THE EFFECTS OF CERTAIN REINFORCEMENT VARIABLES UPON THE PERFORMANCE OF NORMAL AND MENTALLY RETARDED ELEMENTARY SCHOOL CHILDREN IN A PROBABILITY LEARNING SITUATION

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CHAPTER I

THE PROBLEM

Purpose of the Study

During the two preceding decades, psychologists have devoted a good deal of time and effort to the study of probabilistic learning phenomena. By 1951 there had appeared a number of attempts to formulate theories of behavior in terms of probability mathematics, e.g., a Poisson model for application to measures of conditioning (Mueller, 1950), Miller and Frick's (1949) information theory, a stochastic behavioral model (Bush and Mosteller, 1951), and a "Statistical-Association" model (Estes, 1950). The pertinent experiments which antedated and were subsequent to each of these models had primarily used college students and infra-human organisms as subjects and seem to have yielded remarkably reliable results. It would be of interest to determine whether results similar to those found with these populations might also be obtained when other subject-populations are utilized. The purpose of this study, therefore, was to investigate the performances of Normal and Mentally Retarded elementary school children in a probabilistic learning situation and to interpret their behavior within the context of one of the probabilistic models, Statistical Learning Theory (SLT).

Background to the Study

At the time of the initial formulation of Statistical Learning Theory, a number of existing theories (e.g., Hull, 1943) were finding it difficult to account for the observed variability in the performances of experimental subjects in learning situations. Such performance is represented graphically by a curve with a negative acceleration to a stable asymptotic level. However, several investigators had pointed out that this graphic function may be an experimental artifact, i.e., that certain procedures for combining data may distort the picture of acquisition. For one thing, the typical performance of individual subjects is irregular, often indicating instantaneous changes from near-maximum levels of responding, or yielding apparently inexplicable cessations of response during what would appear to be the typical course of acquisition (Guttman and Estes, 1956). A second type of difficulty with these curves is that it has been shown that the curve depicting group performance usually differs somewhat from curves of individual Ss (Bakan, 1954; Estes, 1956; Sidman, 1952). For those theorists interested in the exact description of the learning process, these problems are quite serious since the learning curve is assumed to include those functions thought to represent learning.

The typical curve has been interpreted to imply that learning is a "deterministic growth process" (Graham and Gagne, 1957; Gulliksen, 1943; Hull, 1943). Such an interpretation implicitly suggests that learning is a positive growth function, i.e., that learning increases in given increments contingent upon the presence or absence of some variable, e.g., reinforcement, reward, etc., in the presence of a constant complex of stimuli. This hypothesis, although consistent with an interpretation of group curves, would not predict individual variations.

There are, obviously, alternate assumptions that can be made regarding the nature of learning. It could be assumed, for example, that learning is statistical in nature, i.e., that responses are elicited upon one occurrence of stimuli and that the stimulus side of learning is composed of many discrete stimuli whose effective occurrence is variable. If there were stimulus fluctuation, individual performance would be expected to vary, since it is the nature of the statistical process that exceptions are bound to occur within a sampling process. Thus, the typical smooth performance curve would be the result of averaging the individual Ss behavior.

Beginning with the assumption that learning is essentially statistical in nature, Estes has presented a series of mathematical models (which, when considered together, comprise Statistical Learning Theory) whose underlying assumptions and orienting attitudes are very similar to Gutherie's contiguity approach to learning (Gutherie, 1935). Thus, the "Statistical-Association Model" (so called by Hilgard, 1956, p. 389) maintains that learning is complete in a single trial, i.e., stimuli and responses are connected during a single pairing. The dependent variable within this system is taken to be response probability, and the major theoretical constructs are learning, response class, stimulus event, and reinforcement.

Statistical Learning Theory considers response variables in the following manner: behaviors to be considered in a given situation are categorized into mutually exclusive and exhaustive response classes on the basis of objective criteria. Response does not refer to any physiologically or anatomically defined unit but, rather, to classes of overt, observable activities.

The stimulus complex is assumed to consist of a finite population of relatively independent environmental events which are determined by the experimental situation. At any one time, only a portion of these stimulus elements are effective (i.e., occur). Every element is considered to be equally likely to occur on a given trial, with the occurrence of one element being independent of the probability of occurrence of every other element. The proportion of elements that occur on any trial is defined as being equal to θ, and the proportion not occurring is equal to $1 - \theta$.

The term reinforcement is regarded as a convenient label for those procedures which either elicit novel responses in a stimulus situation or which "protect" newly formed stimulus-response associations by removing the stimuli before interfering responses are elicited. The symbol π is used to represent the percentage of times in a series of trials that a given reinforcement will appear and, thus, the probability of the occurrence of this reinforcement for a given trial.

Learning refers to those changes in response probabilities which cannot be entirely reversed without additional exposure to the experimental situation. These changes are conceptualized in terms of probabilistic relations between operationally defined response classes and operationally defined classes of stimuli. Learning is assumed to occur on an "all-or-none" basis, relative to aspects of the stimulus complex which occur on a given trial.

The basic theoretical dependent variable in this system, the probability of occurrence of any given response class, is defined as the average frequency of occurrence of members of a response class relative to the maximum possible frequency in a given situation.

The essentials of the theory are as follows: The experimental situation is regarded as consisting of a finite population of stimulus elements, a proportion, θ, of which is effective, or sampled, on any given trial. Subsequent to trial 1, the stimulus samples that occur will consist of some elements which were previously conditioned to a given response and some which were not. After a number of trials, the portion of elements occurring on a trial which are not connected to the response will decrease, until all elements in the population have been conditioned to a response.

Consider a situation in which, following a signal, one or the other of two reinforcing events, E_1 and E_2, occurs with the probability of occurrency for any trial being π and $1 - \pi$, respectively. The classes of responses available to the subject are classified as A_1 (anticipating an E_1 event), and A_2 (anticipating an E_2 event). The subject is conceived of as sampling from the population of stimulus elements each time a response is made. The proportion of stimuli sampled, or effective, on any trial is equal to θ, and those elements in the complex not effective at a particular time may be represented by $1 - \theta$.

On each trial, the stimulus elements present at the time the response occurs become connected to that response. Reinforcements serve to elicit new responses in a stimulus situation, and to protect those stimulus-response connections already formed, by removing the stimuli before incompatible responses can be elicited. Each element in the stimulus population is connected to (i.e., tends to elicit) either an A_1 or an A_2 response. Therefore, the subject's behavior on any trial will be determined by the proportion of the elements in the sample that are connected to A_1 responses. Further, when an E_1 reinforcing event occurs, it elicits from the subject responses compatible with making A_1 responses (the same is true for the occurrence of E_2 events), and all stimulus elements sampled on that trial become connected with A_1 (or A_2) responses.

If an E_1 event occurs on trial N, the probability that response A_1 will be made on trial N + 1 is stated according to the equation

$$P(n+1) - P(n) = \theta\,[1 - P(n)]\,. \tag{1}$$

Thus, the increase in probability per trial is a constant fraction of the amount remaining to be learned, $1 - P(n)$ being the difference between total A_1 responding and the present probability. If E_2 occurs, the probability of predicting E_1 diminishes according to the equation

$$P(n+1) - P(n) = -\theta P(n). \qquad (2)$$

The above equations precisely state the assumption that the probability of repeating one of a pair of alternative response classes increases with occurrences and decreases with non-occurrences of the given reinforcing event.

If E_1 and E_2 occur with fixed probabilities, but in a random sequence, it is possible to combine equations (1) and (2) and derive an equation which yields the expected changes in the probability of making an A_1 response from one trial to the next

$$P(n+1) - P(n) = \theta [\pi - P(n)] . \qquad (3)$$

The probability of making an A_1 response on any given trial (from trials 0 to N) is stated

$$P(n) = \pi - [\pi - P(o)] \quad (1-\theta)^{n-1}. \qquad (4)$$

It can be seen in the last equation that, as the number of trials increases, the second term of the equation, $(1-\theta)^{n-1}$, approaches zero since the exponent n-1 increases, the equation becomes

$$P(n) = \pi . \qquad (5)$$

Reading the last equation, it is apparent that the mean probability of making an A_1 response on trial N is equal to the probability of the occurrence of an E_1 reinforcing event. Thus, over a series of trials, the group-mean probability that an A_1 response will occur on a given trial is equal to the probability that an E_1 reinforcing event will occur on that trial. It can also be seen that π, in addition to representing the percentage of times in the series of trials that the E_1 reinforcement occurs, also corresponds to the mean asymptotic performance level. Further, θ, which symbolizes the proportion of elements sampled or effective on a given trial, also indicates the slope of the learning curve, or the rate of approach to asymptote.

To briefly summarize Estes' probabilistic learning theory, the model pertains only to the performance of subjects in the "probabilistic learning situation," and generally states that frequency of occurrence of a specified class of responses will numerically approximate the frequency of occurrence of a particular class of reinforcements. There are a number of aspects of the model that appear to need clarification, and for which empirical and theoretical expositions are not readily apparent. These will be discussed in the following paragraphs.

Perhaps the major point in Statistical Learning Theory that is difficult to interpret is what exactly the model means by "probabilistic learning situation." The learning situation most frequently referred to as being "probabilistic" typically consists of requiring the subject(s) to predict on each trial whether a particular event (reinforcing) will occur, or, predicting which of two or more events will occur on a given trial. Obviously, there is a large number of such situations, but apparently not all of these can be considered as "probabilistic learning situations" within the Estes framework. On the basis of published literature, one must conclude that the Humphrey's type guessing situation, or some marginal variation of it, represent the most acceptable probabilistic learning paradigm for the use of human subjects. As will be evident in the following chapter, the literature indicates that the more the deviation from the Humphrey paradigm, the lower the probability of obtaining results predicted by Statistical Learning Theory.

A second vague aspect of Estes' model is in regard to the concept of "stimuli." The theory states that the population of relevant stimuli is experimentally defined by the nature of the task. Further, certain, and apparently unknowable, proportions of these stimuli are "connected" to each of the experimentally defined classes of responses, prior to the onset of the experiment! These stimuli, or as Estes (1959) states, "stimulus elements," are randomly sampled by the subject on each trial, so that in each sample there are elements which would elicit each of the classes of responses.

It is recognized that Estes treats the above statements as premises, i.e., untestable assumptions that must be accepted, and that testable hypotheses are derived from them. However, the available theoretical rationale is, at a minimum, somewhat confusing and questionable, and certainly needs clarification.

There are, perhaps, other aspects of the model that presently are insufficiently discussed. These include the mechanism of reinforcement, the nature of the reinforcing stimuli, and the rationale for the concept of θ. In regard to the θ variable, it will be shown in later chapters that the quantification of θ is questionable on a conceptual basis, and that previous attempts have yielded unreliable results.

In spite of these confusing aspects of the model, there remains a considerable number of hypotheses that may be subjected to the experimental test. A number of these are considered in this study.

Statement of the Present Problems

Statistical Learning Theory predicts that, in a situation where one of two reinforcing events occurs with a fixed probability in a random sequence, the frequency with which subjects anticipate the occurrence of the reinforcement numerically approximates its actual occurrence. Evidence supporting this prediction to date has been obtained from a small number of subject-populations, almost all of which performed in the "Humphrey's type" guessing situation. The present experiment was concerned with certain aspects of Statistical Learning Theory which have not received adequate attention.

The general method of this study was to provide a probabilistic learning situation in which it would be possible to test a number of assumptions and hypotheses derived from Estes' model. These assumptions and hypotheses pertained to two general classes of variables, Subjects and Reinforcements. Concerning reinforcement variables, attention was focused upon both Conditions of Reinforcement and Reinforcement Magnitudes. These variables will be discussed in the following paragraphs.

Subject Variables: Little evidence is available concerning Estes' assumption that the probabilistic matching phenomenon occurs for all types of subjects. Generally, only two types of subject-populations have been utilized to an appreciable extent, college students and rats.

One of the purposes of the present experiment was to obtain data from two additional populations, young normal and institutionalized mentally retarded children. To this end, a group of normal youngsters were selected from among students in an elementary school, and a group of retarded children were obtained from educable special educational classes of the Austin State School.

Reinforcement Conditions: In previous studies, an operationally defined reinforcing event occurred on each trial in the probabilistic learning situation. The reinforcing stimulus always occurred, in spite of the subject's initial response on a given trial, so that the occurrence of the reinforcement was not contingent upon a particular response by the subject. It was assumed that the reinforcement served to increase the probability that those stimulus and response elements present during the reinforcing event would become connected. Thus, if a reinforcement did not occur on a given trial, the probability that stimuli and responses would become connected would decrease, and learning would be slower. Stated another way, subjects for whom a reinforcement occurs on each trial should approach asymptotic performance more rapidly than subjects for whom a reinforcing stimulus does not occur on all trials.

