as indicated in Tables III and IV, reveals no differentiation for this variable. Ss at all levels of trials per session show similar improvement from Trial 1 to Trial 8 and from Trial 1 to Trial 5.

These two tables also present the total number of Ss whose threshold values increased, decreased, and remained unchanged over periods of eight and five trials. Both comparisons are highly significant ($X^2 < .001$ for Table III and $X^2 < .005$ for Table IV), indicating that most subjects showed improvement and that the improvement was evident as early as Trial 5. Trial 5 was selected for comparison in Table IV since this was the first trial that reflected the effects of trials per session and days between sessions for all groups. Examination of Table XXI reveals that the Ss who improved did not differ from the others in their absolute threshold value for Trial 1.

To further investigate the effects of trials per session an analysis of the trial to trial threshold changes was undertaken under conditions of massed and spaced distribution of trials. In Table V no differentiation was found for the three values of trials per session in the number of Ss showing a majority of increases and decreases for consecutive spaced trials. Table VI presents the results for consecutive trial changes in threshold value under massed distribution of trials. As indicated, most Ss with more than one trial per session show an adaptation effect when their threshold values for consecutive trials within the same session are compared. While the effect is not large, it contrasts sharply with the results of trial to trial changes for one trial per session. Most Ss under this condition showed decreases in sensitivity. However, neither this comparison nor any other for Table V or Table VI approached significance.

TABLE III

NUMBER OF SUBJECTS IN EXPERIMENT I WHOSE THRESHOLD VALUES INCREASED, DECREASED, AND REMAINED UNCHANGED FROM TRIAL 1 TO TRIAL 8 FOR ONE, TWO, AND FOUR TRIALS PER SESSION

Trials Per Session	Group	Increase	Decrease	No Change	Total
4	D1T4	0	3	0	3
	D2T4	1	2	0	3
	D4T4	0	3	0	3
	Total	1	8	0	9
2	D1T2	2	1	0	3
	D2T2	0	3	[illegible]	3
	D4T2	0	2	1	3
	Total	2	6	1	9
1	D1T1	0	3	0	3
	D2T1	0	3	0	3
	D4T1	0	3	0	3
	Total	0	9	0	9
Grand Total		3	23	1	27

TABLE IV

NUMBER OF SUBJECTS IN EXPERIMENT I WHOSE THRESHOLD VALUES INCREASED, DECREASED, AND REMAINED UNCHANGED FROM TRIAL 1 TO TRIAL 5 FOR ONE, TWO, AND FOUR TRIALS PER SESSION

Trials Per Session	Group	Increase	Decrease	No Change	Total
4	D1T4	0	3	0	3
	D2T4	2	1	0	3
	D4T4	0	3	0	3
	Total	2	7	0	9
2	D1T2	2	1	0	3
	D2T2	0	3	0	3
	D4T2	1	2	0	3
	Total	3	6	0	9
1	D1T1	0	3	0	3
	D2T1	0	2	1	3
	D4T1	0	3	0	3
	Total	0	8	1	9
Grand	Total	5	21	1	27

TABLE V

NUMBER OF SUBJECTS IN EXPERIMENT I WHOSE THRESHOLD VALUES FOR CONSECUTIVE TRIALS, SPACED WITH RESPECT TO TRIALS PER SESSION FOR EACH CONDITION, SHOWED A MAJORITY OF INCREASES, A MAJORITY OF DECREASES, AND NO CONSISTENT CHANGE

Consecutive Trial Comparisons	Group	Majority of Increases	Majority of Decreases	No Change	Total
4-5	D1T4	1	1	1	3
4-5	D2T4	2	1	0	3
4-5	D4T4	0	3	0	3
	Total T4	3	5	1	9
2-3,4-5,6-7	D1T2	1	2	0	3
2-3,4-5,6-7	D2T2	0	3	0	3
2-3,4-5,6-7	D4T2	1	2	0	3
	Total T2	2	7	0	9
1-2,2-3...7-8	D1T1	1	2	0	3
1-2,2-3...7-8	D2T1	1	1	1	3
1-2,2-3...7-8	D4T1	0	2	1	3
	Total T1	2	5	2	9
Grand Total		7	17	3	27

TABLE VI

NUMBER OF SUBJECTS IN EXPERIMENT I WHOSE THRESHOLD VALUES FOR CONSECUTIVE TRIALS, MASSED WITH RESPECT TO TRIALS PER SESSION FOR EACH CONDITION, SHOWED A MAJORITY OF INCREASES, A MAJORITY OF DECREASES, AND NO CONSISTENT CHANGE

Consecutive Trial Comparisons	Group	Majority of Increases	Majority of Decreases	No Change	Total
1-2,2-3...7-8	D1T1	1	2	0	3
1-2,2-3...7-8	D2T1	1	1	1	3
1-2,2-3...7-8	D4T1	0	2	1	3
	Total T1	2	5	2	9
1-2,3-4,5-6,7-8	D1T2	2	1	0	3
1-2,3-4,5-6,7-8	D2T2	2	1	0	3
1-2,3-4,5-6,7-8	D4T2	2	1	0	3
	Total T2	6	3	0	9
1-2...3-4,5-6...7-8	D1T4	1	2	0	3
1-2...3-4,5-6...7-8	D2T4	1	1	1	3
1-2...3-4,5-6...7-8	D4T4	2	0	1	3
	Total T4	4	3	2	9
Grand Total		12	11	4	27

In summary, the over-all trend for the eight trials was found to be significantly linear and this result is supported by the corresponding significance of the number of subjects who showed decreases in threshold. No significant differentiation was found for the variable of trials per session in contributing to this decrease. Trial to trial analysis of threshold values for spaced trials revealed a majority of Ss increasing but again no differentiation for the three levels of trials per session. The corresponding analysis of massed trials revealed increased thresholds for most Ss with more than one trial per session and decreased sensitivity for those under the condition for one trial per session.

