3-1961

Extinction Following Qualitative Change in the Reinforcing Stimulus

Robert E. Taylor
University of Tennessee - Knoxville

To the Graduate Council:

I am submitting herewith a dissertation written by Robert E. Taylor entitled "Extinction Following Qualitative Change in the Reinforcing Stimulus." 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.

W. O. Jenkins, Major Professor

We have read this dissertation and recommend its acceptance:

Gerald R. Pascal, Virgil E. Long, Clifford R. Swensen, Ronald Fraser

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 25, 1960

To the Graduate Council:

I am submitting herewith a thesis written by Robert E. Taylor entitled "Extinction Following Qualitative Change in the Reinforcing Stimulus." I recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Psychology.

W. O. Jenkins
Major Professor

We have read this thesis and recommend its acceptance:

Clifford H. Swensen, Jr.

[illegible]

Ronald C. Fraser

Virgil E. Herrick

Accepted for the Council:

H. E. Spivey
Acting Dean of the Graduate School

EXTINCTION FOLLOWING QUALITATIVE CHANGE IN THE REINFORCING STIMULUS

A Dissertation
Presented to
the Graduate Council of
The University of Tennessee

In Partial Fulfillment
of the Requirements for the Degree
Doctor of Philosophy

by
Robert E. Taylor
March 1961

ACKNOWLEDGMENT

The writer will always be indebted to his chairman, Dr. William O. Jenkins, whose consistent encouragement, tutelage, and inspiration during the past five years has made this study possible. Dr. Gerald R. Pascal deserves full credit for maintaining an atmosphere in which the scientific study of behavior may be directed toward humanitarian ends. Drs. Clifford R. Swensen, Jr., Virgil E. Long, and Ronald C. Fraser provided immeasurable benefits through their genuine interest in the problem and by posing many challenging questions which stimulated the writer to broaden his thinking and improve the quality of his efforts.

To Dr. Paul S. Siegel and his staff at the University of Alabama thanks are due for the provision of research space and subjects during the course of the pilot study. Drs. Charles Rickard and Michael Dinoff were most helpful in offering suggestions based on their prior experience in related studies.

The work could not have been carried out without the subjects obtained through the efforts of Dr. William F. Gwynn, Dr. Raymond R. Shrader, Mr. Harry Williams, Mr. Wayne Henderson, and Mr. John Clark.

The many unnamed friends, colleagues, and teachers whose influence and support has profoundly affected the writer's educational and personal development to date merit far greater recognition than can be extended in these brief paragraphs.

For the writer's wife, Cathy, whose heroic labors on this manuscript symbolize the unceasing devotion and faith displayed for ten trying years, can only be offered a very humble thank you, and the hope that the future

may be dedicated to providing the rewards she has so long been denied.

R. E. T.

TABLE OF CONTENTS

LIST OF TABLES

CHAPTER I

INTRODUCTION

The ensuing pages report an attempt to evaluate the effects of certain systematic variations in a stimulus situation designed to condition verbal habits in human subjects. More specifically, the studies focus upon the effects of changes in the quality of the reinforcing stimulus in relation to differing reinforcement schedules.

I. THE SCIENCE OF PSYCHOLOGY

Since any investigator's definition of research is bounded by his knowledge of a given subject matter and his personal approach to the questions raised by his studies (the latter being a rather indirect function of his training and consisting of, in the sense intended by Barzun (1955), his education) a statement of research biases seems an appropriate preface to the experimental procedures.

Psychology is essentially a search, sometimes disappointing, for means of understanding the behavior of our environment. Both the means and understanding should ultimately be couched in a form readily communicable to others engaged in similar endeavors. The search, since the subject matter is so broad, should be conducted in an orderly and selective fashion. Within such a framework, bias (or theory) and the methodology which follows from it become exploratory tools which may be modified or discarded as their utility warrants. The appropriateness of hypotheses or experiments are not, then, evaluated in terms of the answers they

provide, but instead are viewed with respect to the further hypotheses and experiments they suggest.

Clinical psychology is primarily directed to the behavior of humans. The behavior most fitting for study appears to be that of the whole, intact organism. One might legitimately choose to investigate behaviors of individual biological systems or particular cell types of which members of our species are comprised. However, such endeavors currently show little promise as a means of effectively dealing with, for example, a nine-year-old boy brought to the clinic because he stood barefooted in the snow for two hours screaming "for all he was worth."

An approach appropriate to the question raised by the foregoing example has often been decried by clinical psychologists because, oddly enough, of its apparent simplicity. This approach is the now classic stimulus-response framework born during this century in the animal laboratory. Within this orientation, some pertinent questions related to the example might be: How often does this behavior occur? Where is it displayed? What events precede, accompany, and follow it? When did it first appear? What were the circumstances then? Is there a display of other similar behaviors? How can this behavior be described most accurately? How can it be modified?

To the last question, many parents tend to respond with, "It can't." Many techniques have, fortunately, been evolved which do indeed modify human behavior and often do so drastically. They are used constantly, albeit unsystematically, by people everywhere. Techniques frequently utilized by the psychologist and teacher have literally and figuratively

been learned from animals. One is often struck by the ironic fact that many persons are far better at training their bird dogs than they are at equipping their children with even elementary skills.

This study does not treat the multitude of ways human behavior can be modified. Suffice it to say that several modes are available which yield varying probabilities of success in individual situations. The applicability of these techniques to clinical practice and the circumstances in which each may be best applied has been recently delineated by Pascal (1959).

The present study results from a desire to find ways of increasing the efficiency of principles already in use. It is rooted in the conviction that behavior is most readily modified when we can state the relative weighting of the factors under which it is acquired. It has often been demonstrated that a change in stimulation, such as the introduction of food, will serve to increase the probability of the reoccurrence of the behavior taking place at the moment the change was introduced (Jenkins, 1956a). The occurrence of the behavior is most likely when the total stimulus situation again duplicates that present when the behavior originally occurred (Guthrie, 1935). Furthermore, it is extremely probable that if a piece of behavior is strengthened in the foregoing fashion it will persist longer after complete omission of the strengthening agent when this agent is not presented every time the behavior occurs in the conditioning or learning phase, but is introduced only some portion of the time (Jenkins & Stanley, 1950; Lewis, 1960).

While various kinds of stimulus change have been utilized in

strengthening behavior (Forgays & Levin, 1959; Young, 1959), little experimental work is reported in which many types of stimulus change were used successively in the conditioning process. Natural experience lacks the orderliness and regularity of experimental procedures. For example, a child may be rewarded for a certain behavior by the presentation of a lollipop on one occasion, an ice cream cone on another, or perhaps money on yet another "trial." In addition, the therapist working in the clinic rarely attempts to strengthen a given behavior by the introduction of exactly identical stimulus changes each time the behavior occurs. (In this case, one might be attempting to increase a client's verbalizations of "self importance.") The therapist may, and undoubtedly does, respond to statements of self esteem with a wide variety of reinforcing comments. It seems pertinent, therefore, to ask how variations in reinforcement affect the frequency of a given bit of behavior in the conditioning process, and furthermore, to attempt to measure the extent to which such variations render the behavior more or less modifiable when conditioning has ceased.

The experiments which are reported represent an attempt to probe this area in the light of certain hypotheses. Before proceeding directly to the problem, a brief historical summary and a survey of the literature relevant to the question is presented.

II. EARLY EXPERIMENTATION

Thorndike (1898) and Pavlov (1928) can probably be best regarded as the initiators of relatively modern systematic studies concerning the

means by which various behaviors may be strengthened, maintained, or weakened. While Thorndike emphasized behaviors of a problem-solving nature, and Pavlov studied behavior of a more reflex kind, the similarity of their efforts was noted by Pavlov within the framework of attempts at understanding neural activities (1928, p. 6). Probably both Pavlov and Thorndike would be somewhat startled by other similarities which more recent theorists propose. The techniques utilized by Pavlov and Thorndike are not discussed in great detail here since these are generally well known. It should perhaps be noted, however, that Pavlov was well acquainted with the effects of stimulus change, and stated (1928, p. 38): ". . . any agent in nature which acts on any adequate receptor apparatus of an organism can be made into a conditioned stimulus for that organism." Pavlov also extensively investigated techniques of weakening behavior, and it is to him that we are indebted for the useful concept of extinction. While Pavlov did not extend his investigations to the human organism, he commented at great length upon the application of his findings to a wide variety of human behavior, including hypnosis and various pathological states.

Watson discarded most of Pavlov's neurology, but extended the empirical principles derived from classical conditioning to the human organism and went so far as to state (1924, p. 247): "Some day we shall have hospitals devoted to helping us change our personality because we can change the personality as easily as we can change the shape of the nose, only it takes more time." Psychology has not yet fulfilled this prediction, but Watson's impact on psychology in America was revolutionary.

It was through Watson, more than any other man, that the approach exemplified in the present study evolved.

B. F. Skinner (1938) was also quick to foresee the implications of Pavlov's work and was among the first to systematically investigate the extension of Pavlov's principles to behaviors of a more global nature than reflex activity.

C. L. Hull's (1934) extensive and scholarly exposition of conditioned reflex techniques applied to various human and infra-human activities stands as an imposing tribute to the influence of Pavlov in man's continuing attempt to understand human behavior. Hull also indicated the possible benefits to be derived from the application of principles learned with the conditioned reaction situation to more complex behavioral processes.

III. THE QUESTION OF METHOD

An imposing variety of experimental methodology has evolved from Pavlov's early conditioning work and Thorndike's (1898) investigations of his "law of effect." An examination of some of these experimental techniques would seem necessary before proceeding further, in that the bulk of the data reported in the present study was obtained in a situation which has probably received too little attention. Learning and conditioning are terms applied to several procedures, often with little regard for the appropriateness of such application. In addition, concepts associated with these processes are frequently used interchangeably or with only slight modification in definition (Osgood, 1953). Many current

writers, such as Lawson (1960), exhibit a preference for some verbal "model" with which several experiments may be compared and/or contrasted in a review of the literature. Behaviors elicited in many settings can, however, deviate from a particular model to a not inconsiderable extent. A typical trend, as illustrated by Lawson, is for a paradigm in which some form of energy stemming either from within the organism or the external environment (selection here depending on the researcher's bias) is identified as a "stimulus" for a particular activity of the organism as measured by the experimenter (again locus of measurement emerges as a biased choice) which is most frequently identified as a "response." This response may either act upon the environment in some manner or simply be accompanied by a change in environmental stimulation. As previously mentioned, certain changes in the environment, or sometimes perhaps in the internal condition of the organism, appear to increase the likelihood of reoccurrence of the stimulus-response sequence which immediately preceded them. Such changes are commonly identified as "reinforcing" or "reinforcers." The experimental manipulation of such changes is generally termed "reinforcement." Literally thousands of pages of research findings pertaining to factors such as amount of reinforcement, kind of reinforcement, frequency of reinforcement, delay of reinforcement, and the like have been published since Thorndike (1898) first discussed his law of effect. The whole body of subsequent literature obviously cannot be reviewed here. It is necessary, however, to distinguish the methodology of the present study from the bulk of work preceding it, and to enlarge upon an important factor which appears to have escaped all but

a few writers.

The stimulus-response-reinforcement model and the studies appropriate to it have unquestioned value. There is, nonetheless, some basis for questioning the generality of experimentation performed solely in this setting, and it should be noted that the bulk of Pavlov's studies do not readily fit such a framework. Ferster and Skinner point up the possible weaknesses of such a framework when they state (1957, p. 1):

> The effect of reinforcement in maintaining behavior in the repertoire of an organism has been neglected partly because the contingencies of reinforcement actually studied have usually been of an all-or-nothing nature. An act has been reinforced, or it has not. For example, in the traditional study of "learning," "right" responses are always rewarded and "wrong" responses are always allowed to go unrewarded. But the most casual observation of the normal environment of an organism will show that these conditions are not typical. Behavior of a given form seldom has precisely the same effect upon the environment in two instances, and the kind of effect called a reinforcement is seldom inevitable. Most reinforcements, in other words, are intermittent.

They proceed to point out that (1957, p. 2), "A schedule of reinforcement may be defined without reference to its effect upon behavior"; and in the impressive collection of data which follows, carefully document behavior occurring under a multitude of reinforcement schedules. Closer examination of the procedures utilized provides the following observations. Food, the reinforcement employed here, always was presented, no matter what the schedule, almost immediately after a pecking response was emitted by a pigeon. The pecking behavior represented the variable under study, and the procedure described was in many ways quite appropriate. It represents, however, a mode of investigation which only half meets the objections to the "traditional" learning studies mentioned by the authors. True, the "right" response (pecking) was often reinforced very infrequently rather

than on every occasion it was emitted, but in no reported instance was a "wrong" response (some behavior incompatible with pecking) intentionally followed by the reinforcing stimulus. In fact, in operant conditioning procedures, the experimenter's primary intention is always to reinforce the particular behavior which he wishes to strengthen or "shape" while avoiding, insofar as possible, the presentation of a reinforcing stimulus immediately after an inappropriate response (Verplanck, 1956). While the foregoing procedures have been demonstrated as quite effective in strengthening and maintaining behavior, the point here is that any organism's environment seldom exhibits the consistent and beneficient properties of the laboratory experimenter's procedure.