The present experiment was designed so as to utilize two conditions of reinforcement; within one condition, Contingent, the occurrence of the reinforcement is dependent upon a specific initial response by the subject, while in the second condition, Indeterminant Condition, the reinforcing event occurs regardless of the subject's initial response. Thus, it was possible to compare the rates of approach to asymptotic levels of subjects receiving reinforcements on each trial as opposed to subject's occasionally receiving no reinforcement. Obviously, condition of reinforcement refers to frequency of reinforcement.

Reinforcement Magnitudes: The theoretical interpretation of reinforcement suggests that the level of asymptotic performance is partially dependent upon the magnitude of the reinforcing event. That is, as the magnitude of reinforcement increases, the level of asymptotic responding increases. However, empirical support for this assumption is not evident.

The present study was, in part, designed to test this assumption. Operationally defined High Magnitude Reinforcements (HMR) and Low Magnitude Reinforcements (LMR) were determined in a pre-experimental setting, and were mediated to subjects performing in the probabilistic learning situation in order to investigate the hypothesized relationship between reinforcement magnitude and asymptotic responding.

In summary, this experiment was concerned with the following factors: (1) A comparison of the probabilistic performance of Normal and Mentally Retarded children; (2) the differential effects, if any, of Contingent and Indeterminant Conditions of reinforcement; and (3) the differential effects, if any, of two magnitudes of reinforcement upon asymptotic response levels.

<u>Statement of Hypotheses</u>

Three sets of hypotheses were formulated on the basis of the Statistical Learning Theory and on the basis of previous empirical data. The first set concerned the effects of the independent variables upon the mean frequencies of selection of the reinforcing stimulus for all trials. These hypotheses were:

(1) Normals will select the reinforcing stimulus significantly more than Retardates;

(2) Subjects performing in the Indeterminant Condition will select the reinforcing stimulus significantly more frequently than subjects performing in the Contingent Condition; and

(3) Subjects receiving HMR will select the reinforcing stimulus significantly more than subjects receiving LMR.

The second set of hypotheses concerned a comparison of the obtained asymptotic performances associated with the independent variables. These hypotheses were:

(1) The asymptotic performances of Normal and Retarded subjects will not significantly differ;

(2) The asymptotic performances associated with Contingent and Indeterminant conditions will not significantly differ; and

(3) The asymptotic performance associated with HMR will be significantly greater than the asymptotic performance associated with LMR.

The final set of hypotheses concerned the comparison of obtained and predicted asymptotic performance levels. These hypotheses were:

(1) The obtained asymptotes of both Normal and Retarded subjects will not significantly differ from predicted asymptotes;

(2) The obtained asymptotes associated with both Contingent Indeterminant Conditions will not significantly differ from predicted asymptotes;

(3) The obtained asymptote associated with HMR will not significantly differ from the predicted asymptote; and

(4) The obtained asymptote associated with LMR will differ significantly from the predicted asymptote.

CHAPTER II

REVIEW OF THE LITERATURE

Since the appearance of Estes' probabilistic model, there have been numerous attempts to experimentally evaluate Statistical Learning Theory. Many of the initial studies were concerned with evaluating the theoretical constructs in order to expand or revise the model. Later studies primarily were attempts to test assumptions and hypotheses derived from the model.

The following paragraphs contain a selective review of those studies evaluating the theoretical constructs, and of studies testing hypotheses derived from Statistical Learning Theory.

Evaluation of Theoretical Constructs

The theoretical constructs of major importance are θ and reinforcement. θ represented perhaps the major problem area within the model, and studies concerning this variable are reviewed first.

Conceptually, θ refers to the proportion of elements within the stimulus population which are sampled and are effective in eliciting a response at any given time. This suggests that, behaviorally, θ represents rate of increase in learning, either for individual subjects or for groups of subjects. Quantification of θ's in the former instance is a formidable, if not impossible task, since there are no known reliable methods with which one can assess individual stimuli in any situation. The problem is further complicated by the fact that, theoretically, θ is not solely dependent upon environmental fluctuations but is also somewhat determined by characteristics peculiar to a particular organism. Thus, it is necessary to derive θ values from the subjects' performance. Although it is possible to utilize statistical procedures (e.g., curve fitting) to accomplish this, by so doing one encounters the problem of circularity (i.e., θ is derived from a set of data which, in turn, it predicts). This problem may be partially circumvented by utilizing only a portion of the data (e.g., the initial acquisition trials) to predict subsequent performance.

A more desirable and critical test of the construct would be the determination of the extent of agreement between two estimates of θ derived by independent procedures of assessment. Two studies (Anderson and Grant, 1957; Estes and Straughan, 1954) reported results indicating a lack of agreement when θ's were estimated from the initial trials of mean acquisition curves and also from conditional relative frequencies of a given response class on trials following two types of reinforcements, whereas one study (Estes and Lauer, 1957) reported fairly close agreement between two such estimates.

In those studies demonstrating lack of agreement between the independent estimates of θ, the acquisition phase of the experiments had used massed-trial conditions. Although the studies were not relevant to

Statistical Learning Theory, several investigators (Collier, 1954; Verplanck, Collier, and Colten, 1952) have suggested that there is associated with massed-trial conditions a variable related to sequential behavioral effects. Estes and Straughan (1954) suggested that Statistical Learning Theory was, at that time, inadequate to account for massed-trial phenomena because, as Straughan (1953) reasoned, "...in massed trials there might be a certain amount of lag...in the stimulus sampling process, so that a stimulus element which has been sampled on a given trial would be more likely to be sampled on the following trial than an element which was not...." Estes and Lauer (1957) demonstrated, via an experiment in which there were both massed and spaced trial conditions for rats in a T-maze, that θ values computed from massed-trial data were unreliable, while those computed from spaced-trials were constant and correctly predicted asymptotic behavior. Similarly, for human Ss, when trials are massed, rate of learning increases over successive series (Estes and Straughan, 1954), but as spacing is increased this effect is reduced, and rate of learning is reliable from series to series (Estes, 1955).

In summary then, studies concerned with an evaluation of θ seem to indicate that the assessment of θ values is particularly difficult. Further, it is apparent that the computation of θ values is most appropriate when spaced-trial conditions are present, such as in some animal experimentation. Inasmuch as most experimental work with human subjects utilizes the massed-trial condition, concern with θ values does not seem to be indicated.

The second construct which has been subjected to a good deal of experimental attention is the construct of reinforcement. Within the Statistical Learning Model, nothing is said about why a particular event is reinforcing. The model only states the effect of a reinforcement (e.g., an event which increases the probability of the occurrence of a response is said to be reinforcing). There is a considerable body of research indicating a number of events that were reinforcing in certain situations, e.g., flashing lights (Anderson and Whalen, 1960), "verbal praise" (Humphreys, 1939), food (Estes and Lauer, 1957), knowledge of results (Detambel, 1955), and marbles or trinkets (Stevenson, et al., 1958; 1959). However, it is neither possible to state why these events were reinforcing nor to specify the properties they have in common.

The parameters of the reinforcement constructs which may be examined concern the frequency of occurrence of a reinforcement, and the relative magnitudes of reinforcement. The effects associated with frequency of occurrence of reinforcements were initially studied by Weinstock (1954) and by Lauer and Estes (1955). These studies reported that when a partial reinforcement condition was introduced to the probabilistic learning situation, the rate of learning decreased. It was also concluded that the decremental effect associated with non-reinforcement varies systematically as a function of the number and distribution of reinforced and non-reinforced trials. Since theoretical expectations were that non-reinforced trials affect rate of learning and not asymptotic performance, these conclusions support predictions derived from Estes' model.

According to Statistical Learning Theory assumptions, magnitude of reinforcement is only associated with asymptotic performance level and not to rate of learning (Estes, 1954). In support of this somewhat surprising assumption, Estes (1951) and Hughes (1957) found that the magnitudes of a food-reinforcement did not affect approach to asymptotic performance in animals, but did relate to asymptotic level. In another study, subjects were asked to predict, on each of a series of trials, the particular position of one of two geometrical designs. Magnitude of reinforcement was interpreted as the degree of ambiguity in the reinforcing event. These data indicated that reinforcement magnitude was inversely related to reinforcement ambiguity, and that rate of learning is independent of reinforcement magnitude.

The studies reviewed in this section were significant in that their results were influential in the formulation and revision of the present Statistical Learning Theory model. The studies to be reviewed in subsequent paragraphs constituted experimental test of the model, and when combined with future research will determine the utility and validity of Statistical Learning Theory.

Tests of Hypotheses

Statistical Learning Theory has received most attention from those investigators desiring to test the probability matching phenomenon in the Humphrey's type situation. The prediction implied by

$$P(n) = \pi - [\pi - P(1)]\ (1 - \theta)^{n-1}$$

states that the mean probability of predicting an event should be asymptotically equal to the actual probability of the event. This prediction has been repeatedly tested. Grant and associates (1951) extended the kind of experiment introduced by Humphreys (1939) so that two lights were mounted on a board which was placed in front of the subject. The subject was required to guess, while the left light was on, whether the right light would flash. The guess was recorded, and the subject noted whether or not his guess was correct. The flashes occurred in accordance with a predetermined random schedule, with fixed probabilities of either 0, 25, 50, 75, or 100. ". . . It was noted that the subjects tended to be guessing at about the percentage at which the lights were flashing" (Hilgard, 1956, p. 391).

Estes and Straughan (1954) set up a situation, similar in essentials to that used by Humphreys, Grant, and others, which would permit testing a variety of consequences of Statistical Learning Theory. Each of 48 subjects performed on two successive series of 120 trials each. The subjects were divided into three groups, and for trials 1-120 the π values were 0.30, 0.50, and 0.85 for groups I, II, and III, respectively. For trials 121-240, π was equal to 0.30 for all groups. Within the first series of trials, the investigators were able to compare learning rates and asymptotic levels of groups starting from similar initial values but exposed to different probabilities of reinforcement. The second series of trials allowed the comparisons of groups starting at different initial values but exposed to the same probabilities of reinforcement. Group I was compared to Groups II and III in order to evaluate the stability of learning rates from series to series when the π value does or does not change. Groups II and III were utilized to provide a comparison in which initial response probabilities and π values are the same but the amount of preceding reinforcement differs. Using the last 40 trials of each series as estimates of terminal response probabilities, the following results were indicated: (1) Group I performed significantly below the predicted asymptote in the first series of trials, but approximated theoretical asymptote on the second series; (2) Group II's performance approximated the predicted asymptote in trials 1-120, but tended to differ for trials 121-240; (3) Group III performed as predicted in both series of trials. The authors concluded, "Evidently the predictions concerning mean asymptotic values are correct, but the rate of approach to asymptote is faster with Group III than under other conditions" (p. 229). They further pointed out that learning rates seemed directly related to the differences between initial response probabilities and the probability of reinforcement during a series, and that this relationship might be a function of temporal massing of trials. Finally, it was noted that the subjects did not tend to respond to the series of trials as a whole, but rather became progressively sensitive to the effects of individual reinforcing and non-reinforcing events.

Jarvik (1951) conducted an experiment in which subjects guessed which of two words, "plus" and "check," would appear on each of a number of trials. The subjects were informed that on each trial the experimenter would say "now" and that they were to indicate their guess by writing either the word "plus" or the word "check." After the subject had written his choice, he was then shown the correct answer. There were three series of 87 trials each; in series A, "check" occurred on 60 per cent of the trials, in series B on 67 per cent, and in series C on 75 per cent of the trials. Analysis of the data generally tended to confirm the predicted matching relationship.

A number of studies have attempted to test Estes' implicit assumption that all types of subjects will manifest the "matching phenomenon" in the probabilistic learning situation. Since this paper is concerned with the performance of normal and retarded children, only studies using these subjects will be reviewed in the following paragraphs.

Results obtained when young normal subjects performed in the 2-choice probabilistic situation generally conform to theoretical predictions, e.g., Goodnow and Pettegrew (1955), Goodnow and Postman (1955), and Messick and Solley (1957). However, when the situation becomes more complex, non-predicted behaviors result (e.g., Goodnow and Pettegrew, 1955; and Stevenson and Zigler, 1955).

A representative study in which the matching phenomenon was not obtained is that of Stevenson and Zigler (1955). Subjects performed in a 3-choice guessing task in which the response to only one stimulus was reinforcing. For one group of subjects, each selection of this stimulus was reinforcing, for a second group selection of the stimulus was reinforcing 66 per cent of the time, and for the third group the stimulus was reinforcing only 33 per cent of the trials. An analysis of the terminal response percentages indicated that most of the subjects had adopted a maximizing response strategy, i.e., all groups did not match the predicted levels. However, the experimental situation is not the Humphrey's type, and the study was not a test of Statistical Learning Theory.