The Effects of Days Between Sessions

Examination of Table 1 reveals insignificance for all of the comparisons involving the variable of days between sessions. Of particular interest is the failure of any of the differences between group trends to attain significance with respect to one of the four orders of functions. This lack of differentiation is evident from inspection of Figure 4. All three curves decrease as a function of trials with little difference between the rates of decrease. In other words, Ss for one, two, and four days between sessions show similarity in the gradualness with which they improve.

That the comparison involving the variable of days between sessions is insignificant is not surprising. This result, as was the case with trials per session, compares group means over eight trials and the differential effects of massed and spaced distributions over the eight trials might be expected to cancel each other.

Inspection of the consistency of the effect of days between sessions, as indicated in Tables VII and VIII reveals no significant differentiation for the variable. In both cases, however, the trend is in the expected direction.

Tables IX and X present the results of a consistency analysis of the trial to trial threshold changes under massed and spaced distributions of trials. Examination of both reveals no differentiation for the days between sessions variable. In both tables the results for all three values of this variable are in essentially the same direction. The massed comparisons show an increase in threshold for the majority of *S*s at two of the three levels while the spaced comparisons exhibit decreases in threshold values for *S*s at all three levels.

Experiment II

The results of Experiment II were analyzed with the same techniques as Experiment I. The analyses are presented in the same tabular and figural form.

The Effects of Trials per Session

The results of the analysis of trends of Experiment

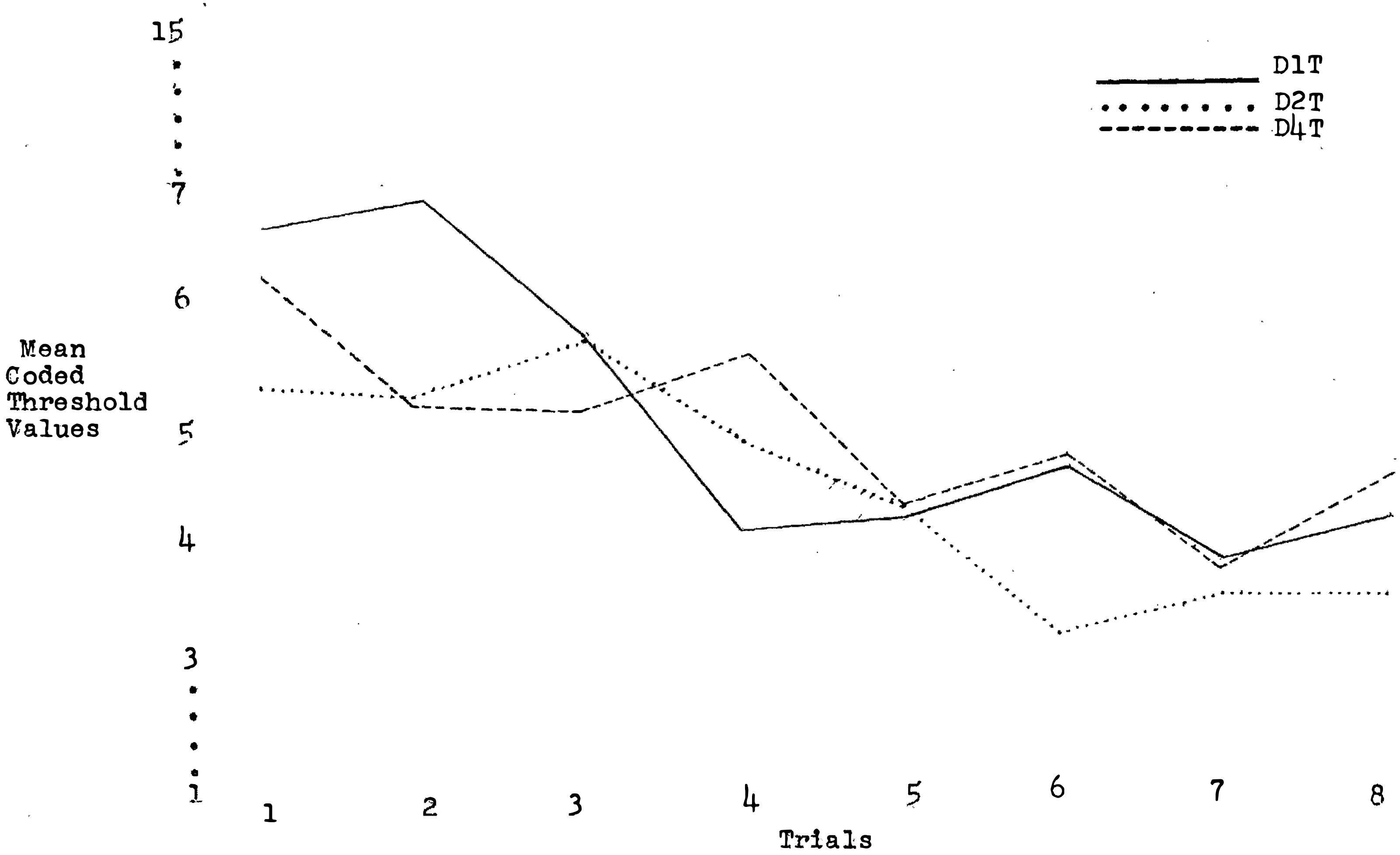

Figure 4. Mean coded threshold values across trials for one, two, and four days between sessions in Experiment I.