Often a specific (reinforcing) change of stimulation may follow two, three, four, or more qualitatively different responses, many of which cannot be emitted in the same temporal interval. How, then, does a given response become "right"? The answer is that any one response may be "right" only part of the time. Other responses may also become "right" on some proportion of the learning trials. The former instance is represented by the experiments of Skinner and others; the latter case seems with but few exceptions to have been generally overlooked. In all fairness to Skinner, mention must be made of studies he has conducted in which reinforcement was delivered independent of a specific response and resulted in the strengthening of a variety of behaviors which he labeled "superstitious." However, in a discussion of these findings (Skinner, 1953, pp. 84-87) he identifies such events as instances where "the process of conditioning has miscarried," although noting that these behaviors

become more likely as increased susceptivity to conditioning accompanied evolutionary development.

Humphreys (1939a) reported results of a classical conditioning experiment in which conditioned responses reinforced (followed by the US) only 50 per cent of the time evidenced greater resistance to extinction procedures than responses reinforced on every trial. This is the often-cited "Humphreys effect"--startling because it was inconsistent with predictions arising from Hullian theory of that day (Hull, 1937). The effect has subsequently approached the status of a law as Lewis (1960) has recently commented. This situation has followed principally from the efforts of Jenkins and Stanley (1950) in their review of the pertinent literature. More important is the study which Humphreys (1939b) devised to test the influence of a S's "expectancy" of US stimulation in the eyelid reaction experiment. Humphreys applied a technique which he carefully termed "analogous to conditioning," a semantic distinction of considerable importance. He instructed his Ss to guess whether or not the onset of a signal light should be followed by the illumination of a second light. Students were exposed to conditions in which the second light was illuminated on every trial or on only half the trials on a random basis. The extinction effects noted in the eyelid reaction experiment also emerged here. There were, however, differences in the acquisition phase worthy of note. While both groups showed an asymptote of performance in responding about 85 per cent of the time in the eyeblink study, the frequency of expectation study revealed significantly different performances for the two groups. Here the 100 per cent group responded with ex-expectation of stimulation almost 100 per cent of the time. The 50 per cent

random group responded with an expectation of stimulation about 50 per cent of the time. Humphreys also reports approximately equal performance at the end of acquisition for the two conditions of reinforcement in a study utilizing the PGR (1940).

Humphreys' identification of the stimulus elements in the verbal expectation experiment deserves comment. He called the signal light the "CS," the S's positive guess, i.e., anticipation of the right light, the "CR," and the illumination of the right light was termed the "US." As Humphreys emphasized, this situation has only an analogous relation to Pavlovian conditioning. In no way is the illumination of a light bulb a stimulus for an "unconditioned" "yes" or "no" response in humans. It appears to this writer that the classical conditioning model is inappropriate in this instance. This problem might be partially resolved if one views verbal expectation of stimulation, or more specifically the "yes" response, as a response previously conditioned to a wide variety of conditioned stimuli here associated, via instructions, as a response to the conditioned stimulus of "right light illumination." This more closely resembles the higher order conditioning procedures employed by Pavlov (1928) wherein a stimulus to which a response has been conditioned is utilized as a US for associating the response with yet another conditioned stimulus. It would still seem legitimate to question the analogy in that one might ask if the "yes" response was ever an unconditioned reaction to environmental stimulation. Furthermore, the differences in acquisition data for the classical conditioning versus the expectation studies can be viewed as additional support for the existence of real disparity in the

two situations.

Another conditioning paradigm, elaborated by Skinner and labeled "operant" by him (1935) is discriminated from the Pavlovian situation in which reinforcing US stimulation is related to the presence of another stimulus (CS). He described a situation in which the emphasis is on the relation between reinforcement and a specific response. Reinforcement, as defined in the latter instance, bears no relation to the elicitation of the response, but simply rests on the empirical observation that any behavior immediately followed by (in this case) presentation of food tends to occur more frequently thereafter. The important distinction in the operant situation is that specific eliciting stimuli for the behavior measured are not readily identifiable, and reinforcement is contingent upon emission of a specific response.

To return to Humphreys' study--it can be observed that the stimulus situation was held relatively constant from trial to trial, i.e., the ready signal and cues associated with it did not change. In such circumstances, the stimulus for the verbal response does lack identifiability as in the typical operant situation. However, due to the randomness of occurrence of stimulus change following the response, this change is not directly related to a specific response and, therefore, does not constitute reinforcement as it occurs in operant conditioning.

Now it has been shown that if the reinforcing change of stimulation is effected according to some regular plan or pattern, this pattern will be learned by the S and the S can thereby emit the correct response on almost every trial (Lowy, 1956). However, in the random case no pattern

exists for the subject to learn. Nonetheless, the latter procedure has demonstrable efficacy in controlling behavior (Estes & Straughan, 1954), (Lowy, 1956), (Rickard, 1959). Furthermore, Lowy's data indicate that such procedures yield greater resistance to extinction than those in which a pattern is present. This finding is consistent with the hypothesis advanced by Jenkins and Stanley (1950) relating resistance to extinction to the degree of similarity in the stimulus situations existing in the conditioning and extinction phases.

Estes and Straughan (1951), Grant, Hake, and Hornseth (1951), and Jarvik (1951) observed that a S tended to match his response frequency to the rate of occurrence of the predicted event. This finding also emerged in the work of Lowy and Rickard. Such a contingency is altogether rational in the instance where the stimulus change proceeds according to a pattern. However, the behavior seems quite irrational when the predicted event occurs on a chance basis. Let us examine a specific hypothetical example. Suppose one learns that a given event occurs 90 per cent of the time in a certain situation, but at irregular intervals. Predicting this event 100 per cent of the time will obviously lead to 90 per cent accuracy in one's prediction. Suppose, however, one decides to predict the event only 90 per cent of the time. Since the latter procedure does not maximize the proportion of successful predictions, a subsequent decline in accuracy will follow. Yet this latter course is precisely that taken by the great preponderance of Ss in those experiments based on Humphreys' procedures. Their response frequency, in conforming closely to the rate of occurrence of an event, would seem

to indicate that the frequency has been learned, but the failure to utilize the learning experience to maximize accuracy of performance, still awaits a wholly satisfactory explanation. The behavior displayed in such circumstances closely resembles that of the naive poker player who always keeps a "kicker" and draws two to his pair, despite the lowered probability of resulting improvement in his hand.

Estes has attempted to incorporate such behavior in his attempts at constructing a mathematical model of learning (1950; 1953; 1954; 1957), but while such an attempt demonstrates that performance can be described by theoretical functions, efforts to date give little indication of generating novel testable hypotheses.

IV. THE QUESTION OF PARTIAL REINFORCEMENT

Since the bulk of the work reported in the present study was performed in a setting wherein partial reinforcement was employed, a brief review of the partial reinforcement area is presented as a prelude to the literature bearing more directly upon the experimental question. Pavlov (1928) experimented with presentation of the US on various proportions of conditioning trials, and Skinner (1933; 1936) conducted many of the earliest systematic investigations of partial reinforcement.

Jenkins and Stanley (1950) were apparently among the first to note the significance of "Humphreys' effect," and their review of the partial reinforcement question yielded the following generalizations:

1. Acquisition. Response strength is built up somewhat more rapidly under a schedule of 100% reinforcement than under a partial regimen. Differences in learning, however, are not always large, and with prolonged training the ultimate level of acquisition for partially

rewarded subjects may approach that for the 100% ones.

2. Maintenance. While the behavior in post-acquisition performance is stable in the partial reinforcement situation, it is usually at a lower level than in the 100% instance. Nevertheless, the differences are not always statistically significant and may well be of no great practical consequence.

3. Resistance to extinction. The most striking effects of partial reinforcement are apparent in response strength as measured by resistance to extinction. In almost every experiment, large and significant differences in extinction favoring the groups partially reinforced in conditioning over the 100% ones were found.

Lewis (1960) presents another review covering the period following the Jenkins and Stanley article. Lewis reports essential agreement with the conclusions offered by Jenkins and Stanley. As Jenkins and Stanley noted, Sheffield (1949) reported a study in which the results were interpreted to indicate that the partial reinforcement effect in extinction could be obtained if acquisition trials were massed, but not if these trials were distributed. This is still a controversial question; however, there is no evidence to indicate that the intervals used in the present experiments were great enough to have any bearing on this matter.

Lowy (1956), Tyler, Wortz, and Bitterman (1953), and Mowrer and Jones (1945) present results which demonstrate rather conclusively that resistance to extinction is greater in the partial reinforcement situation when the reinforcing stimulus is presented on a random rather than on an alternating or patterned basis.

Capaldi (1957; 1959) reported two experiments bearing upon the amount of training utilized when random versus patterned reinforcement is employed. He concluded that the amount of training has no effect on extinction behavior when a random schedule is employed, but that resistance

to extinction does vary with amount of training when the reinforcement is patterned. With increasing amounts of training in the alternating reinforcement situation, resistance to extinction decreases.

Longenecker, Krauskopf, and Bitterman (1952) report that a situation involving classical conditioning of the psychogalvanic response with 50 per cent random and alternating schedules yielded identical levels of responding at the end of the conditioning phase, but the random group displayed greater resistance to extinction.

Wilson (1960) found that when monkeys are exposed to a situation in which they are presented with a choice as to two means of finding reinforcement and one choice is rewarded 75 per cent of the time and the other 25 per cent of the time, both on a random basis, that, unlike human _Ss_, the monkeys tend to respond more than 95 per cent of the time to the most probable choice. Another exception to the response rate typically recorded in random partial reinforcement settings is found in an experiment conducted by Wyckoff and Sidowski (1955). Sixty male students were run for 320 trials on a task involving the tracking of a marker which arced either from the right or left and which was virtually impossible to track accurately unless the _S_ correctly anticipated the side the marker was coming from. The different groups were exposed to 25, 40, 50, 60, and 75 per cent of targets from the right. In an analysis the 25 and 75 per cent groups were combined, and the 40 and 60 per cent groups were combined in order to balance out side preferences. "Correct anticipations" were scored as responses from the side on which the target was most frequently appearing. The percentages of these correct anticipations were 93 for

the 75 per cent group and 79 for the 60 per cent group. The authors suggest that their results differ from the predictions based on prior verbal studies because their task was not presented as a guessing or problem-solving situation to the subjects. However, Brand, Sakado, and Woods (1957), and Brown and Webb (1960) report that variations in instructions have no effect on response strength in conditioning when a partial random schedule is employed. Brand, et al., even went so far as to tell one group of subjects that the schedule was random and could not possibly be correctly anticipated.

Lewis and Duncan (1956) report results in a situation wherein the S played cards and was instructed to guess if his hand was a winner or not. The S was paid five cents if the hand was a winner whether the guess was correct or not. Fifty and 100 per cent reinforcement schedules were utilized, but the authors do not state whether the 50 per cent schedule was random. The 50 per cent group responded with fewer winning guesses in extinction than the 100 per cent group. The authors contend that these results are not consistent with the usual partial reinforcement findings. However, this conclusion is due to their failure to partial out the differences in positive guesses at the end of the acquisition phase with the 100 per cent group being the higher. Jenkins and Stanley (1950) cautioned against overlooking differences in performance at the end of acquisition and clearly state that the partial reinforcement effect emerges consistently only when behavior is measured in terms of single responses.

The effects of successive changes in the quality of the reinforcing stimulus during conditioning have not been extensively investigated and

the potential relationship of such effects within various methodological frameworks and reinforcement settings remains an experimental question. The present studies were oriented toward exploration of these issues.

CHAPTER II

A REVIEW OF THE LITERATURE ON CHANGES IN THE REINFORCING STIMULATION DURING CONDITIONING

The following appraisal of the literature is necessarily selective and restricted to those types of changes in the reinforcing stimulus which appear to have a rather direct relation to the changes utilized in the present study. For reasons previously discussed, the literature is divided into those studies in which the procedures utilized were essentially operant and those which were based on probability conditioning techniques. In the area of classical conditioning apparently no work has been conducted in which the reinforcing stimulus, in this case the US, has been varied on a trial by trial basis. In this latter respect, one obvious handicap is that relatively few US variables are available for the elicitation of a single response.

I. PROBABILITY CONDITIONING STUDIES

Only three experiments are reported in which variations in the reinforcing stimulus were present. In none of these three experiments were extinction trials carried out. Anderson and Grant (1957) utilized human Ss in an extremely complex design in which the stimulus event to be anticipated could be either a left light, a right light, neither light, or both lights with differing probability for the occurrence of each of these events. The Ss were told to press only one of two keys on each trial and that both lights would be counted as a correct event and neither light

occurrence would not be counted against them. Four different sets of instructions were also utilized, and no differences emerged as a function of the instructions. This design tested predictions based on Estes' model for single events (the occurrence of either left light or right light) versus double stimulus events (left light, right light, neither light, or both lights). The double event, whether neither light or both lights, tended to lower response strength to the single lights, and the probability matching response phenomenon did not emerge in this case.

Brand, Sakado, and Woods (1957) administered 120 conditioning trials on an apparatus with a green signal light and a panel behind which either a red or white light appeared after the subject pressed a lever. The red light was designated correct, and random reinforcement schedules of several proportions were used. The apparatus was set up so that E could make either the left, right, or both levers correct or incorrect on a given trial. In this instance the response strength predictions derived from Estes' model significantly underestimated the empirical asymptotes.

Gardner (1957) used an apparatus comprised of three boxes with a light on the top of each box and individual switches for each box. The S indicated by throwing the switch which light he expected to come on. In two phases of this experiment wherein the light was the same color on the top of each of the three boxes, the Ss were exposed to conditions in which either only two or all three of the possible choices were reinforced on varying proportioned random schedules. The two-choice groups

responded with the predicted proportions. However, eight out of nine of the three-choice groups deviated significantly from the actual proportions by over-responding to the most frequently occurring light. In a third phase, two groups were presented the three-choice situations, and the lights on the boxes were blue, amber, and green. In this case the Ss' responses were significantly different from those of all the other three-choice groups and came closer to the actual proportion of stimulus presentation.