Several conditions have been shown to affect the performance of young children in the probabilistic learning situation. In the Stevenson and Zigler study, it was also found that pre-experimental experiences were associated with variations in asymptotic responding. Goodnow and associates (1955; 1955) found that children tended to maximize the frequency of choosing a particular stimulus in a situation involving gambling or games of skill. Stevenson and Weir (1959) hypothesized that subjects' ages and the frequency of reinforcement would interact to affect asymptotic performances, and obtained data were in general agreement with their prediction. These investigators also found that magnitude and frequency of reinforcement may affect asymptotic responding. Again, it should be noted that these situations did not utilize the Humphrey's paradigm.

Unfortunately, no studies are apparent in which only mentally retarded individuals served as subjects. However, at least two studies have matched normal and retarded children on the basis of scores from standard psychometric instruments and compared their performances in the probabilistic learning situation. The studies are reviewed in subsequent paragraphs.

Shipe (1959) presented 200 trials in a card guessing situation to 30 normal and 30 retarded subjects who were matched on the basis of mental age. The subjects were instructed to guess which of two card-designs, a 2-inch square and a 1-inch square, would appear on each trial. For the first 100 trials, the larger design appeared 80 per cent of the time, and during the second 100 trials the larger design appeared on only 60 per cent of the trials. It was found that both groups of subjects reached the 80 per cent asymptote by the end of the first series of trials. For trials 101-200, the retarded subjects reached asymptotic responding much faster than did the normals.

In Metzger's study (1960), familial and non-familial retardates were matched on the basis of mental ages with normal subjects. Subjects were categorized as to high and low mental ages, so that there were a total of six groups. All subjects received 451 trials in the "Humphreys type" light guessing situation. The dominant light appeared with a probability of 0.7, and the alternate light with a probability of 0.3. Asymptotic performances were obtained from the terminal 150 trials. The percentage of responses to the dominant light ranged from 65 to 70 per cent for all of the six groups.

Summary

A general review of the literature concerning Statistical Learning Theory indicates the following findings that apply to the present investigation:

(1) Very few types of subjects have been utilized to date. Although there is some indication that normal and retarded children perform as predicted, the data are equivocal.

(2) No studies are apparent in which "Contingent" and "Indeterminant" Conditions of reinforcement were utilized, although there are some definite theoretical predictions concerning these.

(3) There has been no systematic variation of magnitudes of reinforcement in the probabilistic learning situation. What evidence that is available is difficult to interpret, but seems to suggest that this condition is related to rate of learning.

CHAPTER III

METHOD

Independent and Dependent Variables

Independent variables in this study consisted of: (1) type of subject (i.e., mentally retarded vs normal); (2) level of reinforcement (i.e., high magnitude vs low magnitude reinforcers); and (3) type of reinforcing condition (i.e., series of trials in which a reinforcement occurs on every trial vs series containing blank trials). Frequency of choice of one of the two discriminada in each series of 10 trials represented the dependent variable and response measure.

The experimental method will be presented in four sections: (1) Subjects; (2) Apparatus; (3) Experimental Design; and (4) Procedure.

Subjects

Forty normal and forty mentally retarded boys and girls were utilized as Ss. Twenty male and twenty female normal students, ranging in age from 6 years, 6 months to 8 years, 5 months, were selected from first and second grade classes in a public elementary school. Twenty male and twenty female mentally retarded students, ranging in age from 13 years, 9 months to 16 years, 2 months and whose Mental Ages, as determined by a psychometric instrument (Stanford-Binet Test, L-M), were between 6 years, 6 months and 8 years, 4 months, were obtained from first and second grade-level classes from the academic school program at the Austin State School.

Table I shows the mean age and the age range of the normal subjects, and the mean M.A. and M.A. range for the mentally retarded subjects. A "t" test of significance of the difference between the mean age of the normals and the mean M.A. of the defectives was computed, and a value of 0.59 was obtained, which was not significant.

TABLE I

MEAN AGE AND AGE RANGE FOR NORMAL, AND MEAN M.A. AND M.A. RANGE FOR RETARDED SUBJECTS

	Normals	Retarded
Range	6-6 to 8-5	6-6 to 8-4
Mean	7-7	7-6

The subjects were selected so that all were proficient at the first or second grade academic level, and so that the average M.A. of the retarded group would be equal to the average age of the normal group. Accelerated or "slow" students from the normal classes were excluded from the study. All of the retardates had been institutionalized for at least one year, but not more than three years, prior to the experiment.

All subjects were right-handed, and only those retardates without obvious sensory or motor impairments were utilized.

See Appendix A for age distribution of the subjects.

Apparatus

The apparatus, depicted in Figure 1, was a simplified modification of the Multipurpose Discrimination Apparatus (Kent and Tyler, 1960). The experimenter and the subject were seated on opposite sides of a small table and were separated by a vertical wooden shield, 24 in. high and 18 in. wide. Two in. from the top of the shield, a 10 in. square viewing window was centered. Four in. from the bottom of the shield was a slot, 2 in. high and 12 in. wide, in which was placed a retractable drawer, 1 and 1/2 in. high, 12 in. wide, and 18 in. long. Two in. from the end of the drawer, and equidistant from each other and from the sides of the drawer, were the discriminanda, a 4 in. square, and a circle with a 4 in. diameter. These were removable insets, placed in 1 in.-deep recesses of the same respective sizes and shapes. The under sides of the discriminanda were hollowed to a depth of 1/2 in., thus making it possible to place a small object under them.

For a given trial, the drawer was placed on the experimenter's side of the shield, and the problem was set. The drawer was then positioned to the subject's side of the shield, and once the subject made his response, was retracted to the experimenter's side again. The entire procedure was repeated on each trial.

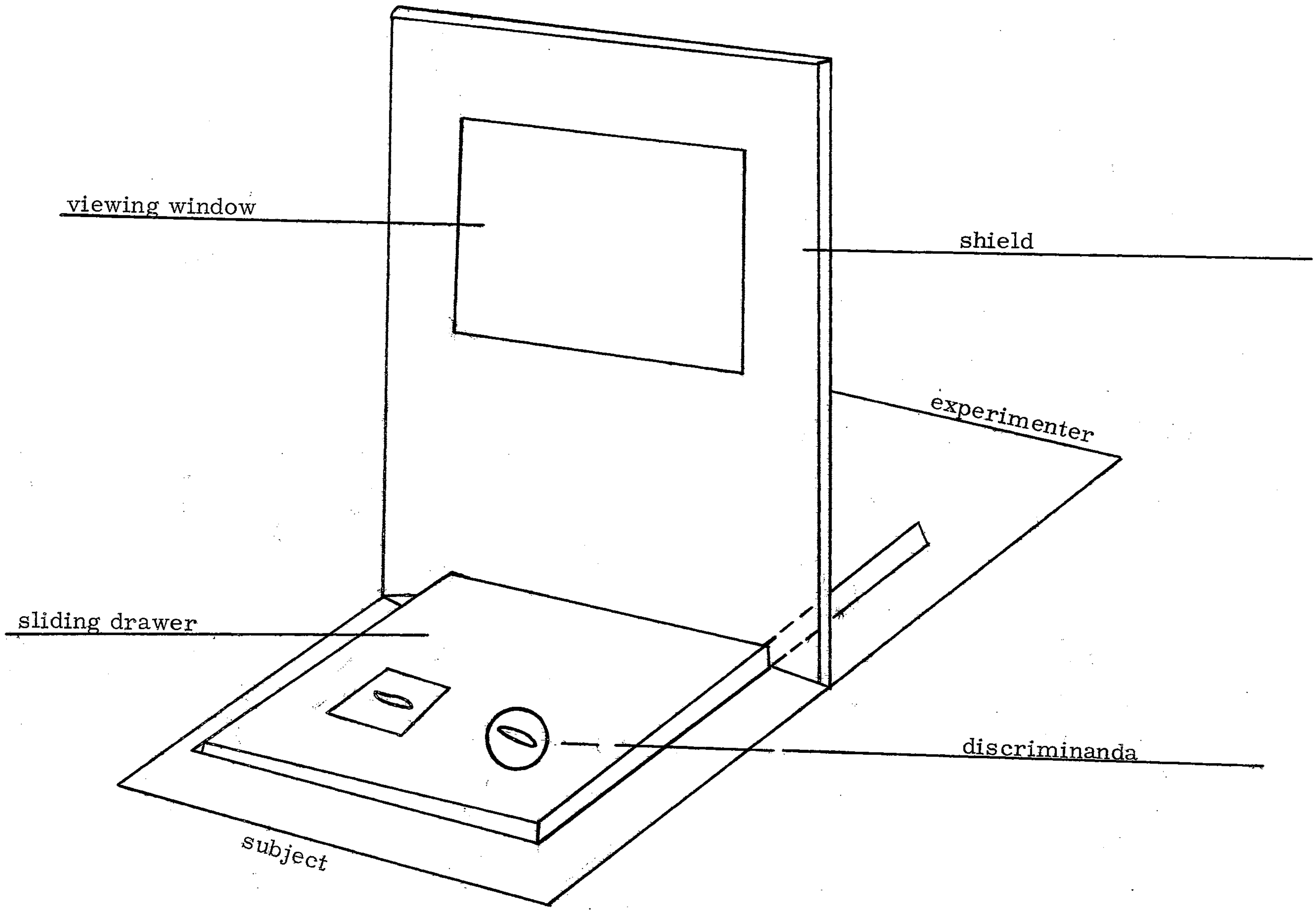

Fig. 1 A Schematic Diagram of the Apparatus

The experimenter was able to observe the subject's responses through the viewing window, and on each trial the response was recorded.

Experimental Design

The design of this experiment was developed to provide a probabilistic learning situation in which the effects of a number of variables, which had not previously received a great deal of experimental attention, could be studied. Specifically, these were: (1) Normal and Mentally Retarded Subjects; (2) Contingent and Indeterminant Conditions of Reinforcement; and (3) High and Low Magnitudes of Reinforcement.

Conditions of Reinforcement refer to the factors associated with occurrence of the reinforcements. Contingent Condition describes the situation wherein the subject is reinforced (i.e., receives a piece of candy) only on those trials in which he makes the correct response. The subject's receiving the reinforcement is contingent upon his selecting the discriminanda under which the reinforcement is hidden. Indeterminant refers to the condition wherein the subject receives the reinforcement on each trial, regardless of his response. When the initial response is incorrect, the subject is allowed to take the candy from under the other discriminanda.

Magnitudes of Reinforcement refer to the subjects' relative preferences for several types of candies. High Magnitude Reinforcement (HMR) refers to the type of candy that each subject ranked as his most preferred from among the several types presented to him prior to the

TABLE II

DIAGRAMMATIC REPRESENTATION OF EXPERIMENTAL DESIGN

NORMALS				RETARDATES			
Contingent		Indeterminant		Contingent		Indeterminant	
HMR	LMR	HMR	LMR	HMR	LMR	HMR	LMR
Ten Subjects	Ten Subjects	Ten Subjects	Ten Subjects	Ten Subjects	Ten Subjects	Ten Subjects	Ten Subjects
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							

experiment. Low Magnitude Reinforcement (LMR) refers to candy that the subjects' rank as "least preferred."

All levels of all variables were combined in all possible ways, eventuating in eight treatment-combinations. The subjects were assigned to the eight groups, so that there were ten subjects in each group. The eight groups are represented diagrammatically in Table II.

Procedure

Although the normal subjects and the retarded subjects participated in the experiment in different geographical locations, the two experimental rooms were highly similar. Both rooms were approximately 8 feet by 12 feet in size, and were void of all furnishings except those necessary to the experiment.

All subjects participated during one month, and in all cases, the subject was excused from his classroom to take part in the study.

Several days prior to the onset of the experiment, each of the subjects was brought into the experimental room and shown three types of candy (M & M chocolates, Spanish peanuts, and Brach's small peppermints). The subject was told that the experimenter needed his help in discovering the favorite types of candy for school children. He was then informed that he would be given the three pieces of candy on the table before him as soon as he helped the experimenter. The subject was told to pick up his favorite piece and place it in a small sack that the experimenter handed him. Next he was instructed to pick up his favorite of the remaining two pieces of candy, and to place it in the sack. Subsequently, he was given the third piece.

Each choice was recorded, and the subject was thanked and returned to his classroom.

Practice trials: Within one week following the ranking of the candies, the subjects were brought in for practice trials. Each subject entered the room and was seated at the table so that he was facing the examiner, although they were separated by the shield of the apparatus. The subject was informed that the following was to be a guessing game in which he would be given an opportunity to win some of the candy that he had previously been shown. He was then told which of the candies he would have a chance to "win." Half of the subjects received HMR and half, LMR.

The subject was requested to attend to the apparatus, and was told that the retractable drawer would be moved to the experimenter's side of the shield, and that a piece of candy would be placed under either the circle or the square. He was told that in order to prevent his observing the placement of the candy, he should close his eyes each time that the drawer was on the experimenter's side of the shield, and that he was not to open them until the experimenter said "now." Each subject was given 4 practice trials. During these trials, the reinforcements were alternately placed under the circle and the square, and the subject was allowed to take the candy on each trial.