TABLE VII

NUMBER OF SUBJECTS IN EXPERIMENT I WHOSE THRESHOLD VALUES INCREASED, DECREASED, AND REMAINED UNCHANGED FROM TRIAL 1 TO TRIAL 8 FOR ONE, TWO, AND FOUR DAYS BETWEEN SESSIONS

Days Between Sessions	Group	Increase	Decrease	No Change	Total
1	D1T1	0	3	0	3
	D1T2	2	1	0	3
	D1T4	0	3	0	3
Total		2	7	0	9
2	D2T1	0	3	0	3
	D2T2	0	3	0	3
	D2T4	1	2	0	3
Total		1	8	0	9
4	D4T1	0	3	0	3
	D4T2	0	2	1	3
	D4T4	0	3	0	3
Total		0	8	1	9
Grand Total		3	23	1	27

TABLE VIII

NUMBER OF SUBJECTS IN EXPERIMENT I WHOSE THRESHOLD VALUES INCREASED, DECREASED, AND REMAINED UNCHANGED FROM TRIAL 1 TO TRIAL 5 FOR ONE, TWO, AND FOUR DAYS BETWEEN SESSIONS

Days Between Sessions	Group	Increase	Decrease	No Change	Total
1	D1T1	0	3	0	3
	D1T2	2	1	0	3
	D1T4	0	3	0	3
Total		2	7	0	9
2	D2T1	0	2	1	3
	D2T2	0	3	0	3
	D2T4	2	1	0	3
Total		2	6	1	9
4	D4T1	0	3	0	3
	D4T2	1	2	0	3
	D4T4	0	3	0	3
Total		1	8	0	9
Grand Total		5	21	1	27

TABLE IX

NUMBER OF SUBJECTS IN EXPERIMENT I WHOSE THRESHOLD VALUES FOR CONSECUTIVE TRIALS, SPACED WITH RESPECT TO DAYS BETWEEN SESSIONS FOR EACH CONDITION, SHOWED A MAJORITY OF INCREASES, A MAJORITY OF DECREASES, AND NO CONSISTENT CHANGE

Consecutive Trial Comparisons	Group	Majority of Increases	Majority of Decreases	No Change	Total
1-2,2-3...7-8	D1T1	1	2	0	3
2-3,4-5,6-7	D1T2	1	2	0	3
4-5	D1T4	1	1	1	3
	Total D1	3	5	1	9
1-2,2-3...7-8	D2T1	1	1	1	3
2-3,4-5,6-7	D2T2	0	3	0	3
4-5	D2T4	2	1	0	3
	Total D2	3	5	1	9
1-2,2-3...7-8	D4T1	0	2	1	3
2-3,4-5,6-7	D4T2	1	2	0	3
4-5	D4T4	0	3	0	3
	Total D4	1	7	1	9
Grand Total		7	17	3	27

TABLE X

NUMBER OF SUBJECTS IN EXPERIMENT I WHOSE THRESHOLD VALUES FOR CONSECUTIVE TRIALS, MASSED WITH RESPECT TO DAYS BETWEEN SESSIONS FOR EACH CONDITION, SHOWED A MAJORITY OF INCREASES, A MAJORITY OF DECREASES, AND NO CONSISTENT CHANGE

Consecutive Trial Comparisons	Group	Majority of Increases	Majority of Decreases	No Change	Total
1-2,2-3...7-8	D4T1	0	2	1	3
1-2,3-4,5-6...7-8	D4T2	2	1	0	3
1-2...3-4,5-6...7-8	D4T4	2	0	1	3
Total	D4	4	3	2	9
1-2,2-3...7-8	D2T1	1	1	1	3
1-2,3-4,5-6,7-8	D2T2	2	1	0	3
1-2...3-4,5-6...7-8	D2T4	1	1	1	3
Total	D2	4	3	2	9
1-2,2-3...7-8	D1T1	1	2	0	3
1-2,3-4,5-6,7-8	D1T2	2	1	0	3
1-2...3-4,5-6...7-8	D1T4	1	2	0	3
Total	D1	4	5	0	9
Grand Total		12	11	4	27

II (Grant, 1956) are presented in Table XI. Here as in Experiment I, caution must be exercised in the interpretation of this table since the assumption of homogeneity of variance for groups within the same trial may be violated. Table XII presents the ranges and means for each group at each trial. As in the initial experiment, the ranges are seen to vary for groups of the same trial. And since wide differences hold for some trials and not for others, no transformation of the data was performed.

As indicated in Table XI, neither the over-all trend or any of its components were significant. In other words, the mean threshold value for the twelve Ss did not change significantly from Trial 1 to Trial 8 in any direction. Another point of interest is the high reliability of the measure as indicated by the significant differences between individual means. The quartric comparisons of the differences between group trend are all significant but interpretation is extremely difficult at this level. The quartric differences are not apparent in the graphical representation of the mean threshold values over trials as a function of days between sessions, as depicted in Figure 6. The oscillating curve DT1 in Figure 5 however, appears to be primarily quartric in shape, and quite different in this respect from curve DT4. The psychological significance of this deviation remains obscure.