Herrnstein and Morse (1957) utilized a procedure exhibiting characteristics of both operant and probability techniques. Pigeons were trained on an intermittent schedule until the operant response stabilized. Then a neutral stimulus was presented aperiodically for a fixed duration and was followed by a food reinforcement delivered independently of the animal's response. The effect emerging was a large increase in the rate of the ongoing operant response.

II. STUDIES EMPLOYING OPERANT TECHNIQUES

Wolfle (1936) appears to have been the first investigator interested in the effects of varied stimulation during learning and pointed out several considerations necessary in such studies, such as, the particular element varied, the extent of variation, the S's recognition of the variation, and the type of learning task utilized. In 1935 he published a study in which human Ss were presented during learning with from one to five forms of a maze in which the sequence of turns, number of units, and total length were held constant, but the length of the

various legs on the mazes was varied. The resulting data show much overlap and only the most extreme conditions, where four or five maze forms were employed, deviated from the other groups in terms of slower learning.

Grether and Wolfle (1936) presented rats with four different pairs of lights which varied in intensity, although the intensity ratio was 16 to 1 in each pair. The four sets of pairs were presented in random order during conditioning on the discrimination involving responding to the brightest light. The rats had to traverse one of two bridges and received mash for a correct choice and were dropped for an incorrect choice. The brightest light was always correct. The group exposed to four different pairs of lights showed significantly more retardation in learning than groups exposed to one, two, or three pairs. The authors concluded that increasing amounts of stimulus variation increased difficulty in learning. Wolfle (1936) also trained 427 students on from one to nine mazes and found again tremendous overlap in the learning task, but evidence of slightly slower learning as the number of mazes used in learning increased.

Studies in variation of the amount of reinforcement were initiated by Crespi in 1942 although he employed only one shift during conditioning. Dinoff (1960) has already reviewed this area, and Pubols (1960) also provided an excellent review. He points out that quantitative variation seems to have no effect on the rate of learning, although most studies have involved 100 per cent reinforcement schedules and only one shift in magnitude. Pubols states that consumatory activity and stimulation from

the incentive associated with the consumatory activity seemed to be a "sufficient" mechanism and a far more important parameter than amount of reinforcement per se.

Mackintosh (1957) reported a study designed to test Hullian predictions for performance in a situation in which rats were presented with two manipulanda in a response box each of which was associated with food reinforcement in a random order. She did not, however, provide a control group in which the manipulanda were not varied, although it should be noted that the number of incorrect responses fell far below that predicted by the theoretical postulate.

Mc Clelland and Mc Gown (1953) exposed rats to different types of food reinforcement on every trial as well as conditions in which the food was always to the left of the entry in a circular goal alley, or the placement of the food was varied on a random basis in four different sections of the alley and administered sometimes for stopping and sometimes for running in the appropriate section. The group in which the location of the reinforcement was varied learned better than control groups given no food, but not as well as the group in which the food was always placed in the same location. In extinction a choice point was added on the way to the circular goal alley which was available through only one of the two possible paths. Here the group which received varied reinforcement ran faster and yielded fewer errors in the middle of the extinction series than the group reinforced previously in one specific place. Mc Clelland and Mc Gown claim superiority for the varied stimulation condition in extinction; however several criticisms should be mentioned.

The varied stimulation group spent more total time in the circular alley than the specific group, and of four measures of behavior utilized, log running time provided the only significant difference. Also, the similarity of conditioning and extinction stimulus situations seems widely disparate, and it could be contended that extinction may have represented a new learning task altogether since no choice point was present on the approach during conditioning. Furthermore, so many factors were varied during conditioning that it is not possible to say specifically what may have generated the difference.

Mackintosh (1955) trained forty-eight animals in twelve groups in which three sources of variation were presented in an apparatus with a start box, response box, and goal box. One variation occurred in the reinforcement schedules where 100 per cent and 80 per cent reinforcement were utilized. The number of manipulanda in the response box was varied from one to three, and the number of drives reduced was varied by providing either food or both food and water for rats deprived of food and water. She hypothesized that more irregular reinforcement, more kinds of responses, and a greater number of drives reduced would all yield greater resistance to extinction. Her results support the first two hypotheses on measures of trials to criteria, but it should be noted that the statistical treatment involved combining the irregular reinforcement and number of manipulanda groups, and that the difference in performance appears to have been generated by the reinforcement groups. However, since her reinforcement variation consisted of what is essentially simply a 100 per cent versus a partial reinforcement treatment,

the findings are not surprising and should more probably be attributed to the partial reinforcement effect than to other variations in the stimulus situation present in conditioning.

Dinoff (1960) conditioned pigeons on a three minute aperiodic schedule in situations involving three degrees of reinforcement variations. The variation consisted of the presence of one, two, or three colors of food. The results show that higher responding accompanied increasing reinforcement variation. In extinction the higher response level present in conditioning also occurred. While these differences were consistent, the extent of difference was not highly significant, particularly in the extinction phases. Dinoff also found, as some other investigators also report, heightened variability in response levels with increasing reinforcement variation.

Logan, Beier, and Ellis (1955) studied the effect of variation in magnitude and variation in delay of reinforcement on speed of locomotion. In the experiment in which magnitude was varied, the animals ran significantly slower than a group provided with a large reward, and in the varied delay experiment, the animals ran as fast as the fastest of the constant delay groups. Another group was then run in a condition in which omission of reinforcement was substituted for the delay, thus yielding a 50 per cent random reinforcement group which performed significantly faster than all the other groups.

Logan, Beier, and Kincaid (1956) reported extinction data for the experiment previously cited. They found no significant differences for the delay groups in extinction and a suggestion that the varied magnitude

group extinguished somewhat slower than the constant magnitude groups. The partial reinforcement group extinguished at about the same rate as the varied magnitude group. In this article another varied delay experiment is reported in which one group was immediately reinforced on all trials, another group was reinforced immediately or after nine seconds on a random schedule, and a third group was reinforced immediately or after thirty seconds on a random schedule. The third group was significantly more resistant to extinction than the first two groups which did not differ from each other.

McNamara and Wike (1958) utilized fifty rats in five different conditions on a standard runway and measured median running time. A control group received immediate food reinforcement. Other experimental groups found hurdles on the way to the goal box, a changing goal box, side linings, and lights on or off. Drive, delay, and amount of reward were also varied. In acquisition the control group ran the fastest while the two experimental groups having the greatest number of variations presented ran significantly slower than the other groups. In extinction the same differences were evident in a reversed order, and the groups with the most variation in conditioning extinguished slowest. The authors concluded that greater irregularity of training conditions leads to greater resistance to extinction. It should be noted, however, that the two groups most resistant to extinction were exposed to delayed reinforcement as part of the variation.

Scott and Wike (1956) trained rats in a runway under conditions of 100 per cent reinforcement, 50 per cent reinforcement, spaced trials,

massed trials, and 50 per cent spaced and massed trial groups with reinforcement delayed on half of the training trials on a "quasi random" basis. No significant differences on running time in acquisition emerged. In extinction the groups exposed to partially delayed reinforcement were the most resistant to extinction whether trials were massed or spaced in either acquisition or extinction.

Peterson (1956) ran four groups of animals in a runway under conditions of 100 per cent immediate reward, 100 per cent delay reward with delayed intervals varied randomly, 50 per cent immediate reward, and 50 per cent delayed reward. In acquisition the 100 per cent immediate, 100 per cent delay, and 50 per cent delay groups were all significantly different from each other with the variable delay schedules resulting in weaker response strength. In extinction the measure of trials to extinction criteria showed the 50 per cent delay group most resistant, the 100 per cent delay and 50 per cent immediate groups very similar, and the 100 per cent immediate group extinguished fastest.

Kendler (1959) in his review of learning comments on the effects of delay of reinforcement and points out that the most important variable is probably what the subject does during the delay rather than the length of the delay. It would seem, in fact, that in those instances where the source of variation involves a delay in the presentation of the reinforcement that, particularly on those trials in which long delays are involved, the delay may constitute partial reinforcement since it is highly unlikely that the stimulus change of food presentation immediately follows a running response. The emphasis should be placed on the specific behavior immediately

preceding reinforcement (Jenkins, 1956) at the end of the delay since this behavior may be wholly incompatible with the response being conditioned. Most investigators fail to recognize this consideration and often neither record nor report this important aspect of the data.

Wike and Barrientos (1960) report significantly faster performance at the end of acquisition on a runway when animals were subjected to random food deprivation periods of 18, 23, and 28 hours versus animals kept at constant 23 hour deprivation.

Wike, Kintsch, and Gutekunst (1959) trained seventy-one rats under variable versus constant response, thirst drive, and amount of water reward. The groups were extinguished under constant thirst drive, response, and the reward omitted. Reinforcement was administered on all trials in conditioning. In training, the response variation group performed slowest and neither reward nor drive variation appeared to affect running speed. In extinction the varied drive and reward groups ran significantly faster and were more resistant to extinction than the varied response group.

A summary of the foregoing operant studies suggests the following generalizations: variation in the amount of reward does not appear to significantly affect acquisition or extinction; variation in delay of reward does retard response strength in acquisition and yield greater resistance to extinction, although as previously mentioned, long delays should probably be more accurately viewed as omission of reinforcement and thus the results are easily accounted for on the basis of typical partial reinforcement findings rather than due to variation in delay per se. Two of the studies cited (Mackintosh, 1955; Mc Clelland & Mc Gown, 1953)

contain methodological weaknesses resulting from either uncontrolled differences in reinforcement schedules, drastic cue changes in extinction trials, or so many variations effected at one time that it is not possible to determine specifically which parameters generated the effects reported. The studies involving variation in drive present contradictory results, and it would appear that the only study yielding differences due to qualitative variation of a single type is that of Dinoff (1960), although even here his results do not meet customary statistical criteria.

A number of investigators have not found the results cited in studies previously mentioned. Myers (1957) used both candy and tokens on a random basis as rewards for pushing a clown's nose with young children as Ss. She compared 50 and 100 per cent reinforcement groups with the usual finding for the reinforcement effect, but no differences emerging as a result of varying the reward.

Kendler, Pliskoff, D'Amato, and Katz (1957) deprived rats of both food and water. Among the various reinforcement strengths utilized in conditioning on a runway, they employed a schedule in which the animals were presented with food on one half the trials and water on one half the trials on a random basis. In extinction all groups were food deprived but water satiated. A 50 per cent reinforcement group was most resistant to extinction, but all other groups, including that which was administered food and water, extinguished at the same rate.

Freides (1957) trained rats under differing reinforcement schedules in a runway with different color goal boxes. Two groups were run under conditions of 100 per cent reinforcement, and one of these was exposed to

goal boxes of either black or white on varying trials. Freides found no significant differences between these two groups in conditioning or extinction. However, it is possible that the 100 per cent schedule might have served to override the emergence of effects in extinction.

Jencks and Porter (1960) conducted twelve training trials on a six-unit T-maze under three conditions of reinforcement. One group of animals found purina paste on the table at the end of the maze. Another group found the table empty and were picked up immediately upon reaching it. A third group found a new incentive on every training trial. These incentives included cotton, a ladder, food paste, air blast, a strange rat, perfume stick, a dark enclosure, shredded paper, etc. This third group performed in a fashion almost identical with that of the group which was given food paste on every trial.

Katz (1957) trained animals in two runways in a situation in which they were exposed to 50 per cent reinforcement in one runway and 100 per cent in another, versus 100 per cent reinforcement in both runways. Only small differences emerged in acquisition with all the groups asymtoting at about the same running time. In extinction the group conditioned under 100 per cent reinforcement on both runways extinguished faster than either of the groups exposed to some partial reinforcement, although all animals were extinguished on one runway. The partial reinforcement effect is evident, but no control is provided for the stimulus change groups.

Brown and Bass (1958) trained rats on runways which varied in size, floor texture, etc. All animals were trained under conditions of

100 per cent reinforcement and groups were trained under either constant or varied stimulus conditions, and half of each of these groups were shifted to the alternate condition in extinction. No significant differences emerged during acquisition. In extinction there were no significant differences due to exposure to variation in acquisition, but exposure to variation in extinction led to slightly greater resistance to extinction.

Wyke, Kintsch, and Simpson (1960) trained animals to make a single response on a single unit T-maze. Then, after acquisition, administered habit reversal training. They utilized a 4 x 4 factorial design in which drive was varied and constant, and reward was varied and constant during both original training and reversal training. Varied drive in reversal led to more errors in the reversal period, and varied drive and varied reward in original training had no effect on reversal performance. These results seem consistent with those of Brown and Bass which emphasize the importance of stimulus changes during extinction.

Hulicka, Capehart, and Viney (1960) trained animals in a Skinner box in which five stimuli, such as a pellet of food, the click of a solenoid, a flashing light, a red light, and a buzzer, present for all acquisition training could be systematically varied during extinction. They found that the number of responses during extinction increased with the relative number of stimuli present which had been present during conditioning regardless of variations in the particular stimuli.

In the area of verbal reinforcement, only a limited number of studies are available. Wickes (1956) used the terms "fine," "good," and

"all right" in various orders and combinations in reinforcing movement responses on the Rorschach but did not include a condition in which the reinforcing verbalization was held constant.

Salzinger (1959) in a review of this area does not cite any studies in which systematic variation in the verbal reinforcers was employed on a trial-by-trial basis in conditioning, although he does point out that Humphreys' technique allowed for trial-by-trial manipulation which cannot be performed in many other settings.