Experimental trials: Immediately following the practice trials the experimental phase began. Each normal subject had previously been assigned to one and only one of the 4 treatment-combinations, as presented in Table II. Each retarded subject was also assigned to one and only one of the 4 combinations, as in Table II. These treatment-combinations were as follows:

Contingent Condition --HMR

Contingent Condition --LMR

Indeterminant Condition--HMR

Indeterminant Condition--LMR

Each subject was then given 120 trials. General instructions and procedures were identical for both normal and retarded subjects. For every subject the candy was placed under the circle on 70 per cent of the trials, and under the square on 30 per cent. The order in which the candy was placed was determined by random procedures, so that it appeared under the circle for 7 out of every 10 trials, and under the square for the remaining 3 trials.

In the Contingent Condition, when the subject's initial response was correct, i.e., when he correctly guessed the placement of the candy, he was allowed to remove it from the recess and place it in a small paper bag which the experimenter had placed to one side of the apparatus. When the initial response was incorrect, the subject was told to look under the other stimulus, but was not allowed to remove the candy.

In the Indeterminant Condition, the subject was allowed to find and keep the candy regardless of whether or not his initial response was correct.

Each trial was scored by noting the subject's initial choice. A frequency count of the number of circle choices was taken for each ten trials. (see Appendix C for a sample tabulation sheet)

Analysis of variance was selected as the primary statistical operation for determining the effects of the experimental variables upon the subjects' performances. The present experimental design yielded data that was amenable to such a method of analysis (Edwards, 1960, p. 233-250).

CHAPTER IV

RESULTS

The results are presented in three sections. The first section presents the analysis of the frequency counts of dominant responses associated with the various treatment-combinations. The second section compares the obtained asymptotic levels associated with each of the independent variables. The final section is concerned with an analysis of asymptotic performance levels in terms of discrepancies between predicted and obtained results.

Analysis of Frequency Count of Dominant Responses

The purpose of this analysis was to determine which, if any, of the independent variables, or combinations of the variables, resulted in differential frequencies in the selection of the circle stimulus by the subjects. For each subject, the number of dominant responses in each block of ten trials was counted.

The mean number of dominant responses for each of the eight groups in the twelve trial-blocks is shown in Table III. It can be observed that, for each group, there is an apparent progressive increase in the mean number of dominant responses throughout the trial-block series.

TABLE III

MEAN NUMBER OF DOMINANT RESPONSES FOR EACH OF THE EIGHT GROUPS THROUGHOUT THE SERIES OF TRIAL BLOCKS

			TRIAL BLOCKS											
			1	2	3	4	5	6	7	8	9	10	11	12
Normal Subjects	Contingent Condition	HMR	4.9	5.1	5.5	5.7	6.4	6.4	6.3	6.4	6.0	6.4	6.8	6.4
		LMR	4.7	5.5	4.7	6.1	6.0	5.7	5.8	5.9	5.9	5.8	7.0	6.8
	Indeterminant Condition	HMR	4.4	4.8	5.5	6.4	5.9	6.7	5.7	5.1	6.1	6.5	6.2	5.7
		LMR	5.0	5.2	5.4	6.0	5.6	6.4	6.3	5.9	5.6	6.8	5.9	6.6
Retarded Subjects	Contingent Condition	HMR	4.5	4.2	4.9	5.4	4.6	5.1	4.9	5.4	5.3	6.1	5.6	5.8
		LMR	4.2	4.9	4.9	5.4	5.8	5.9	6.0	6.4	6.1	5.8	7.2	5.9
	Indeterminant Condition	HMR	3.7	4.1	4.3	4.4	6.0	4.4	5.0	5.2	6.5	4.5	6.0	5.8
		LMR	4.1	5.1	4.8	4.6	5.5	5.3	4.6	5.2	5.0	6.5	5.9	6.2

A 2 X 2 X 2 X Trials analysis of variance was also computed on these scores. This analysis was directed toward the systematic variation between Subject, Reinforcement Condition, and Reinforcement Magnitude variables, and was also concerned with the variances associated with the interaction of these variables and trial-block variations. The results of the analysis of variance are presented in Table IV and are summarized below.

Subjects: The only significant F value among the main effects was that associated with the Subjects (F = 6.6661). This ratio, with df = 1 and 72, is greater than the required value of 3.98 for significance at the .05 level of confidence. Thus, the indication is that normal subjects responded with a significantly different frequency than did the retarded subjects. Inspection of the data suggests that normals made a greater number of dominant responses.

Reinforcement Conditions: Contingent and indeterminant reinforcing conditions do not appear to have differentially affected the frequency of dominant responses to a significant degree.

Reinforcement Magnitudes: There was no apparent significant difference between the effects of High and Low Magnitudes of reinforcement.

Main Effect Interactions: None of the obtained F values for the main effect interactions were significant.

Trials: An F value of 12.3959 was obtained when trial variations were compared. This value is significant at beyond the .01 level of

TABLE IV

ANALYSIS OF VARIANCE OF FREQUENCY OF DOMINANT RESPONSES IN TRIAL BLOCKS OF TEN TRIALS

Source	df	Mean Square	F.
Condition (Contingent vs Indeterminant)	1	10.6261	< 1.0000
Magnitude (HMR vs LMR)	1	8.2511	< 1.0000
Subject (Normal vs Retarded)	1	86.0011	6.6661*
Condition x Magnitude	1	.0093	< 1.0000
Condition x Subject	1	3.7093	< 1.0000
Magnitude x Subject	1	12.0510	< 1.0000
Condition x Magnitude x Subject	1	5.5011	< 1.0000
Error (a)	72	12.7728	
Between	79		
Within	880		
Trials	11	24.5415	12.3959**
Condition x Trials	11	1.2442	< 1.0000
Magnitude x Trials	11	.8828	< 1.0000
Subjects x Trials	11	1.9647	< 1.0000
Condition x Magnitude x Trials	11	3.8867	1.9632***
Magnitude x Subject x Trials	11	1.6556	< 1.0000
Condition x Magnitude x Subject x Trials	11	1.7237	< 1.0000
Error (b)	792	1.9798	
Total	959		

*significant at the .05 level of confidence (required F = 3.98)

**significant at the .05 level of confidence (required F = 2.21)

***significant at the .05 level of confidence (required F = 1.80) confidence, and indicates that the apparent progressive mean increment in dominant responses throughout the trial-blocks was highly significant.

Trial and Main Effect Interactions: A significant F value (F = 1.9632) was obtained for the Trial X Condition X Magnitude interaction. The obtained F-ratio was significant at the .05 probability level, being greater than the required value of approximately 1.80 when df = 11 and 792. This finding indicates that significant differences existed among the various treatment-combination groups when group scores were compared on the basis of trial variation. Inspection of the data, as presented in Figure 2, suggests that those subjects in the Indeterminant Condition with LMR made progressively more dominant responses than subjects in the other treatment-combinations.

In summary, the analysis of variance of the frequency of dominant responses yielded the following findings: (1) The performances of normal and mentally retarded subjects differed significantly, with normals making the greater number of dominant responses; (2) There was a progressive increment in dominant responses throughout the trial-blocks for all subjects; and (3) Subjects receiving LMR under the Indeterminant Condition made progressively more dominant responses throughout the trial-blocks than did the other groups of subjects.

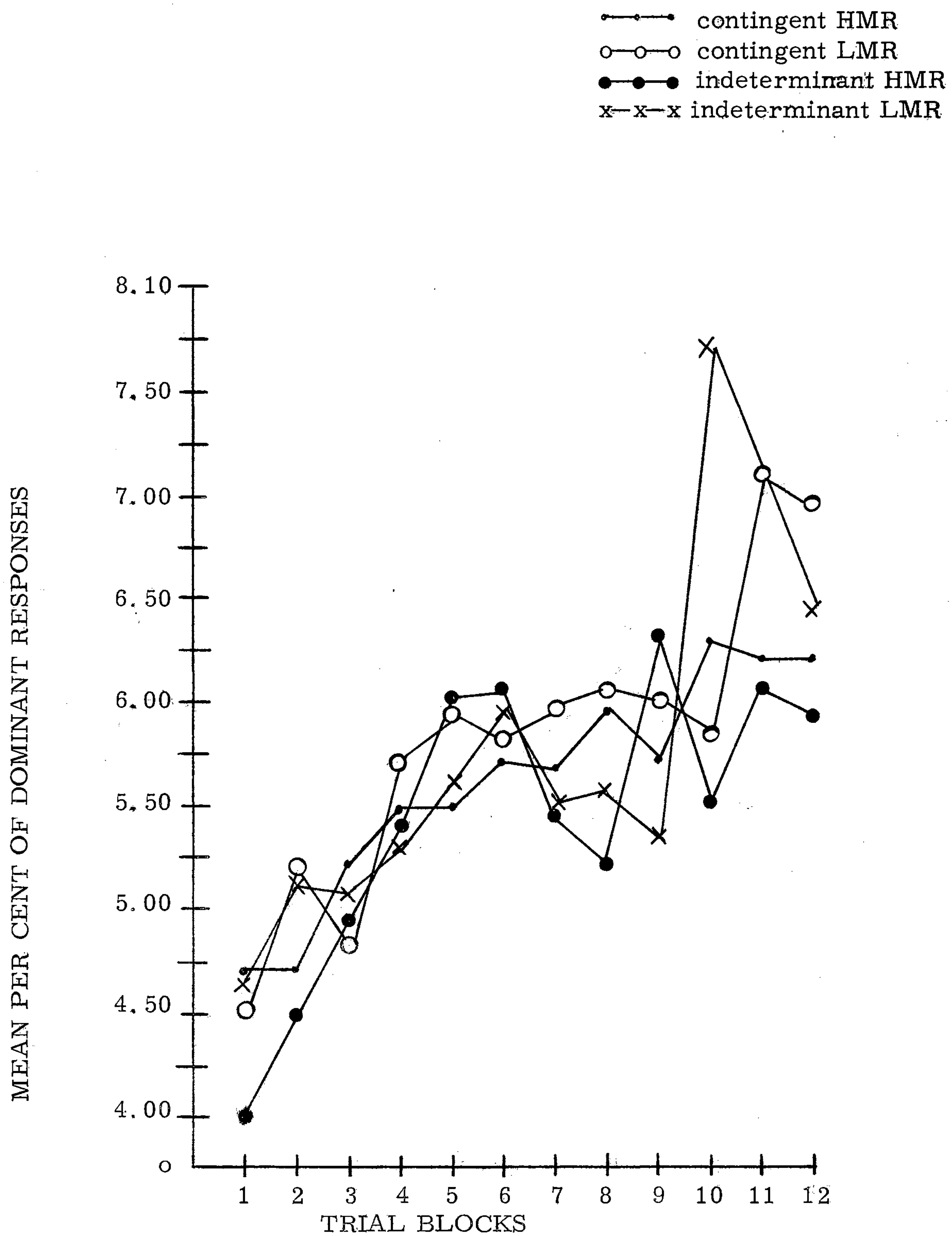

Fig. 2. Variations in Performances of the Eight Treatment Groups in the Twelve Blocks of Trials.

Analysis of Obtained Asymptotic Performances

In order to test predictions concerning asymptotic performances, a count of dominant responses was made in each of the four terminal trial blocks for all treatment-combinations. A 2 x 2 x 2 analysis of variance was computed on these scores, and the results of the analysis are presented in Table V and summarized below.

Subjects: An F value of 7.2537, which is significant at the .05 level of confidence, was obtained when the asymptotic performances of normals and retardates were compared. Figure 3, which depicts these asymptotes, suggested that the asymptotic performance of normals is greater than that of retardates.

Reinforcement Conditions: The F-ratio associated with the comparison of Contingent and Indeterminant conditions of reinforcement is not significant. The asymptotic performance curves, as presented in Figure 4, suggest that subjects in the Contingent condition tended to make a slightly greater number of dominant responses during the terminal trial blocks, but as indicated below, the difference is not statistically significant.

Reinforcement Magnitudes: In Figure 5, it is apparent that subjects receiving LMR made more dominant responses during the final trials than did subjects receiving HMR. The F-ratio associated with this comparison is significant at the .05 level of confidence (F = 4.8161).