Examination of the consistency of the effects of the

TABLE XI

SUMMARY OF ANALYSIS OF TRENDS OF CODED THRESHOLD VALUES FOR EXPERIMENT II

Source of Variation	df	Mean Square	F
A. Over-all Trend	7	2.3836	1.22
1. Linear	1	5.9475	1.77
2. Quadratic	1	7.4436	2.58
3. Cubic	1	0.0038	0.00
4. Quartic	1	0.0414	0.04
5. Higher Order	3		
B. Between Group Means	3	24.8221	0.94
a. Trials	1	69.1901	2.63
b. Days	1	5.2734	0.20
c. Interaction	1	0.0027	0.00
C. Between Group Trends	21	3.2843	1.67
1. Linear	3	5.7009	1.70
a. Trials	1	0.0150	0.00
b. Days	1	14.7601	4.39
c. Interaction	1	2.3275	0.69
2. Quadratic	3	3.7812	1.31
a. Trials	1	10.6459	3.68
b. Days	1	0.4922	0.17
c. Interaction	1	0.2055	0.07
3. Cubic	3	3.0001	2.46
a. Trials	1	6.0248	4.94
b. Days	1	1.2369	1.01
c. Interaction	1	1.7386	1.42
4. Quartic	3	5.5492	4.70*
a. Trials	1	9.5774	8.11*
b. Days	1	7.0431	5.96*
c. Interaction	1	0.0271	0.02
5. Higher Order	9		
D. Between Individual Means	8	26.2813	13.53**
E. Between Individual Trends	56	1.9420	
1. Linear	8	3.3611	
2. Quadratic	8	2.8907	
3. Cubic	8	1.2205	
4. Quartic	8	1.1809	
5. Higher Order	24		
Total	95		

* Significant at 5% confidence level
** Significant at 1% confidence level

TABLE XII

MEANS AND RANGES OF THE CODED THRESHOLD VALUES ACROSS TRIALS BY GROUP IN EXPERIMENT II

Group		1	2	3	4	5	6	7	8
D1T1	Mean	5.3	6.7	5.8	3.7	4.7	5.5	4.8	4.2
	Range	0.5	2.0	1.5	2.0	6.0	3.0	3.5	2.0
D4T1	Mean	5.7	5.8	4.3	5.2	6.7	6.3	5.5	4.8
	Range	2.0	4.0	4.0	8.5	8.0	5.0	6.0	5.0
D1T4	Mean	5.3	4.7	3.3	3.5	2.2	2.3	2.2	3.5
	Range	2.5	2.0	4.0	4.0	2.5	3.0	2.5	2.0
D4T4	Mean	4.5	2.8	3.7	3.7	4.7	2.2	3.8	5.8
	Range	3.0	4.0	4.5	4.5	6.5	3.0	5.5	5.5
Grand Mean		5.2	5.0	4.3	4.0	4.5	4.1	4.1	4.6

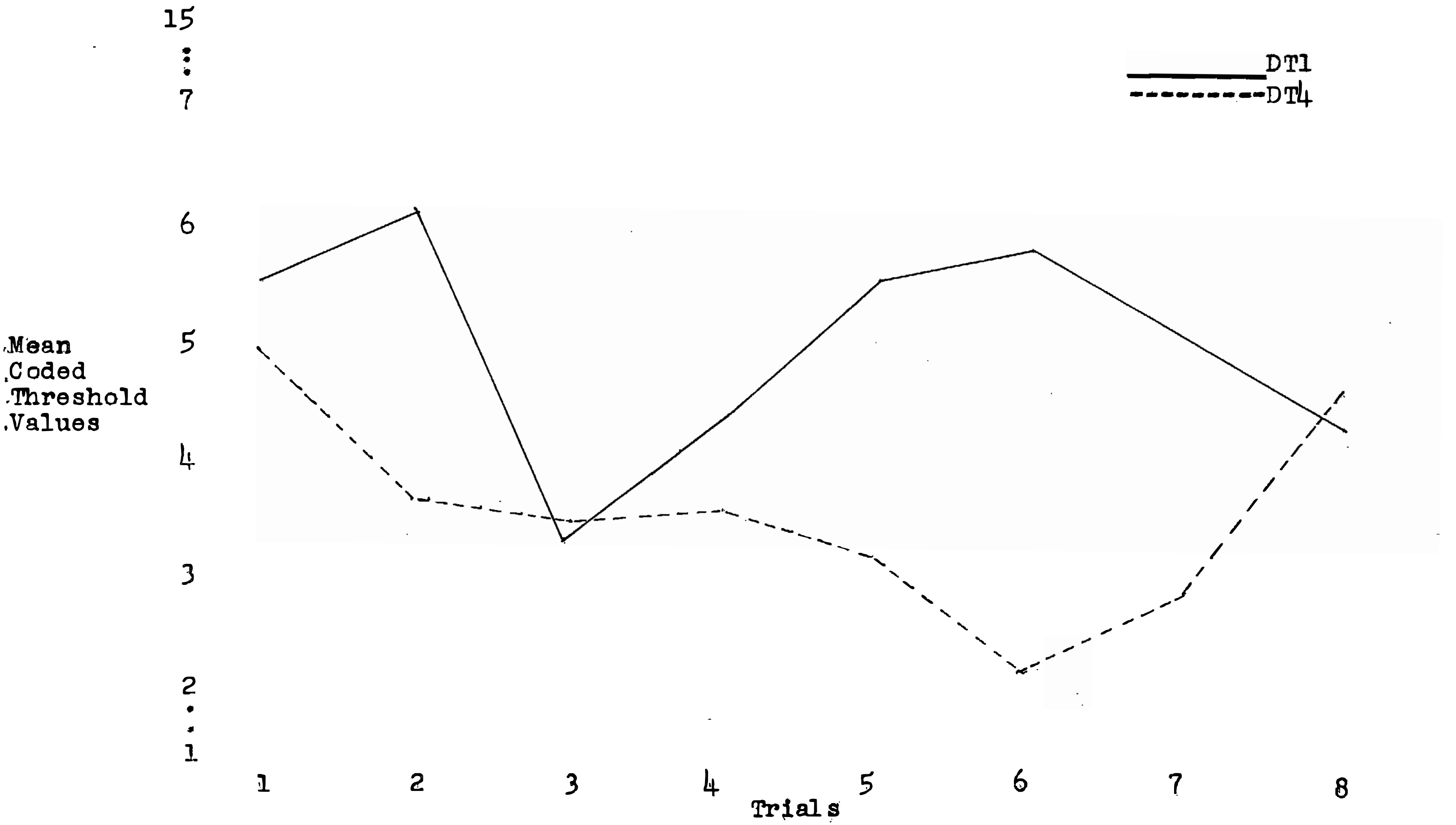

Figure 5. Mean coded threshold values across trials for one and four trials per session in Experiment II.