Krasner (1958) in another review omits all experimentation performed in the Humphreys verbal expectation setting. In the operant studies which he cites, the use of verbal and non-verbal reinforcers or different verbal comments had no effect in conditioning or extinction.

Variation of the reinforcing stimulus might also be viewed within the novel stimulation paradigm. Young (1959) has provided an exceptionally adequate review of this area. Suffice it to say that the relevant literature is both contradictory and confusing with indications that novel stimulation sometimes enhances a given behavior while apparently suppressing the same behavior when a different "novel" stimulus is employed. Much of the difficulty here seems to stem from the fact that no reliable means are yet available for determining both relative and absolute magnitudes with which to compare the various possible stimulus changes except in terms of their empirical effect on behavior. It may be that "novel" encompasses too wide a range of stimulus magnitude to be a useful concept.

III. STATEMENT OF THE PROBLEM

As indicated in the foregoing review of the literature, contradictory evidence exists concerning the effect of variation in the qualitative aspects of the reinforcing stimulus in particular. In the probability conditioning situation which most nearly resembles the experimental history of the human organism, no work is available concerning the effect of variation in terms of the resistance to extinction measures. Furthermore, only a limited number of kinds of reinforcing stimulation have been employed in the probability conditioning framework. The purpose of the present study was to attempt further evaluation of the effects of change in the reinforcing stimulus within a partial reinforcement parameter and in a probability conditioning situation. This study also attempted to determine if the addition of verbal reinforcement, which is perhaps more meaningful to human subjects, would affect behavior significantly, and if any differences emerging from changes in the reinforcing stimulus were also present when the stimulus was partially verbal. Since one of the most significant aspects of behavior is its durability, the present study is designed to focus on the strength of conditioned behavior in extinction.

IV. DEFINITIONS

The term "reinforcement" as used throughout this study was in accordance with the definition proposed by Lowy (1956), and it was considered to be the application of a stimulus which systematically alters the probability of reoccurrence of the behavior immediately preceding it. "Learning" or "conditioning" was defined as a change

in response to a situation resulting from past responses to the same or similar situations and not affected extensively by an interval in which neither the original stimulus nor any similar situation is present (Voeks, 1950). "Extinction" was considered to be the omission of the reinforcing stimulation.

V. HYPOTHESES

1. It was expected that the partial reinforcement effect would again be demonstrated in that the groups exposed to the greater frequency of reinforcement would show higher responding in conditioning and lowered resistance to extinction.

2. In the light of the high degree of stability found in behaviors conditioned in the probability setting, it was hypothesized that no significant difference in response strength in conditioning would result from changes in the reinforcing stimulus during conditioning.

3. Dinoff (1960) proposed that varying the reinforcing stimulus might be viewed as a special case of partial reinforcement. While the nature of such a relationship is not obvious, the hypothesis in the present study was that when reinforcement was administered on a partial basis and at a low enough frequency to allow for differences to emerge in extinction, changing the reinforcing stimulus in conditioning would result in greater resistance to extinction than when the reinforcing stimulus was held constant.

4. No definite hypothesis was offered with respect to the effect of the addition of verbal stimulation in this study. However, if a

significant difference should emerge, it would probably be evidenced in increased responsivity in conditioning and greater resistance to extinction.

CHAPTER III

THE PILOT STUDY

I. INTRODUCTION

The following is a preliminary investigation in which an attempt was made to determine the effect of variation in the reinforcing stimulus during conditioning in an operant situation.

II. SUBJECTS

The *S*s were ten volunteers from an undergraduate psychology class at the University of Alabama. Their age, sex, and I. Q. as estimated from Cureton's (1954) scoring of the Binet Vocabulary are shown in Table I.

III. METHOD

Apparatus

This consisted of the board used by Rickard (1959) and contained five light bulbs arranged in a horizontal row. In this study, the bulbs utilized were of various colors. They were 25 watt General Electric bulbs, and the colors utilized were red, blue, green, yellow, and white. An opaque plastic panel was installed over the back of the lights so that, when one was lit, the entire panel glowed in the appropriate color. This plastic panel also served to prevent the *S* from seeing the various colored bulbs when they were not lit. The *E* could switch on individual lights in any order with switches concealed from *S*'s view. Unfortunately, however, the switches were not a silent type.

TABLE I

IDENTIFYING INFORMATION ON THE TEN SUBJECTS EMPLOYED IN THE PILOT STUDY

S	Age	Sex	Class	Major	Estimated I. Q.
1	21	F	Senior	Business	102
2	19	M	Junior	Physics	133
3	20	F	Senior	Business	98
4	23	M	Graduate	Education	126
5	27	M	Graduate	Pre-Med.	126
6	20	M	Junior	Biology	112
7	20	M	Sophomore	Biology	106
8	21	F	Senior	Math	133
9	22	M	Graduate	Psychology	133
10	19	F	Sophomore	Pre-Med.	109

The S was provided with a small pointer and a plastic-covered table composed of five digit random numbers arranged in column blocks of five numbers with eight such blocks to a row. There were five rows, thus yielding a total of 200 numbers on the page.

Procedure

The experiment was conducted during August, 1959. Ss were utilized as follows: each S was given the table of numbers and instructed to point at a number at the rate of about one every three or four seconds. The S was told that some numbers would be "right" and his task was to point to as many right ones as he could in the fewest possible number of attempts. E explained that he would not speak once the experiment began, but that whenever the S pointed to a correct number, the panel before which S was seated would light.

During this experiment all numbers in the right half of the second row on the table were arbitrarily designated as "right." This encompassed 20 numbers. A criterion of 10 consecutive right responses was used for determining problem solution. This proved adequate in 8 of the 10 cases.

Ss were assigned alternately to two conditions. In the first condition, the individual Ss were exposed to only one of the five lights for all of their correct responses. Thus one S was run with the green light, another with the red light, etc.

Ss in the second condition were exposed to various colored lights for individual correct responses on an arbitrary basis chosen by E. Thus a S might receive the blue light on his first correct response, a yellow light on his second correct response, etc.

The experiment proper was followed by administration of the Binet Vocabulary and questioning of the S concerning his impression of the problem and what he was attempting to do.

IV. RESULTS

Two of the ten Ss were discarded because of deviant behaviors. One S met the criterion in eleven trials by repeatedly pointing at the same number but verbalized an incorrect concept. Instructions were modified so as to preclude this possibility with the remaining Ss. Another S failed to meet the criterion for solution after 250 trials. When halted, he verbalized the correct concept but added that he was "checking out" other areas. It was not possible to determine at what point he had acquired the appropriate hypothesis.

Data for the remaining eight subjects are shown in Table II. Inspection of the table clearly shows a lack of significance in performance under the two conditions. The range of total responses was large in both groups.

V. DISCUSSION AND SUMMARY

Questioning of individual Ss and unexpected problems which arose in the conduct of the experiment point up several weaknesses in this particular design.

For example, three Ss in the varied reinforcement condition quickly learned to respond to the click of E's switches and did not attend to the light panel. One of these Ss was unaware of any variation in light color.

TABLE II

NUMBER OF TRIALS TO CRITERION COUNTING FROM THE FIRST REINFORCED RESPONSE IN THE TWO EXPERIMENTAL CONDITIONS

Changing Reinforcement		Constant Reinforcement		
Subject	Trials	Subject	Trials	Color
S-4	89	S-1	34	Red
S-5	25	S-3	70	Green
S-8	130	S-7	146	Blue
S-10	129	S-9	135	White
Mean	93		96	
Median	109		102	
Range	25-130		34-146	

It, therefore, seems plausible that the click was the most important parameter in determining performance of both groups, thus "washing out" the possibility of differences emerging on the basis of the two experimental conditions. In addition, this particular experimental task was conducted using a 100 per cent reinforcement schedule. The results indicate that many Ss would not reach a criterion solution to the problem under partial reinforcement conditions. This task, therefore, does not lend itself to the study of variation in the reinforcing stimulus across some range of partial reinforcement parameters.

The all-or-nothing nature of the task used here severely restricted the potential amplitude of response strength. It also renders extinction procedures difficult since all subjects have learned a biased approach to the problem--namely that of seeking a correct page area. Furthermore, individual responses could not be adequately specified in that E had no convenient means of recording the location of each response and had to restrict himself to attending to only correct responses. Another more general weakness is that tasks such as this represent a rather restricted portion of the total stimulus situation in the live experience of many organisms, thus inhibiting the generality of results obtained utilizing this particular method.

CHAPTER IV

METHOD

I. DESIGN

The design utilized in this study was an incomplete block design composed of six cells. Four of these cells constitute a factorial design in which the two dimensions of variation were the reinforcement schedule utilized and the presence or absence of change in the reinforcing stimulus. In addition, two cells were used wherein the change in the reinforcing stimulus, i.e., the light, was accompanied by verbalizations by the experimenter which were either held constant or changed from reinforced trial to reinforced trial in conjunction with the lights. Both of these cells were run under conditions of 25 per cent reinforcement. The resulting design thus permitted an evaluation of the effects of changing reinforcing stimulation under two widely separated partial reinforcement schedules and under conditions wherein the reinforcing event was increased in complexity and more directly related to the interpersonal situation found in psychotherapy. A summary of the design is shown in Table III.

II. STATISTICAL TREATMENT

The design of the experiment permitted both parametric and non-parametric analyses. The basic statistics indicated were single and double classification analysis of variance for the over-all evaluation. Additional techniques were to be selected for further analysis of the

TABLE III

EXPERIMENTAL DESIGN SHOWING THE SIX EXPERIMENTAL CONDITIONS
FIFTEEN SUBJECTS WERE ASSIGNED TO EACH CELL

Reinforcement Schedule	
25 Per Cent	75 Per Cent
Reinforcing stimulus (light) held constant	Reinforcing stimulus (light) held constant
Reinforcing stimulus (light) changed on successive reinforced trials	Reinforcing stimulus (light) changed on successive reinforced trials
Reinforcing stimulus (light and verbalization by experimenter) held constant	
Reinforcing stimulus (light and verbalization by experimenter) changed on successive reinforced trials	

sub-groups emerging from the anova treatment. Non-parametric ranking techniques were to be employed for evaluation of sub-groups containing small Ns. Tests based on "splits" such as the Fisher-Yates Exact Test and the extension of the median test were contemplated, but the extent of overlap in the resulting data rendered them insensitive.

III. THE SUBJECTS

The Ss were volunteers drawn from psychology courses offered at the University of Tennessee. A total of 127 Ss were scheduled for individual appointments with the experimenter. Of this number, ninety-one, or approximately 72 per cent, appeared for the scheduled appointment or made arrangements to appear at another time if they could not meet as arranged. One S was lost due to a failure of the buzzer on the apparatus during the first twelve extinction trials. Fifteen Ss were assigned to each of the six experimental conditions. In the four conditions involving 75 and 25 per cent reinforcement and change or no change in the reinforcing light, the Ss were assigned on a random basis since the data sheets for these conditions were prepared in advance, shuffled, and utilized in the resulting order irrespective of what S appeared. For the two conditions run under the 25 per cent reinforcement schedule in which the experimenter's verbalization was added, the data sheets for these two conditions were also shuffled and Ss utilized in the order in which they appeared. However, these latter two conditions were run after the data had been collected for the four conditions previously mentioned.

The mean age of all Ss was 20.6 years with a range of 17 to 31 years. The mean ages of the six experimental groups ranged from 19.5 years to 22.5 years. While no attempt was made to control for distribution of sex in the volunteer Ss, forty-five males and forty-five females were employed. The breakdown by sex for the six experimental groups was as follows:

I	75 per cent constant color	6 males	9 females
II	75 per cent changing color	6 males	9 females
III	25 per cent constant color	7 males	8 females
IV	25 per cent changing color	8 males	7 females
V	25 per cent constant color and constant verbalization	7 males	8 females
VI	25 per cent changing color and changing verbalization	11 males	4 females

IV. APPARATUS

An original apparatus was devised to allow the experimenter to select the color of the reinforcing stimulus but which prevented the subject from seeing the color before the reinforcement was presented. This was done by constructing a box which measured sixteen inches by twenty-four inches at the base, which was composed of three-quarter inch plywood. The front of the apparatus was ten inches high and twenty-four inches wide. A four and one-half inch square aperture was located with its center six inches from the base and equidistant from the sides of the panel. This aperture was covered with a five-inch square piece of quarter inch opaque, white plexiglass. The plexiglass was affixed to the

panel with four stove bolts. The sides of the apparatus were sixteen inches at the base, ten inches high at the front, and fourteen and one-half inches at the back, and measured seventeen inches by twenty-four inches. The front, sides, and top panels were constructed of quarter inch plywood. Handles were affixed to the sides for ease in transporting the apparatus. The exterior of the apparatus was painted with flat, light grey paint, excepting, of course, the aperture. The back of the apparatus was left open so that the experimenter could manipulate the controls.