Main Effect Interactions: The obtained F values associated with the four interactions among the independent variables are not significant at an acceptable level of confidence. Figure 6 shows the asymptotic levels

TABLE V

ANALYSIS OF VARIANCE OF MEAN ASYMPTOTIC RESPONSE LEVELS

Source	df	Mean Square	F*
Between Individuals	79		
Subjects	1	12.150	7.2537***
Conditions	1	4.267	2.5475
Reinforcements	1	8.067	4.8161**
Subjects x Conditions	1	.017	< 1.0000
Subjects x Reinforcements	1	2.817	1.6818
Conditions x Reinforcements	1	1.350	< 1.0000
Subjects x Conditions x Reinforcements	1	.333	< 1.0000
Error	160	1.675	
Total	239		

*Significant F value at .05 probability level = 3.91

**Significant at the .05 level of confidence

***Significant at the .01 level of confidence

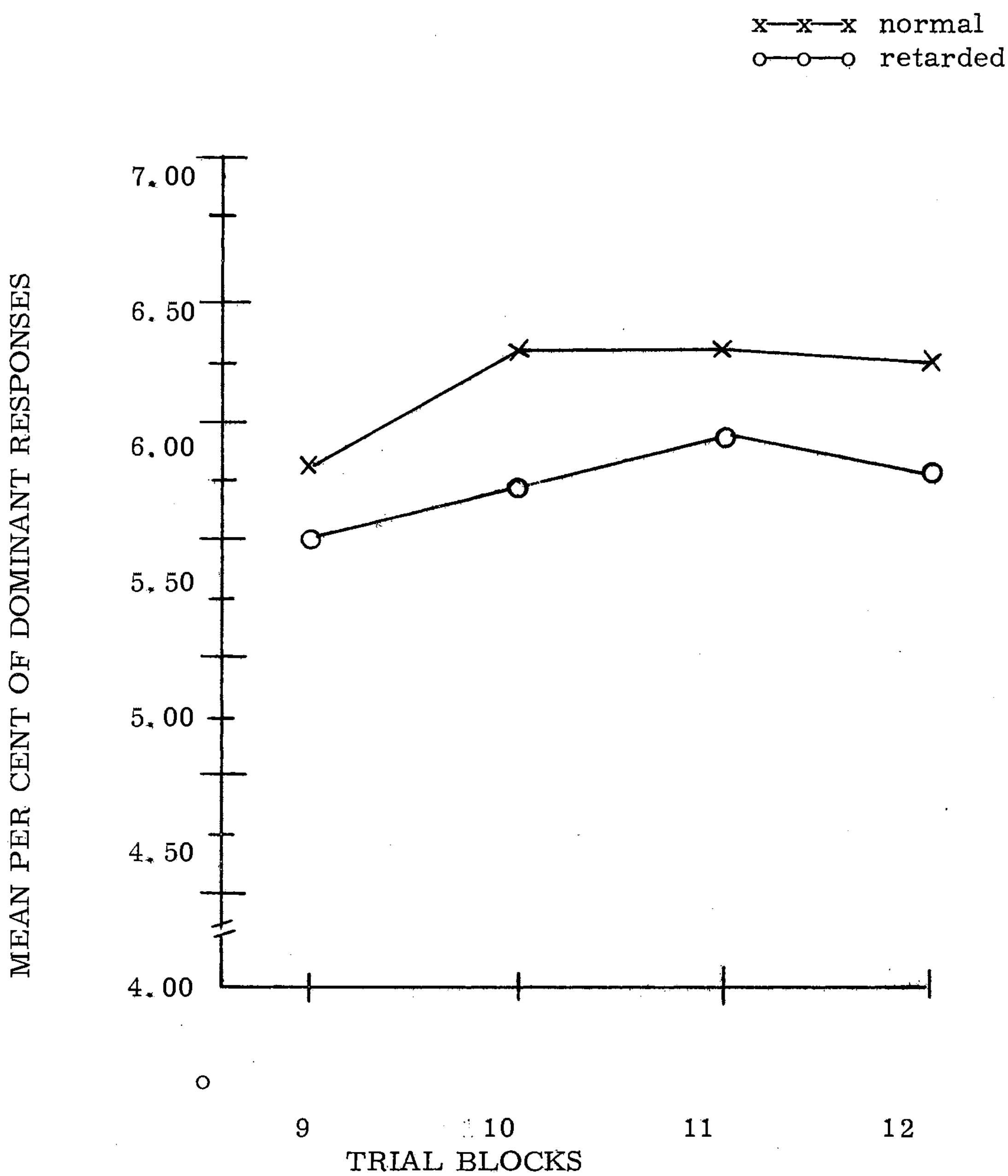

Fig. 3. Variations in Asymptotic Response Levels as Related to Subjects.

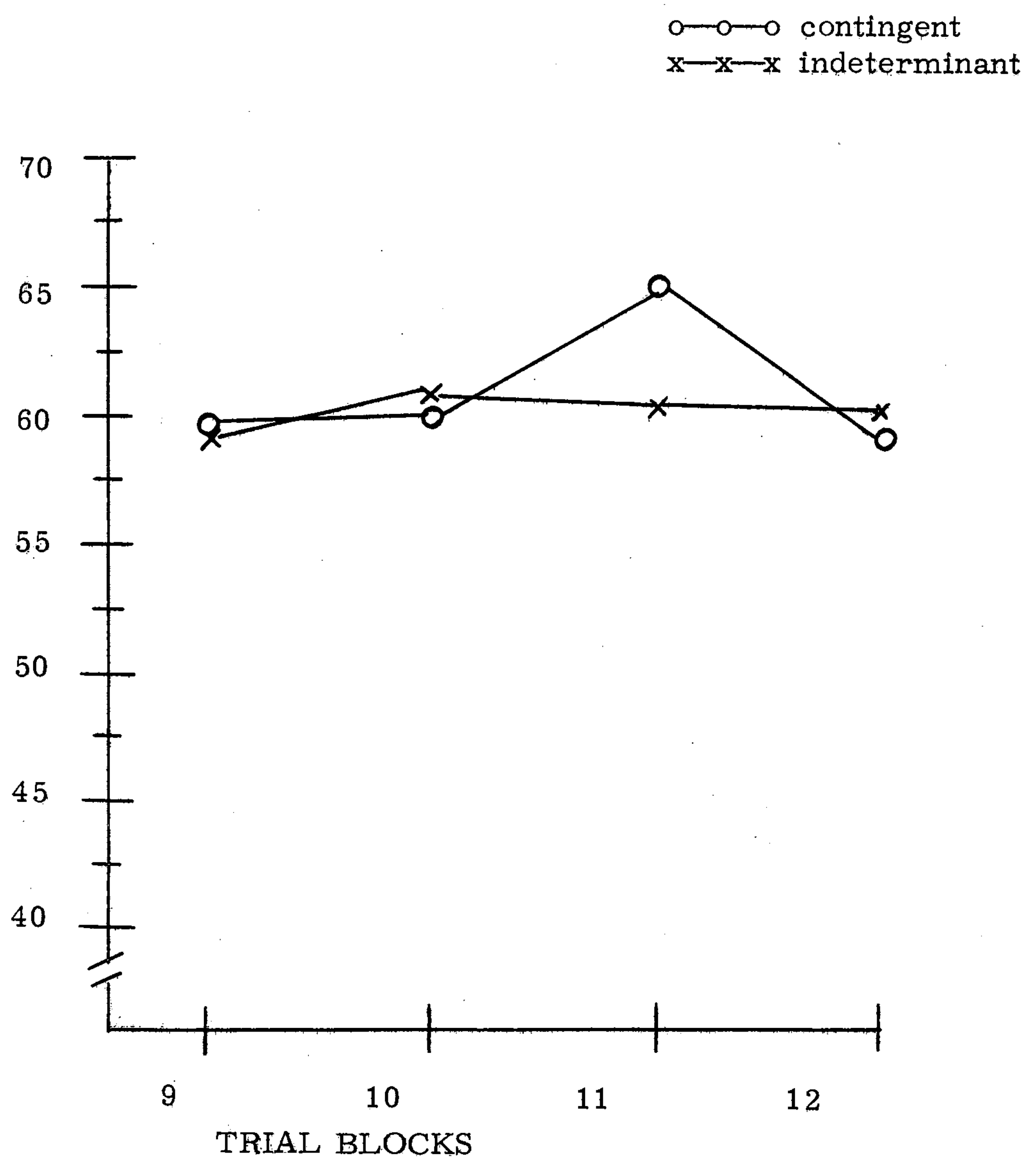

Fig. 4. Variations in Asymptotic Response Levels as Related to Conditions of Reinforcement.

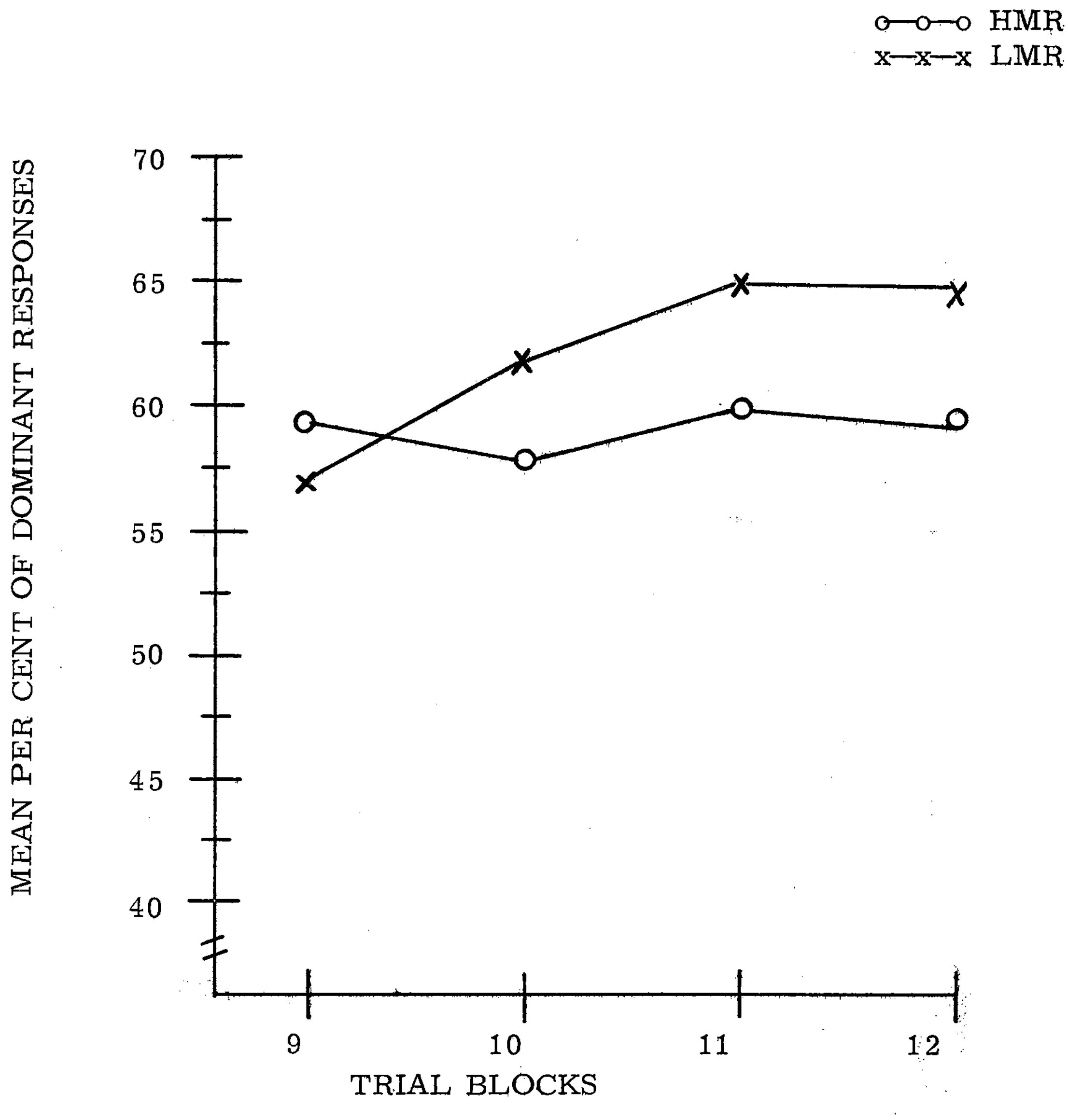

Fig. 5. Variations in Asymptotic Response Level as Related to Magnitudes of Reinforcement.