TABLE XIII

NUMBER OF SUBJECTS IN EXPERIMENT II WHOSE THRESHOLD VALUES INCREASED, DECREASED, AND REMAINED UNCHANGED FROM TRIAL 1 TO TRIAL 8 FOR ONE AND FOUR TRIALS PER SESSION

Trials per Session	Group	Increase	Decrease	Change	Total
4	D1T4	1	2	0	3
	D4T4	2	1	0	3
Total		3	3	0	6
1	D1T1	0	2	1	3
	D4T1	1	1	1	3
Total		1	3	2	6
Grand Total		4	6	2	12

TABLE XIV

NUMBER OF SUBJECTS IN EXPERIMENT II WHOSE THRESHOLD VALUES INCREASED, DECREASED, AND REMAINED UNCHANGED FROM TRIAL 1 TO TRIAL 5 FOR ONE AND FOUR TRIALS PER SESSION

Trials per Session	Group	Increase	Decrease	No Change	Total
4	D1T4	0	3	0	3
	D4T4	2	1	0	3
Total		2	4	0	6
1	D1T1	1	2	0	3
	D4T1	2	1	0	3
Total		3	3	0	6
Grand Total		5	7	0	12

trials per session variable, as indicated in Tables XIII and XIV, reveals no significant differentiation for this variable. Similar improvement was shown for Ss at both levels of trials per session from Trial 1 to Trial 8 and from Trial 1 to Trial 5. The total number of Ss whose threshold values increased, decreased, and remained unchanged for eight and five trials is also presented. Although both comparisons are in the direction of increased sensitivity over trials, neither is significant. The similarity of the two totals for the two tables suggests that little improvement occurred from Trial 5 to Trial 8. The mean trial values of Table XII support this contention.

The trial to trial breakdown for massed and spaced distribution of trials in Experiment II is presented in Tables XV and XVI. Again no significant differentiation exists although most Ss with more than one trial per session showed increases in threshold values for consecutive trials within the same session. Most Ss under conditions of one trial per session show the opposite effect. Also, as Table XV indicates, most Ss showed improvement for consecutive trials over two sessions.

The Effects of Days Between Sessions

As indicated above, only the quartric comparison of the differences between group trends was significant for the variable of days between sessions. Examination of the

TABLE XV

NUMBER OF SUBJECTS IN EXPERIMENT II WHOSE THRESHOLD VALUES FOR CONSECUTIVE TRIALS, SPACED WITH RESPECT TO TRIALS PER SESSION FOR EACH CONDITION, SHOWED A MAJORITY OF INCREASES, A MAJORITY OF DECREASES, AND NO CONSISTENT CHANGE

Consecutive Trial Comparisons	Group	Majority of Increases	Majority of Decreases	No Change	Total
4-5	D1T4	0	3	0	3
4-5	D4T4	1	1	1	3
	Total T4	1	4	1	6
1-2,2-3...7-8	D1T1	1	2	0	3
1-2,2-3...7-8	D4T1	0	3	0	3
	Total T1	1	5	0	6
Grand	Total	2	9	1	12

TABLE XVI

NUMBER OF SUBJECTS IN EXPERIMENT II WHOSE THRESHOLD VALUES FOR CONSECUTIVE TRIALS, MASSED WITH RESPECT TO TRIALS PER SESSION FOR EACH CONDITION, SHOWED A MAJORITY OF INCREASES, A MAJORITY OF DECREASES, AND NO CONSISTENT CHANGE

Consecutive Trial Comparisons	Group	Majority of Increases	Majority of Decreases	Change	Total
1-2,2-3...7-8	D1T1	1	2	0	3
1-2,2-3...7-8	D4T1	0	3	0	3
Total	T1	1	5	0	6
1-2...3-4,5-6...7-8	D1T4	1	1	1	3
1-2...3-4,5-6...7-8	D4T4	2	1	0	3
Total	T4	3	2	1	6
Grand Total		4	7	1	12