The color of the reinforcing stimulus was varied by utilizing 25 watt colored General Electric light bulbs. These were attached to the back of the front panel with a six inch by six inch wooden box surrounding the rear of the aperture. The box was six inches deep and the four sides were covered with krinkled aluminum foil so as to diffuse light. This box was fitted with a removable back on which three stationary standard light sockets were mounted. These sockets were placed at three points equidistant from the center of this board. They were wired in parallel and the leads run through a single hole in the center of the panel. On top of the box, a terminal was constructed so that alligator clips affixed to the leads from the lights could be attached. The interior of the apparatus was also fitted with a data clipboard of standard dimensions over which was located a socket shaded with a standard desk lamp shade and fitted with a 10 watt bulb in order to provide illumination for recording the data. The signal buzzer was also mounted inside the apparatus. It was screwed to the back of the front panel and was of a

standard door bell type. A 10 watt transformer was mounted on the base of the apparatus and wired in the buzzer circuit. Selection of the reinforcing stimulus was controlled by three jackknife switches. These were mounted inside a fiberboard box four and one-half inches high by four and one-half inches wide and five inches deep which was mounted to the base of the apparatus. All parts of the jackknife switches, excepting the contacts, were coated with liquid rubber. In addition, the knife portion of each switch was fitted with an insulated extension which protruded through a one-eighth inch slit in the fiberboard box. The experimenter could thus select the light he wished to operate merely by sliding down one of the three switchblades. This arrangement provided almost inaudible operation of the switches. In fact, several individuals serving as trial subjects were asked to listen for sounds made by these switches and report if they heard such. No one was able to hear them consistently. The apparatus was fitted with three mercury switches and a push button switch for the buzzer, all mounted on a master panel. The experimenter could thereby turn on the light for his data board, activate the buzzer circuit, sound the buzzer, and switch on the pre-selected reinforcing light. The main lead to this panel was standard lamp cord fifteen feet long wound around two posts inside the apparatus. The inside of the apparatus also contained recesses for spare bulbs, pencils, and accumulated data. The interior of the apparatus was painted flat black. When the apparatus was placed on a table of standard height and both _S_ and _E_ were seated in customary straight-backed chairs, the _E_'s arms and shoulders were hidden from the _S_'s view, and when _E_ sat upright, only

his head was visible. In fact, during actual operation, since the E leaned forward recording the data, he was almost completely hidden from the S's view.

The light colors used in this experiment were yellow, green, and red. No judgments of color saturation were obtained since the experimenter was restricted in this respect by available materials. Light intensity was measured with a General Electric model DW68 photo-electric exposure meter. Readings were taken with the meter placed flush against the plexiglass panel. Intensities were as follows:

Yellow - 1,200 foot candles

Red - 45 foot candles

Green - 20 foot candles.

Intensity was found to be constant throughout the illuminated surface of the plexiglass window. In addition, colleagues were asked to view the apparatus with the various lights on and attempt to specify the relative location of the various light bulbs housed therein. No one was able to discriminate bulb location. No attempt was made to equalize the different light intensities, since this would necessitate installing rheostats in individual light bulb circuits. Further, although the intensity did co-vary with color changes, it was felt to be a relatively insignificant dimension of stimulus change. Here again, colleagues were asked to view the various lights, and report on their subjective impression of light intensity. Although many were able to order the intensity correctly, none felt that it was of significant magnitude.

V. REINFORCEMENT SCHEDULES

The data sheet provided for seventy-two conditioning and seventy-two extinction trials. They were duplicated and marked by the experimenter to indicate for any given conditioning trial whether the reinforcement was applied, the color light to be utilized, and, when pertinent, the appropriate verbalization. Twenty-five per cent and 75 per cent partial reinforcement schedules were utilized. They are a slight modification of the schedules used by Lowy (1956) and are identical with those used by Rickard (1959). They are random in nature, excepting that, as outlined by Lowy, certain modifications in the random sequence are effected. The data sheets were marked in sets of fifteen. Within this set of fifteen, five 25 per cent schedules were marked for each of the three reinforcing colors. The 75 per cent schedules were similarly prepared. The manner in which variation in the color of the reinforcement was achieved was as follows. The six possible permutations of the three colors were arranged so that no color appeared twice in succession in the resulting eighteen place sequence. The sequence, using A, B, and C for color designations, was as follows: ABCBCACABACBCBABAC. It can be seen that the color of the reinforcer changed on every reinforced trial. In the 25 per cent schedule, this eighteen place sequence was exposed to the S only one time, since only eighteen reinforced trials occurred. In the 75 per cent case, the S was exposed to this sequence three times, but it was presumed that there was little likelihood of any S learning the entire sequence on three exposures, and in fact, none of the Ss utilized even attempted to verbalize the order in which the different color lights

appeared. In the set of five data sheets described previously, 25 per cent schedules for the changing lights were marked so that the three lights utilized appeared at least once at each position of the reinforcement sequence. The three 75 per cent schedules were prepared in the same fashion. The trials reinforced in the two schedules are shown in Appendix A.

In the two conditions employing the addition of a verbalization by the experimenter, the three verbalizations utilized were: "Keep guessing." "Okay." and "All right." These particular phrases were selected on the basis of appropriateness in terms of whether S's guess was correct or incorrect, and in order to keep S responding. The verbalization was spoken simultaneously with the illumination of the reinforcing light. In the constant color and constant verbalization condition, the five Ss were administered each of the three verbalizations. Within each of these subject groups, the light employed was associated with the particular verbalization for either one or two Ss. The lights were assigned in such a manner that the three colors were represented five times each in the total group of fifteen Ss, but any one light did not appear more than two times with any one verbalization. In the condition where the light and verbalization were both changed, the verbalization also occurred simultaneously with the illumination of the light. For any given S the same verbalization accompanied a single color light, for example, "okay" would be spoken every time the red light was illuminated, "keep guessing" every time the yellow light was illuminated, etc. However, within the group of fifteen Ss, the association of the

verbalization was varied so that "okay" might accompany the green light with one S, the yellow light with another S, and the red light with yet another S.

VI. PROCEDURE

This experiment was conducted in an experimental cubicle in the Psychological Laboratories at the University of Tennessee during the period February 4, 1960, to June 28, 1960. It was not possible to control temperature in this room and, since various activities were taking place outside and in other rooms in the laboratories, the factor of extraneous noise was also not controlled. Ss were run at times of the day varying from 8:00 a.m. to 8:00 p.m., depending upon E's schedule and the time when the Ss were available. Ss were seen on all days of the week, excepting Sunday. Ss were scheduled so that the E completed work with one S and dismissed him or her before another S appeared. By so doing, the possibility of a S hearing the instructions or responses of a previous S before himself serving was precluded.

Each S was greeted by the experimenter in a classroom adjoining the experimental cubicle. The S was then brought to the experimental booth and seated before the apparatus. At this point, E inquired into such factors as the S's major field and conversed with each S briefly in an attempt to establish a working relationship. Each S was then told that the experiment did not involve an evaluation of him personally and that he was serving as part of various experimental groups. They were also told that E was not investigating intellectual, emotional,

or personality factors but was working in an area that was essentially exploratory. E also requested that S not discuss the experiment with other students until informed by E that it would be all right to do so. The S was also told that arrangements would be made for him to secure some knowledge of the results of this study. No S reported hearing anything of the experimental procedures before his appointment with E. Feedback was provided to the Ss by E in the following manner. Near the termination of each academic quarter, E visited each of the classrooms from which he had secured subjects during that quarter and outlined the nature of the problem to the class. The class was then told how far the work had progressed to that date, and provided with E's best estimate of the emerging results at that time. In the case of those Ss utilized at the University of Alabama in the pilot study, E communicated with them by letter after completing the first four experimental conditions of the main problem, and a copy of that letter is provided in Appendix B.

After each individual S was given the preliminary information previously mentioned, E closed the venetian blind covering the one window in the experimental booth and illuminated a single overhead bulb enclosed in a frosted globe. The E then took his seat on the other side of the table behind the experimental apparatus and administered the following instructions:

> I am going to sound a buzzer like this (demonstration). Each time the buzzer sounds you are to guess whether or not the square panel in front of you will light up. If you think it will light, call out "yes." If you don't think it will light, call out "no." Sometimes the panel will light and sometimes it will not. If you guess "yes" when the buzzer sounds and the panel does light, this shows you are right. On the other hand, if you guess "no" and the panel does not light, this

> also means that you are right. Your job is to see if the light and the buzzer follow any sort of pattern. They may and they may not. Try to get as many of your guesses right as possible. Remember, you are to call out "yes" or "no" every time the buzzer sounds. Continue until I tell you to stop. Do you have any questions? I will not be able to answer any questions after we begin.

On rare occasions when questions were asked about the instructions, they were answered with a repetition or paraphrasing of the detail in question. After asking the S if he were ready, E then proceeded with the treatment proper. Each S was administered seventy-two conditioning trials and seventy-two extinction trials. Following this, E questioned each S as to general impressions about the experiment and any system which S may have utilized in arriving at his guessing. In those groups where the color of the reinforcing light changed during the conditioning phase, the S was asked directly, if he had not already mentioned it, whether or not he was aware of the change in the color of the lights and if he attempted to utilize these changes in arriving at his guesses. In only one case did a S report some confusion as to the colors of the lights utilized. This S was administered the Isihara test for color weakness and performed successfully on all patterns in this test.

The inter-trial interval, as determined by E's subjective estimate, was maintained at a two to three second duration. Since the duration of individual trials was affected by the latency of the S's response, consistent control of this variable was not possible. However, if a S asked how long he would have to make his guess, he was told that there was no time limit, but that it was not necessary to consider an individual response very long. Response latency for all Ss never appeared to exceed five seconds and most responded immediately following the cessation of the signal buzz.

CHAPTER V

RESULTS

I. CONDITIONING

Table IV presents the summarized data for all six experimental groups in terms of the number of "yes" responses during the last twenty-four conditioning trials. The response strength is also expressed as a percentage of total possible responses, and inspection of the table clearly shows that the two 75 per cent groups performing close to the frequency with which they were reinforced. In the case of the four groups reinforced at the 25 per cent level, all of the groups exceeded the 25 per cent response strength by about 3 to 9 per cent. Lowy (1956) and Rickard (1959) have shown the operant strength of the "yes" response in similar populations to be about 58 per cent, and the effect of the reinforcement schedules utilized here is evident in the table. Appendix D presents the S by S data for the various experimental conditions and for the complete block of seventy-two conditioning trials. Inspection of Table IV shows the widely divergent differences in performance between the 25 and 75 conditions. Within these parameters the groups were strikingly similar, and no extensive analysis was needed to demonstrate the null hypothesis of insignificant variation within a given reinforcement schedule. One of the most sensitive tests available, the F-range (Jenkins, 1956b), yielded p values of only .18 and .17 for differences within the 75 per cent and 25 per cent groups respectively.

For those groups exposed to constant reinforcing change of

TABLE IV

THE MEAN, VARIANCE, MEDIAN, AND RANGE OF THE NUMBER OF "YES" RESPONSES DURING THE LAST TWENTY-FOUR CONDITIONING TRIALS IN EACH OF THE SIX EXPERIMENTAL CONDITIONS. MEAN NUMBER OF RESPONSES ARE ALSO SHOWN, IN PARENTHESES, AS PERCENTAGES OF TOTAL POSSIBLE RESPONSES

Condition	Mean	Variance	Median	Range
75 per cent constant color	19.1 (79.7)	3.4	19	16 - 22
75 per cent changing color	17.8 (74.2)	11.6	18	10 - 22
25 per cent constant color	8.1 (33.6)	8.5	8	3 - 13
25 per cent changing color	8.1 (33.6)	8.2	8	4 - 12
25 per cent constant color and constant verbalization	6.8 (28.3)	4.8	7	3 - 10
25 per cent changing color and changing verbalization	7.9 (32.8)	8.5	8	4 - 13

stimulation, the sub-groups exposed to particular reinforcing changes, such as each of the three individual lights and each of the three individual verbalizations, were compared by a rank analysis of variance (Siegel, 1956), and no differential responsivity to any one of the kinds of stimulus changes utilized was found. The complete rankings and probabilities are in Appendix C.

II. EXTINCTION

The three primary measures of extinction behavior recorded were: absolute number of "yes" responses over the entire seventy-two extinction trials, the per cent of "yes" responses in extinction using as a baseline for each subject the number of "yes" responses emitted during the last twenty-four conditioning trials multiplied by a factor of three, and the number of trials to the last "yes" response emitted before fifteen consecutive "no" responses. The latter was selected as a criterion for extinction of the response. Appendix E shows complete extinction data for each S as well as number of "yes" responses emitted during extinction in blocks of twelve trials.

Table V shows the summarized data for the number of "yes" responses emitted in extinction. Most noteworthy here are the inflated variances for the 75 per cent changing color group and the 25 per cent changing color and changing verbalization group. The extreme variance in both these groups was due to the presence of one rather deviant S within each group. In the 75 per cent group, one S emitted "yeses" throughout extinction and, when questioned about his performance, stated that since he

TABLE V

THE MEAN, VARIANCE, MEDIAN, AND RANGE OF THE NUMBER OF "YES" RESPONSES DURING THE SEVENTY-TWO EXTINCTION TRIALS IN EACH OF THE SIX EXPERIMENTAL CONDITIONS

Condition	Mean	Variance	Median	Range
75 per cent constant color	9.9	81.1	6	3 - 39
75 per cent changing color	11.3	296.7	6	3 - 72
25 per cent constant color	9.5	32.9	9	2 - 21
25 per cent changing color	11.1	42.3	9	4 - 23
25 per cent constant color and constant verbalization	11.5	24.9	10	4 - 17
25 per cent changing color and changing verbalization	15.4	127.8	13	1 - 38

could not tell exactly when the reinforcing light would appear he decided to stick to the "yes" response since he felt the chances were just as good that the light would come on as that it would not. This *S*'s performance was extremely atypical for that of his experimental condition, but excluding his performance from the data would serve only to render the summarized data for his group as a whole more like that of the comparable 75 per cent constant color condition, and it was decided to include his performance unless a significant difference emerged which might be attributed to the deviant behavior of this one *S*. The deviant *S* in the 25 per cent changing color and changing verbalization group emitted only one "yes" throughout extinction and that on the seventeenth trial. This *S* stated that she had decided to wait and see if the reinforcing light would ever come on before risking another "yes" guess. Here again the decision was to include this *S*'s performance since exclusion would serve to render the summarized data for that experimental condition more like that of its comparable control condition and it did not seem necessary to exclude this *S* unless her performance might have resulted in a spurious rejection of the null hypothesis.