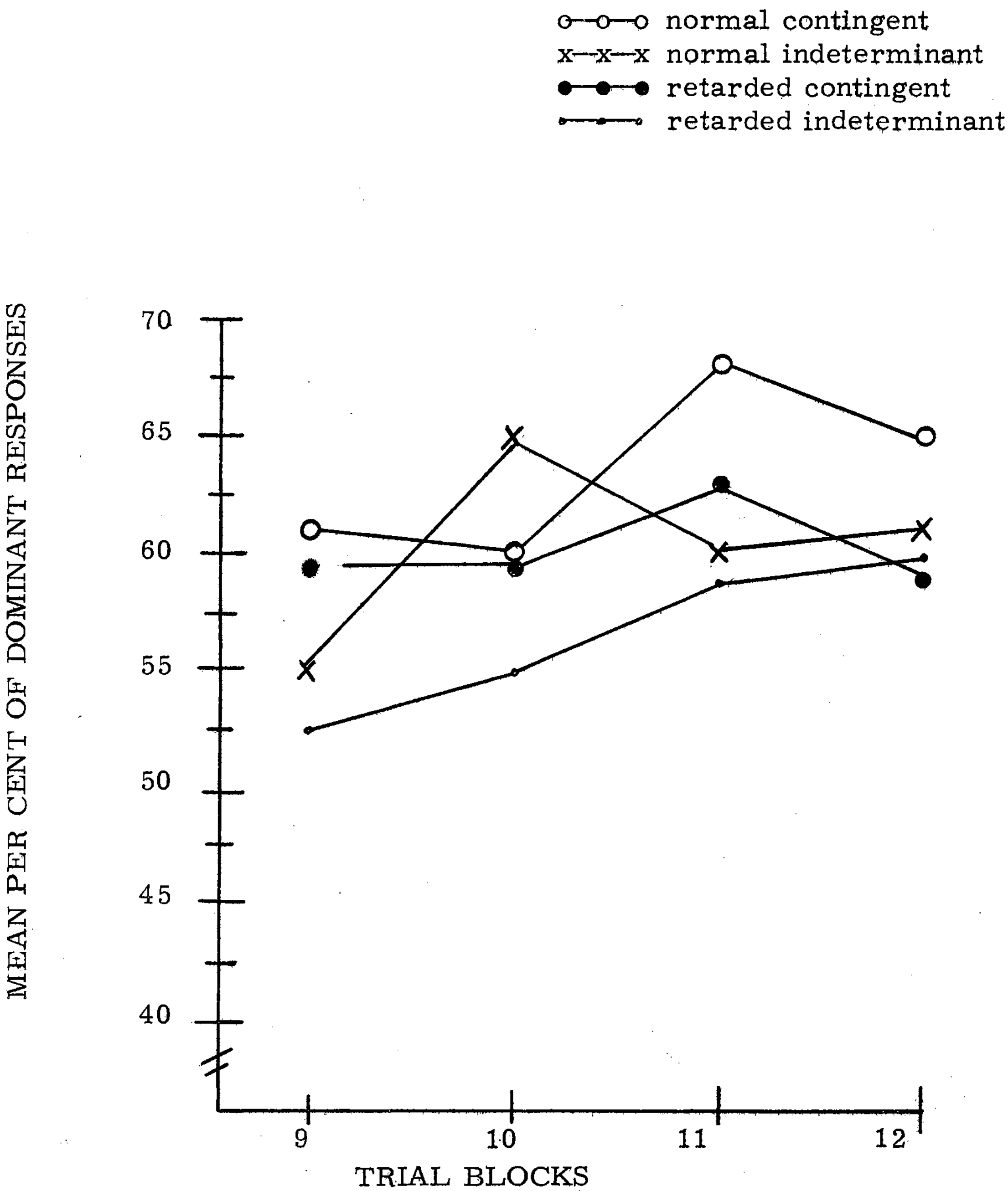

Fig. 6. Variations in Asymptotic Response Level as Related to Interactions between Subjects and Conditions of Reinforcement.

for the Subject Condition of Reinforcement interaction. The asymptotic levels for the Subject Reinforcement Magnitude interaction are depicted in Figure 7. Figure 8 presents the asymptotes for the Condition of Reinforcement-Reinforcement Magnitude interaction.

In summary, when the asymptotic levels of each of the eight treatment-combination groups were compared, the following results were obtained: (1) the asymptote for Normals was significantly higher than the asymptote for the Retarded, and (2) subjects receiving LMR yielded a significantly higher asymptotic level than did subjects receiving HMR.

Comparison of Predicted and Obtained Asymptotic Performances

On the basis of the Statistical Learning Model, it was predicted that asymptotic levels would be at the 70 per cent level, i.e., subjects would select the circle stimulus a mean of seven out of each ten trials during the final trial-blocks. In order to test this prediction, the mean percentage of dominant responses during the last forty trials was computed for each of the following variables: Normal Subjects; Retarded Subjects; Contingent Condition; Indeterminant Condition; High Magnitude Reinforcement; and Low Magnitude Reinforcement. A "t" test was computed between each of these means and the predicted mean of 70 per cent. The results of these "t" tests are presented in Table VI.

It can be observed that each of the "t" values is significant at beyond the .05 level of confidence, and it is readily apparent that in each instance, the obtained mean is smaller than the predicted value.

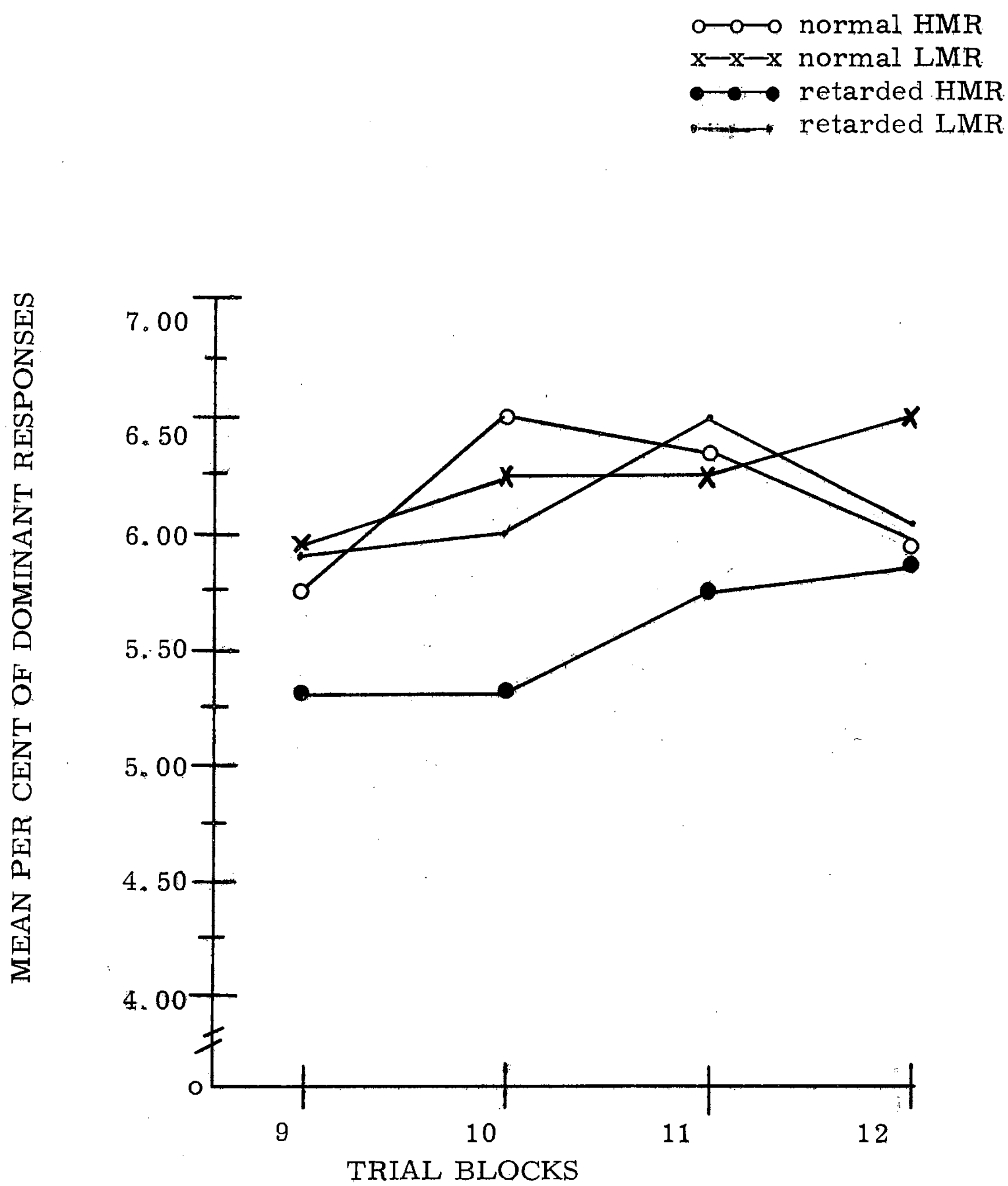

Fig. 7. Variations in Asymptotic Response Levels as Related to Interactions between Subjects and Magnitudes of Reinforcement.

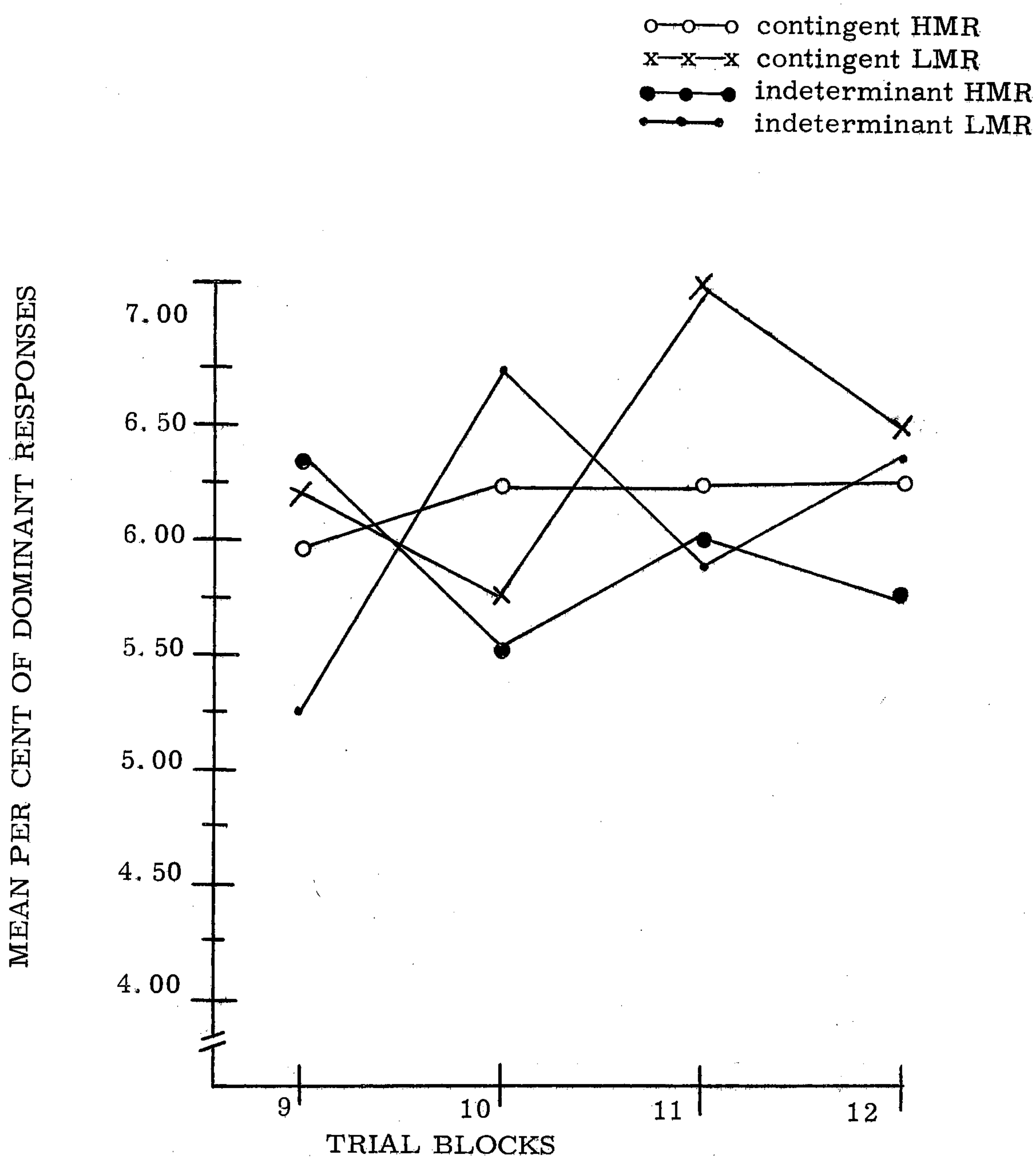

Fig. 8. Variations in Asymptotic Response Levels as Related to Interactions between Conditions and Magnitudes of Reinforcement.

TABLE VI

PREDICTED AND OBTAINED MEAN TERMINAL PERCENTAGES OF DOMINANT RESPONSES FOR EACH OF THE INDEPENDENT VARIABLES

	Predicted Mean Terminal %	Obtained Mean Terminal %	"t"
Normal subjects	70.00	58.95	4.864*
Retarded subjects	70.00	58.00	11.236*
Contingent Condition	70.00	62.81	3.428*
Indeterminant Condition	70.00	59.88	15.589*
High Magnitude Reinforcement	70.00	59.88	12.378*
Low Magnitude Reinforcement	70.00	61.94	4.282*

*significant at the .05 level of confidence (required "t" = 2.353)

To summarize, when the predicted and obtained asymptotic performance levels associated with each of the independent variables were compared, the results indicated that all obtained asymptotes are less than was predicted.