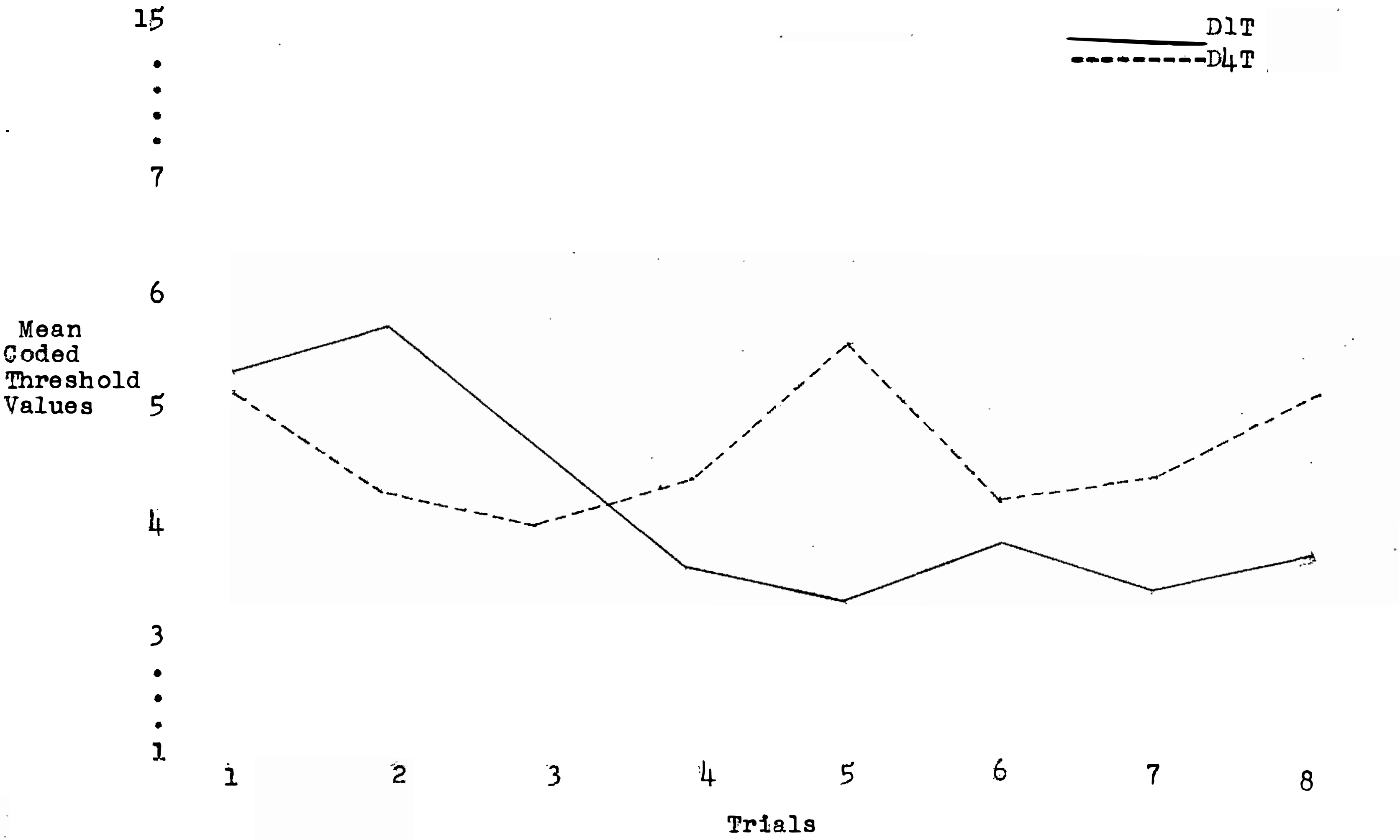

Figure 6. Mean coded threshold values across trials for one and four days between sessions in Experiment II.

TABLE XVII

NUMBER OF SUBJECTS IN EXPERIMENT II WHOSE THRESHOLD VALUES INCREASED, DECREASED, AND REMAINED UNCHANGED FROM TRIAL 1 TO TRIAL 8 FOR ONE AND FOUR DAYS BETWEEN SESSIONS

Days Between Sessions	Group	Increase	Decrease	Change	Total
1	D1T1	0	2	1	3
	D1T4	1	2	0	3
Total		1	4	1	6
4	D4T1	1	1	1	3
	D4T4	2	1	0	3
Total		3	2	1	6
Grand Total		4	6	2	12

TABLE XVIII

NUMBER OF SUBJECTS IN EXPERIMENT II WHOSE THRESHOLD VALUES INCREASED, DECREASED, AND REMAINED UNCHANGED FROM TRIAL 1 TO TRIAL 5 FOR ONE AND FOUR DAYS BETWEEN SESSIONS

Days Between Sessions	Group	Increase	Decrease	No Change	Total
1	D1T1	1	2	0	3
	D1T4	0	3	0	3
Total		1	5	0	6
4	D4T1	2	1	0	3
	D4T4	2	1	0	3
Total		4	2	0	6
Grand Total		5	7	0	12

TABLE XIX

NUMBER OF SUBJECTS IN EXPERIMENT II WHOSE THRESHOLD VALUES FOR CONSECUTIVE TRIALS, SPACED WITH RESPECT TO DAYS BETWEEN SESSIONS FOR EACH CONDITION, SHOWED A MAJORITY OF INCREASES, A MAJORITY OF DECREASES, AND NO CONSISTENT CHANGE

Consecutive Trial Comparisons	Group	Majority of Increases	Majority of Decreases	No Change	Total
1-2,2-3...7-8	D1T4	1	2	0	3
4-5	D1T4	0	3	0	3
Total	D1	1	5	0	6
1-2,2-3...7-8	D4T1	0	3	0	3
4-5	D4T4	1	1	1	3
Total	D4	1	4	1	6
Grand Total		2	9	1	12

TABLE XX

NUMBER OF SUBJECTS IN EXPERIMENT II WHOSE THRESHOLD VALUES FOR CONSECUTIVE TRIALS, MASSED WITH RESPECT TO DAYS BETWEEN SESSIONS FOR EACH CONDITION, SHOWED A MAJORITY OF INCREASES, A MAJORITY OF DECREASES, AND NO CONSISTENT CHANGE

Consecutive Trial Comparisons	Group	Majority of Increases	Majority of Decreases	No Change	Total
1-2,2-3...7-8	D4T1	0	3	0	3
1-2...3-4,4-5...7-8	D4T4	2	1	0	3
Total	D4	2	4	0	6
1-2,2-3...7-8	D1T1	1	2	0	3
1-2...3-4,4-5...7-8	D1T4	1	1	1	3
Total	D1	2	3	1	6
Grand Total		4	7	1	12

effects of this variable in influencing the consistency of the results of Experiment II reveals insignificant trends in a rather unexpected direction. As Tables XVII and XVIII indicate, most _S_s under massed conditions of days between sessions decreased in threshold over eight and five trials respectively, while _S_s under the spaced conditions showed the opposite effect.