A single classification analysis of variance was performed on the data for number of "yes" responses in extinction across all experimental conditions. Hartley's Test of Homogeneity of Variance (Edwards, 1954) required rejection of homogeneity at the 5 per cent level. However, a recent article by Boneau (1960) demonstrates that the classical *t*-test is only inconsequentially affected by violation of the underlying assumptions, and that the same observation applies to the *F* distribution which

is, of course, simply the distribution of t squared. Boneau demonstrates, for example, that with a sample size of fifteen per group and equal N's, if the underlying population distribution is assumed to be nearly the same shape, that at the 5 per cent level the true probabilities will lie within 1 per cent of the nominal value yielded by the t test. Even with sample sizes as small as five, the resulting range of error is only 3 per cent. For these reasons the analysis of variance was judged to be the best over-all evaluative technique with the present data. Table VI presents the results of the single classification analysis for the number of "yes" responses in extinction, and the resulting probability of .44 suggests that the experimental groups do not differ significantly on this measure.

Table VII shows the summarized data for the per cent of "yes" responses emitted in extinction as this measure has been previously defined. The variances shown in this table were not homogeneous as estimated by Hartley's test, and homogeneity was rejected at the .002 level. Single classification analysis of variance as shown in Table VIII for this measure yielded a probability of .0004. The Tukey Gap Test (Edwards, 1954) was then applied to determine which, if any, groups might separate. Choosing the two-sided 5 per cent significant level yielded a smallest significant difference of 20.80 which does not separate any two adjacent means.

A double classification analysis of variance was then performed on the two 75 per cent reinforcement groups and the two 25 per cent reinforcement groups which were not exposed to verbal stimulation by the experimenter in order to evaluate the effects of reinforcement schedules,

TABLE VI

SUMMARY OF THE SINGLE CLASSIFICATION ANALYSIS OF VARIANCE FOR NUMBER OF "YES" RESPONSES IN EXTINCTION ACROSS ALL EXPERIMENTAL CONDITIONS

Condition	Mean
75 per cent constant color	9.9
75 per cent changing color	11.3
25 per cent constant color	9.5
25 per cent changing color	11.1
25 per cent constant color and constant verbalization	11.5
25 per cent changing color and changing verbalization	15.4

Source	Sum of Squares	df	Mean Squares	F
Between	326	5	65.2	.6
Within	8472	84	100.9	
Total	8798	89		

P .44

TABLE VII

THE MEAN, VARIANCE, MEDIAN, AND RANGE OF THE PERCENTAGE OF "YES" RESPONSES IN EXTINCTION IN EACH OF THE SIX EXPERIMENTAL CONDITIONS

Condition	Mean	Variance	Median	Range
75 per cent constant color	18.3	372.6	11.7	4.7- 81.2
75 per cent changing color	23.4	1390.1	10	4.5-150
25 per cent constant color	39.9	487.9	37	16.5-100
25 per cent changing color	49.3	845.9	36	16.6-100
25 per cent constant color and constant verbalization	58.4	513.6	60	16.7-111.1
25 per cent changing color and changing verbalization	62.2	1376.9	53.9	6.7-126.7

TABLE VIII

SUMMARY OF THE SINGLE CLASSIFICATION ANALYSIS OF VARIANCE FOR PERCENTAGE OF "YES" RESPONSES IN EXTINCTION ACROSS ALL EXPERIMENTAL CONDITIONS

Condition	Mean
75 per cent constant color	18.3
75 per cent changing color	23.4
25 per cent constant color	39.9
25 per cent changing color	49.3
25 per cent constant color and constant verbalization	58.4
25 per cent changing color and changing verbalization	62.2

Source	Sum of Squares	df	Mean Square	F
Between	24409	5	4881.8	5.9
Within	69542	84	827.9	
Total	93951	89		

P .0004

change in the reinforcing stimulus, and possible interaction. As Table IX shows, the resulting probability of .012 indicates significant differences, and the breakdown of the between sum of squares shows the reinforcement parameter to be the significant variable with the change and interaction variables contributing very little to the significant variance. In this instance also homogeneity of variance was rejected at the 1 per cent level. The double classification anova was also performed for the four 25 per cent reinforcement groups in order to evaluate the change parameter, the addition of verbal stimulation, and interaction effects, if any. Homogeneity of variance was rejected at the .002 level and the resulting analysis is shown in Table X. The over-all analysis does not yield a p significant at the 5 per cent level, but the breakdown of the between sum of squares does indicate significance for the verbalization parameter with a p value of .04. Here again the change and interaction variances are clearly non-significant.

Table XI presents summary data on the extinction criterion measure. Homogeneity of variance was rejected at the 5 per cent level, and the single classification analysis of variance shown in Table XII yielded an over-all probability of .10. Double classification analysis was performed on this measure for the reinforcement and changing reinforcement parameters and is shown in Table XIII. Here homogeneity of variance could not be rejected at the 50 per cent level. The over-all probability of .31 lacks significance, but the reinforcement parameter yields a p value of .08 which approaches the 5 per cent level and is consistent with the findings on the percentage of "yeses" measured. Double classification

TABLE IX

SUMMARY OF THE DOUBLE CLASSIFICATION ANALYSIS OF VARIANCE FOR PERCENTAGE OF "YES" RESPONSES IN EXTINCTION ACROSS THE CHANGING COLOR AND REINFORCEMENT PARAMETERS

Condition	Mean
75 per cent constant color	18.3
75 per cent changing color	23.4
25 per cent constant color	39.9
25 per cent changing color	49.3

Source	Sum of Squares	df	Mean Square	F	P
Between	9270.6	3	3090.2	4.0	.012
Within	42879.1	56	765.7		
Total	52149.7	59			
Change	770.4	1	770.4	1.0	.29
Reinforcement	8425.4	1	8425.4	11.0	.002
Interaction	74.8	1	74.8	.1	.38

TABLE X

SUMMARY OF THE DOUBLE CLASSIFICATION ANALYSIS OF VARIANCE FOR PERCENTAGE OF "YES" RESPONSES IN EXTINCTION ACROSS THE CHANGING REINFORCEMENT AND VERBALIZATION PARAMETERS

Condition	Mean
25 per cent constant color	39.9
25 per cent changing color	49.3
25 per cent constant color and constant verbalization	58.4
25 per cent changing color and changing verbalization	62.2

Source	Sum of Squares	df	Mean Square	F	P
Between	4402.1	3	1467.4	1.8	.18
Within	45028.9	56	804.1		
Total	49430.0	59			
Change	646.8	1	646.8	.8	.31
Verbalization	3634.8	1	3634.8	4.5	.04
Interaction	120.4	1	120.4	.2	.38

TABLE XI

THE MEAN, VARIANCE, MEDIAN, AND RANGE OF THE NUMBER OF TRIALS TO THE EXTINCTION CRITERION IN EACH OF THE SIX EXPERIMENTAL CONDITIONS

Conditions	Mean	Variance	Median	Range
75 per cent constant color	19.2	389.4	10	3 - 72
75 per cent changing color	18.2	333.8	14	3 - 72
25 per cent constant color	26.9	365	25	6 - 72
25 per cent changing color	28.7	417	22	9 - 72
25 per cent constant color and constant verbalization	31.0	373.9	26	6 - 72
25 per cent changing color and changing verbalization	37.2	639.2	29	0 - 72

TABLE XII

SUMMARY OF THE SINGLE CLASSIFICATION ANALYSIS OF VARIANCE FOR TRIALS TO EXTINCTION CRITERION ACROSS ALL EXPERIMENTAL CONDITIONS

Condition	Mean
75 per cent constant color	19.2
75 per cent changing color	18.2
25 per cent constant color	26.9
25 per cent changing color	28.7
25 per cent constant color and constant verbalization	31
25 per cent changing color and changing verbalization	37.2

Source	Sum of Squares	df	Mean Square	F
Between	3927	5	785.4	1.9
Within	35211	84	419.2	
Total	39138	89		

P .10

TABLE XIII

SUMMARY OF THE DOUBLE CLASSIFICATION ANALYSIS OF VARIANCE FOR TRIALS TO EXTINCTION CRITERION ACROSS THE CHANGING COLOR AND REINFORCEMENT PARAMETERS

Condition	Mean
75 per cent constant color	19.2
75 per cent changing color	18.2
25 per cent constant color	26.9
25 per cent changing color	28.7

Source	Sum of Squares	df	Mean Square	F	P
Between	1275.8	3	425.3	1.1	.31
Within	21071.5	56	376.3		
Total	23347.3	59			
Change	2.8	1	2.8	.01	.39
Reinforcement	1242.2	1	1242.2	3.3	.08
Interaction	30.8	1	30.8	.1	.38

was also performed on the four 25 per cent conditions as shown in Table XIV and homogeneity of variance could not be rejected at the 50 per cent level. Again the over-all probability of .40 is not significant while the verbalization parameter again approaches significance.

At this point it was clearly evident that changes in the reinforcing stimulus had no significant effect on extinction behavior in this experimental setting. However, the expected partial reinforcement effect does emerge with the lower reinforcement schedule yielding greater resistance to extinction on a response unit basis and possibly on the criterion measure. In order to verify those effects which the analysis of variance had suggested as significant, classical t-values were computed for those groups in which the F ratio approximated the 5 per cent level of significance but did not fall below it. Table XV shows the values and probabilities for two such comparisons. It can be seen that the verbalization by the experimenter does significantly affect response strength as measured by the "yes" percentage in extinction. The p-value provided in the table is a two-tailed test. The criterion measure significantly separates the two reinforcement conditions when a one-tailed test was utilized. The results of this analysis thus support the analysis of variance findings.

Since the statistical procedures presented thus far were all of a parametric nature, it was decided that further analysis with non-parametric techniques was indicated in order to control for the remote possibility that previously reported significant findings were generated by the few outlying cases. Table XVI presents the results of the Mann-Whitney U

TABLE XIV

SUMMARY OF THE DOUBLE CLASSIFICATION ANALYSIS OF VARIANCE FOR TRIALS TO EXTINCTION CRITERION ACROSS THE REINFORCEMENT CHANGE AND VERBALIZATION PARAMETERS

Condition	Mean
25 per cent constant color	26.9
25 per cent changing color	28.7
25 per cent constant color and constant verbalization	31
25 per cent changing color and changing verbalization	37.2

Source	Sum of Squares	df	Mean Square	F	P
Between	909.9	3	303.3	.7	.40
Within	25088.0	56	448.0		
Total	25997.9	59			
Change	239.0	1	239.0	.5	.33
Verbalization	601.7	1	601.7	1.3	.25
Interaction	68.3	1	68.3	.2	.38

TABLE XV

CLASSICAL t VALUES FOR THE COMBINED 25 PER CENT GROUPS WITHOUT VERBALIZATION VERSUS THE COMBINED 25 PER CENT GROUPS WITH VERBALIZATION ON THE "YES" PERCENTAGE MEASURE, AND FOR THE COMBINED 75 PER CENT GROUPS VERSUS THE COMBINED 25 PER CENT GROUPS WITHOUT VERBALIZATION ON THE EXTINCTION CRITERION MEASURE

	Measure			
	"Yes" Percentage		Criterion	
	25 Per Cent Without Verbalization	25 Per Cent With Verbalization	75 Per Cent Without Verbalization	25 Per Cent With Verbalization
Mean	44.6	60.3	18.7	27.8
Variance	735.3	1038.7	361.4	405.1
t	2.1		1.8	
P	.045		.038	

Test for the 25 per cent reinforcement groups combined on the presence or absence of the experimenter verbalization parameter, and the constant versus changing reinforcement stimulus conditions for the per cent "yes" measure, as well as the reinforcement schedule comparison and the presence or absence of the experimenter verbalization comparison on the criterion measure. The resulting probabilities are remarkably consistent with the previously stated findings, and it appeared that the partial reinforcement effect may be said to emerge whether a response unit or a criterion measure is utilized. The effects of change in the reinforcing stimulus utilized in the present study remained clearly negligible. The addition of verbal reinforcing stimulation by the experimenter emerged as a significant factor on at least one of the extinction measures (percentage of "yes" responses), but this effect was not so clear with the criterion measure.

At this point it seemed appropriate to assess at which interval in the extinction trials the effects previously cited began to emerge. Inspection of the extinction data suggested that the effects were appearing rather early in extinction (but not immediately) and response strength tapered off rather drastically in all groups during the latter half of extinction. Table XVII presents a breakdown of the number of "yes" responses emitted in all experimental conditions in extinction trials 13 to 24 inclusive. Using the grand median as the separation point, the number of Ss emitting fewer than the median number of "yes" responses may be seen to progressively decrease from the 75 per cent constant color condition through the 25 per cent changing color and changing verbalization condition, while a corresponding increase

TABLE XVI

MANN-WHITNEY U TEST PROBABILITIES FOR THE COMPARISONS INDICATED

"Yes" Percentage	P	Measure Criterion	P
25 per cent without verbalization versus 25 per cent with verbalization	.023	75 per cent without verbalization versus 25 per cent without verbalization	.007
25 per cent constant reinforcer versus 25 per cent changing reinforcer	.312	25 per cent without verbalization versus 25 per cent with verbalization	.20

TABLE XVII

SHOWING NUMBER OF SUBJECTS PER EXPERIMENTAL GROUP FALLING BELOW AND AT OR ABOVE THE GRAND MEDIAN ON NUMBER OF "YES" RESPONSES DURING EXTINCTION TRIALS 13 THROUGH 24

Condition	Below Grand Median	At or Above Grand Median
75 per cent constant color	11	4
75 per cent changing color	9	6
25 per cent constant color	7	8
25 per cent changing color	6	9
25 per cent constant color and constant verbalization	5	10
25 per cent changing color and changing verbalization	4	11

in Ss responding at or above the median is evident. It would, therefore, appear that the effects previously reported could be demonstrated with fewer extinction trials than were utilized in this experiment.