Summary of Results

When the frequencies of dominant responses throughout the 12 blocks of trials, in each of the treatment-combinations, were compared, it was found that: (1) Normals made more dominant responses than Retardates; (2) The frequency of dominant responses increased over trials; and (3) Subjects receiving LMR under the Indeterminant Condition made progressively more dominant responses throughout the trials than other groups.

A comparison of the obtained asymptotic levels of the eight groups indicated: (1) The asymptote of Normals was greater than that of the Retarded, and (2) The asymptotic level of subjects receiving LMR was greater than the level of those receiving HMR.

CHAPTER V

DISCUSSION

Chapter V is concerned with a discussion and interpretation of the present findings as they relate to the hypotheses tested and to previous results. Three major aspects of the data will be discussed: (1) Differences in Frequency of Dominant Responses Among the Treatment Groups; (2) Differences in Obtained Asymptotic Levels; and (3) Discrepancies Between Obtained and Predicted Terminal Response Probabilities. Suggestions for future research will be derived from the preceding considerations.

Differences in Frequency of Dominant Responses Among the Treatment Groups

Subjects: The present results indicate that Normal children made a greater number of dominant responses than did Retarded subjects. This finding is inconsistent with theoretical expectations derived from the Statistical Learning Model, and is somewhat at variance with two previous studies utilizing Normal and Retarded children (i.e., Shipe, 1959; Metzger, 1960). The present results conflict with the Statistical Learning Theory in that the theory makes no provisions for subject differences, i.e., all subject-populations are predicted to perform in a consistent and specified manner.

The findings of Metzger and Shipe appear to support this assumption inasmuch as neither experiment obtained significantly different performances between Normal and institutionalized Retarded subjects. However, each of these studies utilized extremely simple 2-choice tasks and with large numbers of trials. The present study utilized a more complex task, and fewer trials. On the basis of studies comparing the discrimination learning of Normal and Retarded children (e.g., Allen, 1960; Girardeau, 1959), one might expect that as task complexity increases, the difference in discriminatory ability between Normals and Retarded would become more prominent.

Thus, it appears that the performance of mentally retarded subjects in all 2-choice guessing tasks does not conform to the Statistical Learning model assumption of subject-equivalence.

Reinforcement Conditions: The present study obtained no differences in performances under Contingent and Indeterminate reinforcing conditions. This finding is also inconsistent with theoretical expectations. The theory under consideration predicts that subjects in the Contingent Condition would make fewer dominant responses than subjects in the Indeterminate Condition. Since no previous studies comparing these conditions are available for a comparison of finding, it must be concluded that the present results reflect a possible untenable assumption within the Statistical Learning Model.

Reinforcement Magnitudes: No difference between the effects of HMR and LMR were obtained in this experiment. The interpretation of this finding, within the context of the Statistical Learning Theory, is difficult. The Model suggests that asymptotic performance is related to reinforcement magnitude. However, this assumption is based upon an empirical definition of "magnitude" (i.e., those events that increase asymptotic performance are defined as "high magnitude"), and the present study used a rational definition (i.e., "high magnitude" in this study referred to events that were most preferred, on a relative scale). Therefore, it is difficult to determine whether the lack of a significant difference was due to an inappropriate specification of magnitudes of reinforcement, or to an untenable theoretical assumption, or possibly to some other variable.

It should be noted that the assumption concerning Reinforcement Magnitudes relates this factor to asymptotic performance. Therefore, this relationship will be discussed in greater detail in subsequent sections.

Trials: The evidence that the frequency of dominant responses increases as a function of trials is generally consistent with theoretical explanations and with previous research. However, the finding that subjects receiving LMR under the Indeterminate Condition performed significantly different than other groups, is unexpected and possibly inconsistent with theoretical expectations. While it was predicted that subjects in the Indeterminant Condition would make more dominant responses, it was not predicted that LMR would result in more dominant responses. The explanation for the surprising interaction of these variables is not readily apparent.

In summary, theoretical expectations concerning no differences in performance between the two types of subjects are not supported, and doubt is raised as to the applicability of the Statistical Learning Model for the mentally retarded. Further, predictions concerning the differential effects of two Reinforcement Conditions were not substantiated. There also was a possible lack of support for theoretical predictions concerning Reinforcement Magnitudes. The predicted increase in dominant responses through the trial blocks was obtained, but a possible spurious difference was found between those subjects receiving LMR in the Indeterminate Condition and the other groups of subjects. With the exception of the finding of the progressive increment throughout the trials, all of these findings are inconsistent with the Statistical Learning Theory, and question its purported applicability.

Differences in Obtained Asymptotic Levels

Subjects: The asymptotic performance of Normals was found to be greater than that of Retardates. This result is inexplicable in terms of Statistical Learning Theory, and is incompatible with the evidence reported by Shipe (op. cit.) and Metzger (op. cit.). The lack of agreement with these studies is probably a function of differences in task and procedural variables. However, Stevenson and Weir (1959) used a complex task, somewhat analogous to the present task, and reported differences among the asymptotic levels of the groups of children. Thus, the available empirical results suggest that asymptotic levels may be a function of a prior subject difference when the 2-choice task is relatively complex. If this suggestion has merit, it would appear that Statistical Learning Theory is inadequate in attempts to predict what it purports to be able to predict.

Reinforcement Conditions: The conclusion that asymptotic performance is unrelated to Conditions of reinforcement may be uninterpretable within Statistical Learning Theory. The Model suggests that the total number of dominant responses would be greater in the Indeterminate Condition, but predicts nothing about asymptotic performance.

Millard (1960) reported in a study utilizing college students, that the asymptotic level for one type of Contingent Condition did not differ from the asymptote associated with an Indeterminate Condition. In this one instance, the present findings do not conflict with previous results.

Reinforcement Magnitudes: Present findings indicate that subjects receiving LMR yielded significantly higher asymptotic performances than subjects receiving HMR, while theoretical expectations were that HMR would be associated with the higher asymptotes. These data are in agreement with the findings of Stevenson and his associates, who reported that pre-school children made more dominant responses under a "low incentive" condition, than under a "high incentive" condition.

Under conditions of less than 100 per cent reinforcement, the theoretical analysis presented by Goodnow, et al. (1955; 1955) seems to be more appropriate than the Statistical Learning Theory in accounting for asymptotic performances of children. Briefly, Goodnow hypothesizes that a subject performing in a probabilistic situation quickly learns that a particular reinforcing event does not occur on each trial. If the subject "accepts" a less-than-perfect frequency, he will choose the reinforcing event fairly consistently. However, if the less-than-perfect frequency is unacceptable, the subject will adopt a response strategy which, hopefully, will increase the frequency of being reinforced. Reinforcement magnitude is said to affect the strategy by determining the degree to which a subject will accept a given reinforcement frequency. Thus, the higher the incentive value, the lower the acceptance of a less-than-perfect frequency, and the fewer the number of dominant responses.

A review of available literature indicates that studies employing two or more magnitudes of reinforcement in the probabilistic learning of children report results compatible with the above theoretical analysis, and incompatible with predictions derived from the Statistical Learning Theory. Therefore, it seems reasonable to conclude that the Statistical Learning Theory may not be applicable to the probabilistic learning situation when young children are performing under more than one incentive condition.

In summary, theoretical expectations were that: (1) the asymptotic levels of Normal and Retarded subjects would not differ; (2) the asymptotes associated with Contingent and Indeterminate Conditions of reinforcement would not differ; and (3) the asymptote associated with HMR would be greater than the asymptote associated with LMR. The present results indicated that: (1) Normals did perform asymptotically greater than Retardates; (2) there was no significant difference between Contingent and Indeterminate Conditions; and (3) the asymptote for LMR was greater than the asymptote for HMR. With the exception of the second finding, the present results were, by and large, in serious disagreement with the Statistical Learning Theory predictions.

Discrepancies Between Obtained and Predicted Terminal Response Probabilities

None of the asymptotes associated with each level of the three independent variables (i.e., Subjects, Reinforcement of Conditions, and Reinforcement Magnitudes) were at the predicted level of 70 per cent dominant responses. This finding is significant in that it presents the greatest challenge to the Statistical Learning Theory.

Previous studies which have examined the probabilistic performance of young children and/or compared young Normal and Retarded children have yielded confusing and contradictory results. Metzger and Shipe reported that both Normal and Retarded children performed asymptotically at the predicted level, while Stevenson and Weir found that Normal and Retarded children often differed significantly, with the Retarded group demonstrating predicted asymptotes less frequently than Normals. Further, Goodnow and Pettigrew (1955) and Stevenson and Zigler (1955) reported instances where Normals failed to respond at the predicted asymptotic level. However, a careful review of each of these studies indicates that the probabilistic matching phenomenon occurs for both Normals and Retarded only in those studies utilizing the simple, "Humphrey's type" 2-choice guessing task. When this task is altered so that it is even slightly more complex, young children do not appear to perform in the predicted manner. The experiment utilized such a "slightly more complex task."

In summary, one might then conclude, that the evidence concerning the probabilistic matching phenomenon in young children is a situation and task specific phenomenon, and has extremely limited generalizability and applicability. Further, the present findings suggest that manipulation of the reinforcement variable within the classical "Statistical Learning" situation will result in a failure to obtain the "probability matching phenomenon."

Suggestions for Future Research

On the basis of the present findings and a review of previous research concerned with the probabilistic learning of Normal and Retarded children, it is evident that subsequent research in Statistical Learning Theory is needed. Particular attention should be focused upon the situational and task variables to determine the applicability of Statistical Learning Theory and the generalizability of the "probability matching phenomenon." Specific task variables associated with the matching should be determined through the use of task-comparability studies.

The parameters of the reinforcement variable in Statistical Learning Theory need both theoretical and empirical refinement.

Finally, the rates of approach to asymptote and asymptotic levels of several different populations of subjects should be investigated.

CHAPTER VI

SUMMARY AND CONCLUSIONS

Summary

This study represents an attempt to experimentally test a number of hypotheses concerning probabilistic matching behavior within the context of Statistical Learning Theory (Estes, 1959). Forty normal and forty mentally retarded elementary school children were matched on the basis of mental age and academic achievement, and performed for 120 trials in a probability learning situation. Each subject was instructed to guess on each trial which of two stimuli would be reinforcing. One of the stimuli, a circle, yielded a reinforcement on 70 per cent of the trials, and the other stimulus, a square, yielded a reinforcement on 30 per cent of the trials.

Two magnitudes of reinforcement were utilized; one-half of the subjects received a type of candy for which they had previously indicated a relatively strong preference. The other subjects received a type of candy which was relatively less preferred. Reinforcements were mediated within two general conditions, Contingent Condition, wherein the subject was reinforced only on those trials in which he made a particular response, and Indeterminant Condition, wherein the subject was reinforced on each trial, regardless of his response.

The two levels each of the three independent variables (i.e., Normal vs Retarded Subjects, High vs Low Magnitude Reinforcements, and Contingent vs Indeterminant Reinforcing Conditions) were varied in all possible combinations, eventuating in eight treatment groups. Subjects were assigned to the eight treatment-combinations so that there were four groups of normals and four groups of retarded of ten subjects each. The subjects in each of the treatment combinations performed under one, and only one, of the treatment conditions.

The response measure utilized was the number of times that each subject selected the circle stimulus in each block of ten trials. Thus, there were twelve scores for every subject.

A number of testable hypotheses were derived from the theory under consideration. These hypotheses generally stated that Normal and Retarded children would not differ in the frequency of dominant responses (i.e., selection of the circle stimulus), and in their asymptotic performance levels. Predictions also concerned the effects of the two Reinforcement Conditions and the two Magnitudes of Reinforcement. Finally, it was predicted that the asymptotic levels associated with each of the independent variables would be at the 70 per cent level of dominant responses.

The results of the statistical analyses computed upon the data indicated a general failure to obtain predicted results. Normals were found to be superior to Retardates in both mean frequency of dominant responses and in asymptotic levels. Reinforcement Conditions did not differentially affect the mean frequency of dominant responses or the asymptotic levels, Reinforcement Magnitudes differentially affected asymptotic performances. There were significant differences between all obtained and predicted asymptotic levels.

Conclusions

On the basis of the above finding, the following were concluded:

(1) The probability matching phenomenon appears to be a situation and task specific phenomenon;

(2) As the task becomes more complex, there is an apparent difference between the probabilistic performance of Normal and Retarded children;

(3) Conditions of reinforcement do not differentially affect probabilistic performance; and

(4) Additional research is needed to specify and determine the particular Subject Task, and Reinforcement variables associated with the occurrence and non-occurrence of the probability matching phenomenon.

REFERENCES

Allen, B. "A comparison of the utilization behavior of normal and mentally defective subjects." Abst. of Peabody Stud. Ment. Ret., Vol. 1, #32, 1955-60.

Anderson, N.H. & Grant, D.A. "A Test of Statistical Learning Theory model for two-choice behavior with double stimulus events." J. exp. Psychol., 1957, 54, 305-317.