In the analysis of consecutive trial changes for spaced conditions, as presented in Table XIX, no differentiation was found for the variable of days between sessions. Most _S_s under both conditions show decreases in threshold. The trial to trial correlate of the results of Table XVII are presented in Table XX and again, an increase in threshold was found for the majority of _S_s under massed consecutive trials.

A Comparison of Experiment I and II

Although the results of the two experiments differ in many respects, both show a learning effect from Trial 1 to Trial 8 on a magnitude and consistency basis. Only the changes for the first experiment, however, are significant. Further consistency is seen in the significant differences between individual means, indicating high reliability for the measures in both experiment.

The analysis of differences between group trends shows little consistency between experiments, with different components attaining significance for the two experiments. The analysis of differences between group means and its components proved insignificant for both experiments.

In the consistency analysis of the effects of trials per session, little differentiation was found in either experiment for comparisons of Trial 1 and Trial 5 or Trial 1 and Trial 8. In both experiments however, the major portion of the learning occurred by Trial 5.

The trial to trial analysis for spaced distribution of trials revealed no differentiation with Ss at all levels of trials per session showing increased sensitivity for both experiments. The same comparison for massed trials showed that most Ss decreased in sensitivity for consecutive trials within the same session while increases were found for most Ss for trial to trial comparisons involving two sessions. This adaptation effect, however, was not significant for either experiment.

The consistency analysis of the effects of days between sessions revealed insignificant findings for both experiments for the comparison of Trial 1 with Trial 5 and Trial 8.

The consecutive massed trial analysis showed insignificant interaction between trials per session and days between sessions for both experiments. Insignificant differentiation was also found for changes in consecutive spaced trials with respect to days between sessions for the two experiments.

CHAPTER IV

DISCUSSION

In comparing the results of the present study with the empirical literature of perceptual learning, several areas of agreement are evident. As indicated in Chapter I, the finding of improvement in perceptual judgments as a result of practice has been substantiated in a number of diverse settings. Of the sense modalities investigated, improvement was found in vision, audition, gustation and touch. That these findings also hold for olfaction is therefore not surprising.

Another area of agreement concerns the function relating amount of practice and improvement in perceptual judgments. Of the few experiments relating to this topic in which learning curves were plotted (Bevan & Zener, 1952; Howes and Solomon, 1951; Seward, 1931), a gradual continuous increase in improvement was generally found. The present study, and Experiment I in particular, are in close agreement with this general finding. The evidence that the curves for both experiments were negatively accelerated, may be important in clarifying the lack of agreement of direction of acceleration among the aforementioned studies.

Of particular interest to the present study is the empirical evidence for the effects of distribution of practice on perceptual judgment. The one study investigating the effects of this variable (Lewis, 1908) reported positive results. Distributed practice on alternate days accelerated the rate of decrease of the Muller-Lyer illusion. In the present study, both variables of distribution of practice failed to significantly differentiate learning for a variety of consistency and magnitude analyses. In light of the Lewis study and the multitude of positive results of the effects of distribution of practice on learning, further consideration will be given to this lack of differentiation.

One possibility is that the extreme distribution of trials were too spaced to influence performance in a positive direction. It seems likely that Ss reporting to an experiment over a period of twenty-nine days (Group D4T4) will show a decrease in motivation as the period progresses. Also, the routine of eight threshold determinations is not conducive to subject interest. Possibly then, because of the extreme periods of time characterizing the spaced trials, augmented by the routineness of the task, distribution of trials failed to differentiate performance. Certainly further research is called for in this area before any definitive conclusion can be drawn.

Consideration of the effects of massing of trials on adaptation has been shown in a study by Pfaffman and

Schlosberg (1953). These authors report no decrease in sensitivity to taste differences over a forty minute session of testing. These results are not supported by the present investigation. As indicated in Table VIII, six of nine Ss showed a majority of increases in threshold for consecutive trials of a session consisting of two trials. The testing time for a two-trial session is approximately twenty-seven minutes. The two results are not necessarily in conflict since olfaction and gustation may very well differ in their rates of adaptation.

Of particular theoretical importance is the contribution of the present study to a better understanding of the nature of perceptual learning. In Chapter I the relevancy of the present experiment to the two principal theoretical positions in perceptual learning was discussed in detail. The Gibson hypothesis specifically states that perceptual learning consists of responding to variables of stimulation not previously responded to (Gibson & Gibson, 1956a). It was suggested that since the learning task in the present experiment only involved one variable of stimulation, negligible learning should occur according to this hypothesis. However this assumption of the operation of only one variable of stimulation may be entirely erroneous. Consequently the results will be considered to be only suggestive in their relevance to this theoretical issue.

The rival theoretical position in perceptual learning is represented by Postman (1953), who adheres to traditional associationist theory and contends that perceptual learning is no different from any other learning. This position would predict improved performance as long as differential reinforcement was present, which was the case in the present experiment.

On the premise that only one variable of stimulation was operating, the results clearly favor the Postman position. The lack of differentiation for the two variables of distribution of practice, however, somewhat confuses the issue. If perceptual learning is no different from any other learning, why was there no differentiation on the basis of distribution of practice, a variable that effects a huge number of diverse learning situations? The possibility of a decrease in motivation for the spaced trial conditions has been offered to account for these findings but it may be that perceptual learning, or more specifically, sensory learning, is not influenced by distribution of practice. In this sense it may differ from learning in general.