CHAPTER VI

DISCUSSION

While the partial reinforcement effect and the increased resistance to extinction as a function of verbal stimulation by the experimenter are evident, the variability on a S by S basis in all conditions is marked. Jenkins and Stanley (1950) noted that a partial reinforcement schedule is characterized by greater variability in responsivity than a 100 per cent reinforcement schedule. Dinoff (1960) also noted that as the number of variations in the reinforcing stimulus increased, variability in responding also increased. The variability is most pronounced in extinction behavior, although it cannot be stated that responsivity in conditioning was remarkably stable for all experimental subjects.

Of the three extinction measures utilized, the absolute number of "yes" responses emerged as the most insensitive. It would seem primarily due to the fact that such a measure does not reflect differential response strength at the end of the conditioning phase. This weakness is overcome when the "yes" responses are percentagized on the basis of response level in the latter part of conditioning. The latter procedure thus partials out the covariance factor and provides for more adequate evaluation of performance on a subject by subject basis. The sensitivity of the criterion measure utilized in the present study lies somewhere in a position intermediate to the two measures just discussed. The criterion used here was selected prior to the accumulation of the actual data, and since such measures are based on the rather arbitrary judgment of the experimenter,

sensitivity may vary considerably. It is possible, for example, that the effects noted on the percentage response measure may have been just as pronounced had the criterion been set at either ten consecutive "noès" or even twenty consecutive "noès." The criterion measure does, however, provide a more reliable indication of how long behavior persists than do the other two measures.

The reported results are in partial agreement and partially at variance with the hypotheses preceding the study. The partial reinforcement hypothesis was substantiated. The second hypothesis concerning the lack of differences in response strength in conditioning due to changes in the reinforcing stimulus during conditioning was confirmed. The third hypothesis, namely that variation in the reinforcing stimulus would yield significantly greater resistance to extinction, must be rejected. With respect to the effect of verbal stimulation by the experimenter, only an exploratory proposition was offered, but the obtained results are in partial agreement with the anticipated effects of verbal stimulation. Here again responsivity in conditioning is not affected, but significant evidence exists with respect to greater resistance to extinction for subjects exposed to verbal stimulation.

It is not a simple task to ascertain the reason for the failure of a given experimental parameter to generate significant effects. In the present study it is evident that the qualitative changes in the reinforcing stimulation represents such a parameter. It might be possible that the changes introduced in this study were not of a really divergent nature in terms of characteristics of the subject population utilized.

It would be interesting to compare the performance of young children, for example, where it is known that responsivity to colors is much more pronounced than in the adult population.

However, the addition of verbal stimulation by the experimenter did significantly affect extinction behavior. This finding seems most likely due to the fact that the adult human has a large background of experience in learning to respond to verbal stimulation and verbal reinforcement, and such a variable would, therefore, seem to be a much more meaningful stimulus dimension than the illumination of a colored light. It is possible that the mere addition of stimulation whether of a verbal nature of otherwise might account for the present results. This proposition must still remain an experimental question, but the necessary procedures seem quite clear. That is, the reinforcing light might, for example, be accompanied by the sounding of a gong rather than verbalization by the experimenter. The intensity and nature of the reinforcing stimulus must obviously be considered in such studies.

It should be noted that the foregoing parameter also included variation in the reinforcing verbal stimulus. The experimenter found, when addressing groups following accumulation of the data, that while no one specifically mentioned the different reinforcing colors, a number of persons were able to, and commented upon, the three particular verbalizations to which they were exposed. The variation was, therefore, apparently quite evident to the Ss and yet not effective in altering behavior.

The generalization (discrimination) hypothesis advanced by Jenkins

and Stanley (1950) to account for the partial reinforcement effect still remains the best single explanation for the results found in a number of studies since that time. As previously mentioned, Dinoff (1960) hypothesized that the generalization hypothesis might also serve to predict the nature of extinction behavior when variability was introduced in conditioning. It has been shown, for example, that extinction behavior varies quite consistently with the number of cues present in extinction which were also present in conditioning (Hurwitz, 1957; Rickard, 1959; Hulicka, et al., 1960). The qualitative variation utilized herein might be conceptualized as the presence of additional cues which would make the discrimination of extinction procedures more detectable. However, the present results do not directly contradict the generalization hypothesis, for one of the essential characteristics of this formulation is that the particular stimulus characteristics which serve to best discriminate conditioning from extinction are a matter of experimental investigation. Given sufficient data and a thorough knowledge of the organism under study, it is often possible to predict quite reliably which factors will affect discrimination as Lowy (1956) demonstrated.

It may also be that the methodology employed in the present study results in behavior more insensitive to certain kinds of stimulus variation than behaviors conditioned through operant procedures. This proposition might be clarified if an analagous methodology were applied to a wider range of organisms at various developmental levels. Such work has apparently not yet been done, and the implications of such are quite intriguing since at least one investigator (Wilson, 1960), has shown that

an organism lower on the philogenetic scale than man does not respond in a fashion similar to that of human subjects.

It is possible that the probability matching behaviors noted by Estes (1954) and others are a developmental phenomenon. If so, a technique such as this might be implemented within the context of the Hunter-Pascal Concept Formation Test (Pascal & Jenkins, 1959) which attempts to assess behaviors related to development but not necessarily related to intelligence.

The expected result of decreased accuracy in prediction through failure to maximize guesses of the most likely event emerged in the present study, and the number of correct responses during the last twenty-four conditioning trials are shown for all Ss in Appendix D. The mathematical formulation of Estes does not, however, account for the greater resistance to extinction evidenced by the groups exposed to verbal stimulation despite the fact that the behavior of these groups in conditioning is similar to that previously noted by Estes and others.

One aspect of the present study which should also be mentioned is that, while the Ss utilized in the conduct of this research were scheduled and run on an individual basis, most of the previous experimentation involving the present methodology has been performed with Ss run in groups and with more concern for the average group performance than that displayed by individual Ss. The present study could, therefore, bear replication in a group setting in order to further assess the generality of the findings.

It is interesting to speculate as to the implications of these

results in more practical everyday situations. The relative insignificance of variations in the reinforcing stimulus should be of some comfort to psychotherapists and possibly to those concerned with the development of more efficient teaching machines; however, the kind of reinforcing stimulus utilized does appear to be an important parameter in the probability conditioning situation. One rather obvious implication here is that the human therapist as a stimulus may well be an essential component of the therapeutic situation and that program-automated or mechanical therapeutic techniques could be quite limited in effectiveness. Nevertheless, the generality of this consideration must be viewed with respect to the findings pertaining to the conditioning of verbal responses in human subjects through operant techniques. In the latter paradigm many kinds of reinforcing stimuli appear to evidence equivalent properties (Krasner, 1958), although the present study suggests that a more thorough evaluation of this area seems warranted.

Another variation suggested within the framework utilized here is that of changing a different element in the stimulus compound, namely, that of the signal stimulus. It would only be necessary to reverse the order of presentation of stimulation and utilize constant or changing colored lights as the stimuli preceding the aperiodic sounding of the buzzer. Such procedures could be applied to conditioning and extinction in various combinations and might serve as a further test of the applicability of the generalization hypothesis in the present situation. Yet another possibility would be that of instructing the <u>S</u> to predict the cessation rather than the onset of stimulation. Here, the light could

be constantly illuminated and turned off only aperiodically. Such a procedure would lend itself to testing of the cue change (Jenkins, 1956a) interpretation of reinforcing stimulation.

CHAPTER VII

SUMMARY AND CONCLUSIONS

Ninety undergraduate psychology students were individually exposed to one of six experimental conditions. S's task was to verbalize whether or not a light would be presented. All were administered seventy-two conditioning trials in a probability contingent paradigm with seventy-two extinction trials immediately following. The six treatments utilized in conditioning were:

1. Seventy-five per cent reinforcement with a constant color light reinforcer;

2. 75 per cent reinforcement with the color of the reinforcing light changed on each reinforced trial;

3. 25 per cent reinforcement with a constant color light reinforcer;

4. 25 per cent reinforcement with the color of the reinforcing light changed on each reinforced trial;

5. 25 per cent reinforcement with a constant color light reinforcer plus a constant verbalization by the experimenter coinciding with the illumination of the light;

6. 25 per cent reinforcement with the color of the reinforcing light changed on each reinforced trial and the accompanying verbalization by the experimenter also changed.

The typical partial reinforcement effect emerged when the 75 per cent and 25 per cent groups were compared in conditioning and extinction.

No significant differences were evident in conditioning as a function of either the change in the reinforcing stimulus or the verbalization by the experimenter.

In extinction, the change in the reinforcing stimulus again failed to contribute significant behavioral differences. However, the additional reinforcing stimulation of verbalization by the experimenter did yield significantly greater resistance to extinction when the combined verbalization groups were compared to the groups not so treated under the 25 per cent reinforcement schedule. All interactions of reinforcement schedule and other stimulus changes were negligible.

The results were discussed with respect to the generalization hypothesis and two possible explanations for the verbalization effect were offered. One concerned the impact of the reinforcing stimulation in terms of the life history of the organism under study, while the other pertains to the possible effects of complexity of the reinforcing stimulus. Further studies were suggested.

It was concluded that the typical partial reinforcement effect findings were again substantiated, but that systematic qualitative variation in the reinforcing stimulus did not produce similar effects in either conditioning or extinction when the probability conditioning technique is utilized. The latter finding is contrary to that proposed by the present investigator and reported by several previous investigators.

BIBLIOGRAPHY

BIBLIOGRAPHY

Anderson, N. H., and Grant, D. A. A test of a statistical learning theory model for two-choice behavior with double stimulus events. J. exp. Psychol., 1957, 54, 305-317.

Barzun, J. Teacher in America. Garden City, N. Y.: Doubleday and Co., 1955.

Boneau, C. A. The effect of violations of assumptions underlying the t test. Psychol. Bull., 1960, 57, 49-64.

Brand, H., Sakado, J. M., and Woods, P. J. Contingent partial reinforcement and the anticipation of correct alternatives. J. exp. Psychol., 1957, 53, 417-424.

Brand, H., Sakado, J. M., and Woods, P. J. Effects of a random vs. pattern instructional set in a contingent partial reinforcement situation. Psychol. Repts., 1957, 3, 473-479.

Brown, Frances, and Webb, W. B. A study of set effects in the verbal conditioning experiment. Psychol. Repts., 1960, 6, 50.

Brown, J. S., and Bass, Bettina. The acquisition and extinction of an instrumental response under constant and variable stimulus conditions. J. comp. physiol. Psychol., 1958, 51, 499-504.

Capaldi, E. J. The effect of different amounts of alternating partial reinforcement on resistance to extinction. Amer. J. Psychol., 1957, 70, 451-452.

Capaldi, E. J. The effect of different amounts of training on the resistance to extinction of different patterns of partially reinforced responses. J. comp. physiol. Psychol., 1958, 51, 367-371.

Crespi, L. P. Quantitative variation of incentive and performance in the white rat. Amer. J. Psychol., 1942, 55, 467-517.

Cureton, E. E. I. Q. estimates from the Stanford-Binet vocabulary. Unpub. ms., Univ. of Tennessee, 1954.

Dinoff, M. The effect of continually changing reinforcement on learning and extinction. Unpub. Ph. D. diss., Univ. of Tennessee, 1960.

Edwards, A. L. Statistical methods for the behavioral sciences. New York: Rinehart, 1954.

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

Estes, W. K. Theory of learning with constant, variable, or contingent probabilities of reinforcement. Psychometrika, 1957, 22, 113-132.

Estes, W. K., and Burke, C. J. Stimulus variability in learning. Psychol. Rev., 1953, 60, 276-286.

Estes, W. K., and Straughan, J. H. Analysis of a verbal conditioning situation in terms of statistical learning theory. J. exp. Psychol., 1954, 47, 225-234.

Ferster, C. B., and Skinner, B. F. Schedules of reinforcement. New York: Appleton-Century-Crofts, 1957.

Forgays, D. G., and Levin, H. Discrimination and reversal learning as a function of change of sensory stimulation. J. comp. physiol. Psychol., 1959, 52, 191-193.

Freides, D. Goal box cues and pattern of reinforcement. J. exp. Psychol., 1957, 53, 361-371.

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

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

Grether, W. F., and Wolfle, D. The relative efficiency of constant and varied stimulation during learning. II. White rats on a brightness discrimination problem. J. comp. physiol. Psychol., 1936, 22, 365-374.

Guthrie, E. R. The psychology of learning. New York: Harper, 1935.

Herrnstein, R. J., and Morse, W. H. Some effects of response-independent positive reinforcement on maintained operant behavior. J. comp. physiol. Psychol., 1957, 50, 461-467.

Hulicka, Irene, Capehart, J., and Viney, W. The effect of stimulus variation on response probability during extinction. J. comp. physiol. Psychol., 1960, 53, 79-82.

Hull, C. L. Learning: II. The factor of the conditioned reflex. Chapter 9 in A handbook of general experimental psychology. Worcester, Mass.: Clark Univ. Press, 1934.

Hull, C. L. Mind, mechanism, and adaptive behavior. Psychol. Rev., 1937, 44, 1-32.