Anderson, N.H. & Whalen, R.W. "Liklihood judgements and sequential effects in a two-choice probability learning situation." J. exp. Psychol., 1960, 60, 111-120.

Atkinson, R.E. & Luppes, P. "An analysis of two-person game situations in terms of statistical learning theory." Tech. Rept. No. 8, Stanford Univer., Calif., 1957.

Bakan, D. "A generalization of Sidman's results on group and individual functions and a criterion." Psychol. Bull., 1954, 51, 63-64.

Brand, H., Sakoda, J.M. & Woods, D.J. "Contingent partial reinforcement and the anticipation of correct alternatives." J. exp. Psychol., 1957, 59, 417-424.

Brody, A.C. "Statistical Learning Theory applied to an instrumental avoidance situation." J. exp. Psychol., 1957, 54, 240-245.

Burke, C.J. & Estes, W.K. "A component model for stimulus variables in discrimination learning." Psychometrika, 1957, 22, 133-146.

Bush, R.R. & Mosteller, F. "A mathematical model for simple learning." Psychol. Rev., 1951, 58, 413-423.

Collier, G.H. "Probability of response and intertrial association as functions of monocular and binocular stimulation." J. exp. Psychol., 1954, 47, 75-83.

Detambel, J.H. "Human escape learning in relation to reinforcement variables and intertrial conditions." J. exp. Psychol., 1956, 52, 1-8.

Edwards, A.L. Experimental Design in Psychological Research. New York: Rinehart & Co., 1960.

Estes, W.K. "Toward a statistical theory of learning." Psychol. Rev., 1950, 57, 94-107.

Estes, W.K. "Need reduction vs. stimulus characteristics as determiners of response latency." Paper read at Midwest Psychol. Assoc., 1951.

__________. "Individual behavior in uncertain situations: an interpretation in terms of Statistical Learning Theory." In R.M. Thrall, C.H. Comb, & R.L. Davis (Eds.) Decision Processes. New York: Wiley, 1954, 127-137.

__________. "Statistical theory of spontaneous recovery and regression." Psychol. Rev., 1955, 62, 145-154.

__________. "Learning." Annu. Rev. Psychol., 1956, 7, 1-38.

__________. "Of models and men." Amer. Psychol., 1957, 12, 609-617.

__________. "The statistical approach to learning." In S. Kock (Ed.) Psychology: A Study of a Science, vol. 2, New York: McGraw-Hill, 1959.

__________. "Learning theory and the new mental chemistry." Psychol. Rev., 1960, 67, 207-223.

__________ & Burke, C.J. "A theory of stimulus variability in learning." Psychol. Rev., 1953, 60, 276-286.

__________ & Burke, C.J. "Application of a statistical model to simple discrimination learning in human subjects." J. exp. Psychol., 1955, 50, 81-88.

__________ & Lauer, D.W. "Conditions of invariance and modifiability in simple reversed learning." J. comp. physiol. Psychol., 1957, 50, 199-206.

__________ & Straughan, J.H. "Analysis of a verbal conditioning situation in terms of Statistical Learning Theory." J. exp. Psychol., 1954, 47, 225-234.

Gardner, R.A. "Probability learning with two and three choices." Amer. J. Psychol., 1957, 70, 174-185.

Girardeau, F. "Discrimination learning in normal and mongoloid children." J. comp. physiol. Psychol., 52, LII (1959), 566-570.

Goodnow, J.J. "Determinants of choice distributions in two-choice situations." Amer. J. Psychol., 1955, 68, 106-116.

__________ & Pettegrew, T.F. "Effects of prior pattern of experience upon strategies and learning situations." J. exp. Psychol., 1955, 49, 381-389.

__________ & Postman, L. "Probability learning in problem solving situations." J. exp. Psychol., 1955, 49, 16-22.

Graham, C.H. & Gagne, R.M. "The acquisition, extinction, and spontaneous recovery of a conditioned operant response." J. exp. Psychol., 1957, 26, 251-281.

Grant, D.A., Hake, H., & Hornseth, J.P. "Acquisition and extinction of a verbal conditioned response with differing percentages of reinforcement." J. exp. Psychol., 1951, 42, 1-5.

Gulliksen, H. "A rational equation of the learning curve based on Thorndike's law of effect." J. gen. Psychol., 1934, 11, 395-434.

Gutherie, E.R. The Psychology of Learning. New York: Harper, 1935.

Guttman, N. & Estes, W.K. "A modified approach for the study of operant behavior in the rat." J. gen. Psychol., 1949, 41, 297-301.

Hilgard, E.R. Theories of Learning. New York: Appleton-Century-Crofts, 1956.

Homme, L.E. "Spontaneous recovery and statistical learning theory." J. exp. Psychol., 1956, 51, 205-212.

Hughes, L.H. "Saccharine reinforcement in a T-maze." J. comp. physiol. Psychol., 1957, 50, 431-435.

Hull, C.L. Principles of Behavior. New York: Appleton-Century-Crofts, 1943.

Humphreys, L.G. "Acquisition and extinction of verbal expectations in a situation analogous to conditioning." J. exp. Psychol., 1939, 25, 294-301.

Jarvick, M.E. "Probability learning and a negative recency effect in the serial anticipation of alternative symbols." J. exp. Psychol., 1951, 41, 291-297.

Kent, N.D. & Tyler, D.W. "A multipurpose discrimination apparatus for general laboratory use." Psychol. Repts., 1960, 6, 222.

Lauer, D.W. & Estes, W.K. "Observed and predicted terminal distributions of response probability under two conditions of random reinforcement." Amer. Psychol., 1954, 9, 413.

Messick, S.J. & Solley, E.M. "Probability learning in children: some exploratory studies." J. genet. Psychol., 1957, 90, 23-32.

Metzger, R. "Probability learning in children and aments." Amer. J. ment. Defic., 1960, 64, 869-874.

Millard, R.B. "Verbal conditioning experiment with contingent and indeterminant reinforcements." Paper read at Midwest Psychol. Assoc., 1960.

Miller, G.A. & Frich, F.C. "Statistical behaviorists and sequences of responses." Psychol. Rev., 1949, 56, 311-324.

Mueller, C.G. "Theoretical relationships among some measures of conditioning." Proc. nat. Acad. Sci., 1950, 36, 123-130.

Neimark, E. "Effects of two types of non-reinforcement and number of alternative responses in two verbal conditioning situations," J. exp. Psychol., 1956, 52, 209-220.

Nicks, D.C. "Prediction of sequential two-choice decisions from event runs." J. exp. Psychol., 1959, 57, 105-144.

Shipe, D. "A comparison of probability learning in mentally retarded and normal children." Unpublished manuscript, George Peabody Coll., Tenn., 1959.

Sidman, M. "A note on functional relations obtained from group data." Psychol. Bull., 1952, 49, 236-269.

Spence, K.H. Behavior Theory and Conditioning. New Haven: Yale Univ. Press, 1956.

Stevenson, H.W. & Snyder, L.C. "Performance as a function of interaction of incentive conditions." Amer. J. ment. Defic., 1959, 1-11.

__________ & Zigler, E.F. "Discrimination learning and rigidity in normal and feebleminded individuals." J. Pers., 1957, 25, 699-711.

__________ & Zigler, E.F. "Probability learning in Children." J. exp. Psychol., 1958, 56, 185-192.

__________ & Weir, M.W. "Variables affecting children's performance in a probability learning situation." J. exp. Psychol., 1959, 57, 403-412.

Straughan, J.H. "An application of Statistical Learning Theory to an escape learning situation using human subjects." Unpublished doctoral dissertation, Indiana Univer., 1953.

__________. "Human escape learning in relation to reinforcement variables and intertrial conditions." J. exp. Psychol., 1956, 52, 1-8.

Verplank, W.S., Collier, G.H., & Cotten, J.W. "Non-independence of successive responses in measurements of the visual threshold." J. exp. Psychol., 1952, 44, 282.

Weinstock, S. "Resistance to extinction of a running response following partial reinforcement under widely spaced trials." J. comp. physiol. Psychol., 1954, 318, 322.

Wyckoff, L.B. & Sidowski, J.B. "Probability discrimination in a motor task." J. exp. Psychol., 1955, 50, 225, 231.

APPENDICES

APPENDIX A

CHRONOLOGICAL AND MENTAL AGES OF SUBJECTS

Normal Subjects C.A.	Retarded Subjects C.A.	Retarded Subjects M.A.
7-3	13-9	7-8
6-9	15-8	8-2
8-2	15-6	8-3
7-10	16-1	8-0
8-3	13-9	7-2
8-3	15-6	6-10
8-5	15-7	7-4
6-8	15-7	8-4
7-0	15-8	7-3
7-4	15-11	7-8
7-5	14-8	8-0
7-8	14-1	7-4
7-8	14-6	7-3
7-8	15-3	6-9
6-10	15-8	7-0
7-10	14-10	7-1
8-5	16-2	7-1
8-5	16-1	8-3
7-2	15-6	7-7
7-6	15-2	7-10
7-3	15-0	7-3
7-4	15-2	7-4
7-10	15-7	6-7
7-8	15-0	7-10
7-4	15-7	7-10
7-9	14-5	6-6
7-2	15-4	8-0
8-1	16-0	7-9
6-7	15-2	7-3
7-1	15-5	7-7
7-6	15-7	7-6

APPENDIX A--Continued

Normal Subjects	Retarded Subjects	
C. A.	C. A.	M. A.
8-3	13-11	7-2
7-7	15-1	7-8
8-3	15-8	8-4
7-6	16-0	7-10
8-3	15-9	7-5
8-2	15-6	7-8
7-3	15-8	7-10
7-2	14-7	6-10
6-9	15-3	7-8

APPENDIX B

SAMPLE DATA SHEET

Normal_____ Retard_____   Name________________

Contin_____ Indeter_____

Reinforcement Pref.   Sex______ Date_______

High_____ Low_____

Trial	C	S	Trial	C	S	Trial	C	S
1			41			81		
2			42			82		
3			43			83		
4			44			84		
5			45			85		
6			46			86		
7			47			87		
8			48			88		
9			49			89		
10			50			90		
11			51			91		
12			52			92		
13			53			93		
14			54			94		
15			55			95		
16			56			96		
17			57			97		
18			58			98		
19			59			99		
20			60			100		
21			61			101		
22			62			102		
23			63			103		
24			64			104		
25			65			105		
26			66			106		
27			67			107		
28			68			108		
29			69			109		
30			70			110		
31			71			111		
32			72			112		
33			73			113		
34			74			114		
35			75			115		
36			76			116		
37			77			117		
38			78			118		
39			79			119		
40			80			120		

APPENDIX C

INSTRUCTIONS

Instructions for ranking of candies: Following the introduction, the experimenter says, "I would like to have you help me find out the favorite candy of school children. See the three pieces of candy on the table?... Can you name them? (The subject is given help, if needed)... Now I'm going to give those to you for helping me, just as soon as we finish... Tell me, do you like to eat every one of those kinds of candy?... Good... Here's a sack... Now pick up your favorite piece of candy and you can put it in your sack.... Good... Now, pick up the one of these two that you like the best... Good... Do you like this kind of candy too?... Good, you can have this... Thank you." If other comments were necessary to clarify the situation, or to answer any of the subject's questions, they were made by the experimenter.

Instructions for the experiment: "We're going to play a game now, and you will have a chance to win some of that candy I showed you the other day... First let me show you the kind of candy you will be able to win... NOW--Here's the way you can win the candy. See this drawer... I can slide it back and forth, from one side to the other...see? And see this circle and square? See how they are lids...you can pick them up and take them out of the drawer, like this (demonstrating)...and when you put the lid back in place, you can't tell whether or not there's anything under it, can you?

OKAY--here's the way it works... I'll sit on this side and bring the drawer over to my side. You close your eyes and don't open them until I tell you to. While your eyes are closed, I'll hide a piece of candy under one of the lids, and then I'll push the drawer over to your side. Remember, don't open your eyes until I say now... Now...that's right, open your eyes and guess where the candy is. If you think it's under the circle, pick the circle up with your right hand...this hand, and if you think it's under the square, pick the square up with your left hand... Now pick up the lid you want to... That's right, now let's do it again... (If the subject's first response is incorrect, he is told, you missed it...look under the other lid...see, there it is).

We're going to do this a lot of times, but let's practice some first.

Now remember, close your eyes when I bring the drawer over to my side, and don't open them until I say now...and remember, pick up the circle with your right hand and the square with your left...always pick up the lid like this (demonstrating), and after you've looked and have taken your candy, always put the lid back just the way it was. And always put your candy in this paper bag.

VITA

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Candidate for the Degree of

Doctor of Philosophy

Thesis: THE EFFECTS OF CERTAIN REINFORCEMENT VARIABLES UPON THE PERFORMANCE OF NORMAL AND MENTALLY RETARDED ELEMENTARY SCHOOL CHILDREN IN A PROBABILITY LEARNING SITUATION

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