Another consideration in connection with this theoretical discussion is the forced-choice technique utilized in the threshold determinations. One characteristic of this technique is that <u>S</u> is free to sniff the odorants in a wide variety of ways. He can sniff the odorant with both nostrils, simultaneously or consecutively, or use only one nostril. He can wave the test tube containing the stimulant beneath his nostrils or hold it stationary. He can control the depth of his inhalations. Because of this wide array of responses available to S, it seems possible that differential reinforcement would narrow the alternatives to the most successful ones. If this be the case, a replication of the present experiment under more controlled conditions should give a lesser learning effect, if any. On the other hand, no lessening of the learning effect would imply that the original learning was primarily a result of stimulus elaboration as advocated by the specificity hypothesis of Gibson and Gibson.

The fact that the present experiment failed to clearly differentiate between these two theoretical positions indicates the complexity of the subject matter and the vagueness of the theoretical formulations of a new area of scientific investigation.

CHAPTER V

SUMMARY AND CONCLUSIONS

Two experiments were performed, the second being a partial replication of the first, to determine the role of learning in olfactory sensitivity. The relation between the present study and the empirical and theoretical literature of perceptual learning was discussed with particular emphasis on the current theoretical controversy in this area involving the specificity hypothesis of Gibson and Gibson and the associationist doctrine of Postman.

The two variables of distribution of practice introduced were trials per session and days between sessions. All thirty-nine male subjects were tested over eight trials by a forced-choice technique. Iso-amyl acetate was employed as the odorant.

The results showed a general practice effect over eight trials for both experiments on a magnitude and consistency basis, but only the results for the first experiment were significant. No differentiation was found for the two variables of distribution of practice. The results revealed high reliability for the measures employed in both experiments. The experimental findings were discussed in relation to the pertinent empirical literature and close agreement was found on all comparisons except the effects of distribution of practice.

The significance of the results for perceptual learning theory was discussed and no definitive conclusions were drawn with respect to the Gibson and Gibson or Postman formulations.

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APPENDIX

TABLE XXI

CODED THRESHOLD VALUES ACROSS TRIALS FOR INDIVIDUAL SUBJECTS IN EXPERIMENT I

Group	S	Trial 1	2	3	4	5	6	7	8
D1T1	1	13.0	13.5	12.5	4.0	5.0	4.0	4.5	6.0
	2	6.5	5.5	4.0	3.0	3.0	4.5	2.0	2.0
	3	5.0	5.5	3.0	2.5	2.0	3.0	1.5	1.5
D2T1	4	6.5	3.5	6.5	3.5	4.0	3.0	4.5	6.0
	5	4.5	5.5	4.5	5.5	4.0	4.5	4.5	2.5
	6	2.5	1.0	1.5	1.5	2.5	2.5	1.5	1.0
D4T1	7	8.5	4.5	4.5	5.0	5.5	3.5	3.0	6.5
	8	6.5	4.5	4.5	3.5	4.5	4.5	6.0	5.5
	9	6.5	4.0	4.5	3.0	4.5	6.5	4.5	4.0
D1T2	10	8.0	11.5	11.5	11.0	10.5	11.5	8.0	10.5
	11	5.5	1.0	1.5	2.0	5.0	3.0	3.0	3.0
	12	2.5	5.0	3.0	4.0	3.5	7.0	5.0	4.5
D2T2	13	5.5	6.0	5.0	6.0	4.0	4.0	7.0	5.0
	14	11.0	11.0	12.5	11.5	7.0	3.5	2.5	3.0
	15	4.5	5.5	5.5	6.0	3.0	2.5	2.5	3.5
D4T2	16	4.5	1.5	2.5	2.0	3.0	4.0	3.5	1.5
	17	8.5	9.5	6.0	9.5	7.5	10.0	6.5	8.5
	18	5.0	6.5	5.0	6.0	7.0	5.0	4.0	4.5
D1T4	19	10.0	10.0	9.5	2.5	3.0	2.0	4.5	5.5
	20	3.5	2.0	2.0	2.0	2.0	2.0	2.0	2.0
	21	6.0	8.0	5.5	6.0	4.5	5.5	4.5	4.5
D2T4	22	2.0	2.5	3.5	1.5	5.5	4.0	2.0	1.5
	23	3.0	1.5	1.5	2.5	5.0	2.0	2.5	4.0
	24	9.5	11.5	11.0	6.5	4.5	3.5	5.0	6.0
D4T4	25	5.0	4.5	5.0	6.0	3.5	1.5	1.0	2.0
	26	5.0	6.5	9.0	8.0	2.5	3.5	3.0	3.5
	27	6.5	5.5	6.0	7.0	1.5	4.5	2.5	5.0

TABLE XXII

CODED THRESHOLD VALUES ACROSS TRIALS FOR INDIVIDUAL SUBJECTS IN EXPERIMENT II

		Trial							
Group	S	1	2	3	4	5	6	7	8
D1T1	28	5.0	5.5	6.5	4.5	4.0	4.5	7.0	3.5
	29	5.5	7.0	6.0	2.5	2.0	4.5	3.5	3.5
	30	5.5	7.5	5.0	4.0	8.0	7.5	4.0	5.5
D4T1	31	6.0	4.5	2.5	2.0	3.5	5.0	3.0	2.5
	32	4.5	4.5	4.0	3.0	5.0	4.5	4.5	4.5
	33	6.5	8.5	6.5	10.5	11.5	9.5	9.0	7.5
D1T4	34	6.5	3.5	1.0	1.5	1.0	1.0	1.0	2.5
	35	4.0	5.0	4.0	5.5	3.5	4.0	3.5	4.5
	36	5.5	5.5	5.0	3.5	2.0	2.0	2.0	3.5
D4T4	37	3.5	2.5	5.5	5.5	4.5	4.0	7.0	8.0
	38	3.5	1.0	1.0	1.0	1.0	1.0	1.5	2.5
	39	6.5	5.0	4.5	4.5	7.5	1.5	3.0	7.0