Humphreys, L. G. The effect of random alternation of reinforcement on

the acquisition and extinction of conditioned eyelid reactions. J. exp. Psychol., 1939, 25, 141-158. (a)

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

Humphreys, L. G. Extinction of psycho-galvanic responses following two conditions of reinforcement. J. exp. Psychol., 1940, 27, 71-75.

Hurwitz, H. M. B., and Cutts, J. Discrimination and operant extinction. Brit. J. Psychol., 1957, 48, 90-92.

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

Jenkins, W. O. Behavior and the contiguity principle. Unpub. ms., Univ. of Tennessee, 1956. (a)

Jenkins, W. O. Quick and dirty statistics: techniques and tables. Unpub. ms., Univ. of Tennessee, 1956. (b)

Jenkins, W. O., and Stanley, J. C. Partial reinforcement: a review and critique. Psychol. Bull., 1950, 27, 193-234.

Jencks, Beata, and Porter, J. B. Need reduction and primary reinforcement: varied goal situations as reinforcement in maze learning of rats. J. Psychol., 1960, 49, 139-143.

Katz, S. Stimulus aftereffects and the partial reinforcement extinction effect. J. exp. Psychol., 1957, 53, 167-172.

Kendler, H. H. Learning. Ann. rev. Psychol., 1959, 43-88.

Kendler, H. H., Pliskoff, S. S., D'Amato, M. R., and Katz, S. Non-reinforcements versus reinforcements as variables in the partial reinforcement effect. J. exp. Psychol., 1957, 53, 269-276.

Krasner, L. Studies of the conditioning of verbal behavior. Psychol. Bull., 1958, 55, 148-170.

Lawson, R. Learning and behavior. New York: Macmillan, 1960.

Lewis, D. J. Partial reinforcement: a selective review of the literature since 1950. Psychol. Bull., 1960, 57, 1-28.

Lewis, D. J., and Duncan, C. P. The effect of partial reinforcement and length of acquisition series upon resistance to extinction of a motor and a verbal response. Amer. J. Psychol., 1956, 69, 644-646.

Logan, F. A., Beier, E. M., and Ellis, R. A. Effect of varied reinforcement on speed of locomotion. J. exp. Psychol., 1955, 49, 260-266.

Logan, F. A., Beier, E. M., and Kincaid, W. D. Extinction following partial and varied reinforcement. J. exp. Psychol., 1956, 52, 65-70.

Longenecker, E. D., Krauskopf, J., and Bitterman, M. E. Extinction following alternating and random partial reinforcement. Amer. J. Psychol., 1952, 65, 580-587.

Lowy, D. G. The effect of random and fixed ratio reinforcement schedules upon conditioning and extinction of a class of verbal behavior. Unpub. Ph. D. diss., Univ. of Tennessee, 1956.

Mackintosh, Irene. The resistance to extinction of responses acquired under irregular conditions of learning. J. comp. physiol. Psychol., 1955, 48, 363-370.

Mackintosh, Irene. Hullian predictions for irregular learning conditions. J. gen. Psychol., 1957, 56, 233-241.

Mc Clelland, D. C., and Mc Gown, D. R. The effect of variable food reinforcement on the strength of a secondary reward. J. comp. physiol. Psychol., 1953, 46, 80-86.

Mc Namara, H. J., and Wike, E. L. The effects of irregular learning conditions upon the rate and permanence of learning. J. comp. physiol. Psychol., 1958, 51, 363-366.

Mc Nemar, Q. Psychological statistics. New York: John Wiley and Sons, 1949.

Mowrer, O. H., and Jones, H. Habit strength as a function of the pattern of reinforcement. J. exp. Psychol., 1945, 35, 293-311.

Myers, Nancy. Extinction of an operant response in children following partial and regular primary and secondary reinforcement procedures. Dissertation Abstr., 1957, 11. 2690.

Osgood, C. E. Method and theory in experimental psychology. New York: Oxford Univ. Press, 1953.

Pascal, G. R. Behavioral change in the clinic. New York: Grune and Stratton, 1959.

Pascal, G. R., and Jenkins, W. O. The Hunter-Pascal Concept Formation Test: an experimental approach to the measurement of cortical capacity. J. clin. Psychol., 1959, 15, 159-163.

Pavlov, I. P. Conditioned reflexes: an investigation of the cerebral

cortex. Trans. and edited by G. V. Anrep. Humphrey Milford: Oxford Univ. Press, 1928.

Pearson, E. S., and Hartley, H. O. *Biometrika tables for statisticians.* Cambridge: Harvard University Press, 1954.

Peterson, L. R. Variable delayed reinforcement. *J. comp. physiol. Psychol.*, 1956, *49*, 232-234.

Pubols, B. H., Jr. Incentive magnitude, learning, and performance in animals. *Psychol. Bull.*, 1960, *57*, 89-115.

Rickard, H. C. Partial reinforcement and generalization. Unpub. Ph. D. diss., Univ. of Tennessee, 1959.

Salzinger, K. Experimental manipulation of verbal behavior: a review. *J. gen. Psychol.*, 1959, *61*, 65-94.

Scott, E. D., and Wike, E. L. The effect of partially delayed reinforcement and trial distribution on the extinction of an instrumental response. *Amer. J. Psychol.*, 1956, *69*, 264-268.

Sheffield, Virginia. Resistance to extinction as a function of partial reinforcement and distribution of practice. *J. exp. Psychol.*, 1949, *39*, 511-526.

Siegel, S. *Nonparametric statistics for the behavioral sciences.* New York: McGraw-Hill, 1956.

Skinner, B. F. The rate of establishment of a discrimination, *J. gen. Psychol.*, 1933, *9*, 302-350.

Skinner, B. F. Two types of conditioned reflex and a pseudo type. *J. gen. Psychol.*, 1935, *12*, 66-77.

Skinner, B. F. The extinction ratio and its modification by a temporal discrimination. *Psychol. Bull.*, 1936, *33*, 784.

Skinner, B. F. *The behavior of organisms.* New York: Appleton-Century, 1938.

Skinner, B. F. *Science and human behavior.* New York: Macmillan, 1953.

Thorndike, E. L. Animal intelligence: an experimental study of the associative processes in animals. *Psychol. Rev., Monogr. supplements*, 1898, 2, No. 4.

Tyler, D. W., Wortz, E. C., and Bitterman, M. E. The effect of random and alternating partial reinforcement on resistance to extinction in the rat. *Amer. J. Psychol.*, 1953, *66*, 57-65.

Verplanck, W. S. The operant conditioning of human motor behavior. Psychol. Bull., 1956, 53, 70-84.

Voeks, Virginia. Formalization and clarification of a theory of learning. J. Psychol., 1950, 30, 341-362.

Watson, J. B. Behaviorism. New York: The People's Institute, 1925.

Wickes, T. A., Jr. Examiner influence in a testing situation. J. consult. Psychol., 1956, 20, 23-25.

Wike, E. L., and Barrientos, G. Runway performance as a function of variable deprivation periods. Psychol. repts., 1960, 6, 37-38.

Wike, E. L., Kintsch, W., and Gutekunst, R. The effects of variable drive, reward, and response upon instrumental performance. J. comp. physiol. Psychol., 1959, 52, 403-407.

Wike, E. L., Kintsch, W., and Simpson, C. D. Habit reversal as a function of irregular drive and reward. Psychol. rec., 1960, 10, 39-46.

Wilson, W. A., Jr. Supplementary report: two choice behavior of monkeys. J. exp. Psychol., 1960, 59, 207-208.

Wolfle, D. The relative efficiency of constant and varied stimulation during learning. J. comp. physiol. Psychol., 1935, 19, 5-27.

Wolfle, D. The relative efficiency of constant and varied stimulation during learning. III. The objective extent of stimulus variation. J. comp. physiol. Psychol., 1936, 22, 375-381.

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

Young, W. A. The effect of cue change and drive on a running response. Unpub. Ph. D. diss., Univ. of Tennessee, 1959.

APPENDICES

APPENDIX A

TABLE OF REINFORCED TRIALS

TABLE XVIII

TRIALS ON WHICH THE REINFORCING STIMULUS WAS PRESENTED

75 per cent			25 per cent
1	26	50	1
3	27	51	8
4	29	52	13
5	30	53	16
6	31	54	18
10	32	56	23
11	34	57	27
13	37	58	29
15	38	59	31
16	39	60	37
17	40	62	38
18	41	64	47
20	43	65	51
21	44	66	55
22	45	68	60
23	46	69	61
24	47	70	64
25	48	71	71

APPENDIX B

LETTER TO PILOT SUBJECTS

Department of Psychology
University of Tennessee
Knoxville, Tennessee

Dear

Perhaps you recall serving as a subject in an experiment I conducted last year--perhaps you don't. The following is the feedback you were promised so long ago.

Your task in this experiment involved finding which numbers were "correct" on a sheet listing many numerals. My problem, briefly, was an attempt to discover if systematic variation in a reinforcing stimulus (in this experiment some subjects were exposed to one color light each time they guessed correctly, while others were exposed to a different color light on each correct guess) resulted in faster acquisition of a habit.

The apparatus and task have been modified considerably, and my work on this question is still continuing. However, a portion of the research is complete, and my findings are essentially negative, i.e., irrespective of the ratio of reinforcement (percent of time the reinforcing stimulus follows a correct response), variation in the color of the reinforcing stimulus during learning or conditioning appears to have no effect on: 1) speed of acquisition, 2) strength of habit, or 3) length of time the habit persists in the <u>absence</u> of reinforcement.

I presently plan to follow up this question using a situation in which the complexity of the reinforcing stimulus is greater. However, interpreting the current results loosely, and for whatever it is worth to you, I suspect that it matters not whether an individual always receives the same token for behaving in an appropriate manner (e.g., ice cream cone for finishing the spinach) or tokens of roughly equivalent stimulus value are used on different occasions (say, ice cream one time, lollipop the next). The latter case, of course, is the one more commonly experienced in the reality of daily living.

May I think you again for your help, and wish you many rewards in the years to come.

Sincerely yours,

Robert E. Taylor

RET:c

APPENDIX C

TABLES OF RESPONSES TO SPECIFIC LIGHTS AND VERBALIZATIONS

TABLE XIX

KRUSKAL-WALLIS ONE-WAY ANALYSIS OF VARIANCE FOR "YES" RESPONSES TO THE YELLOW, RED, AND GREEN LIGHTS DURING THE LAST TWENTY-FOUR CONDITIONING TRIALS FOR THE COMBINED 25 PER CENT AND 75 PER CENT CONSTANT COLOR GROUPS

Yellow		Red		Green	
Responses	Rank	Responses	Rank	Responses	Rank
3	30	6	27	4	29
6	27	7	24.5	9	21
6	27	8	23	9	21
7	24.5	9	21	12	17.5
12	17.5	10	19	13	16
16	14.5	17	12.5	16	14.5
17	12.5	21	3.5	18	11
19	9	21	3.5	19	9
19	9	21	3.5	20	6.5
20	6.5	22	1	21	3.5
Sum of Ranks					
	177.5		138.5		149

χ^2_H 1.06 df 2

P .61

TABLE XX

KRUSKAL-WALLIS ONE-WAY ANALYSIS OF VARIANCE FOR "YES" RESPONSES TO THE VERBALIZATIONS OF "KEEP GUESSING," "OKAY," AND "ALL RIGHT" DURING THE LAST TWENTY-FOUR CONDITIONING TRIALS FOR THE 25 PER CENT CONSTANT COLOR AND CONSTANT VERBALIZATION GROUP

Keep Guessing		Okay		All Right	
Responses	Rank	Responses	Rank	Responses	Rank
3	1	5	4	4	2
5	4	5	4	8	10.5
6	6.5	6	6.5	9	12.5
7	8.5	7	8.5	9	12.5
10	14.5	8	10.5	10	14.5
Sum of Ranks					
	34.5		33.5		52

Hc 2.2

P .18

APPENDIX D

TABLES OF CONDITIONING DATA FOR ALL SUBJECTS

TABLE XXI

INDIVIDUAL SUBJECT DATA FOR CONDITIONING PERFORMANCE IN THE 75 PER CENT CONSTANT COLOR GROUP

S	Age	Sex	Color Used	"Yeses" in Blocks of 24 Trials 1st	2nd	3rd	Total Number of "Correct" Responses in Last 24 Trials
1	18	M	Y	16	16	20	18
2	26	M	Y	15	15	16	16
3	17	F	Y	12	13	17	19
4	18	F	Y	12	17	19	15
5	19	F	Y	12	14	19	19
6	20	M	R	6	15	17	13
7	19	M	R	10	11	21	17
8	18	F	R	15	16	21	17
9	19	M	R	14	17	22	18
10	30	M	R	15	18	21	21
11	20	F	G	12	14	18	16
12	19	F	G	14	18	20	22
13	21	F	G	10	14	16	14
14	18	F	G	12	14	21	17
15	19	F	G	11	19	19	19
Mean:	20.1					19.1	17.4
Median:	19					19	17

TABLE XXII

INDIVIDUAL SUBJECT DATA FOR CONDITIONING PERFORMANCE IN THE 75 PER CENT CHANGING COLOR GROUP

S	Age	Sex	Color Used	"Yeses" in Blocks of 24 Trials 1st	2nd	3rd	Total Number of "Correct" Responses in Last 24 Trials
1	19	F	All	14	10	10	14
2	18	M	All	13	20	18	18
3	18	F	All	11	14	18	16
4	19	F	All	8	14	16	14
5	19	F	All	9	19	20	20
6	22	M	All	12	20	16	16
7	18	M	All	12	14	19	17
8	19	F	All	13	12	20	18
9	21	M	All	15	19	12	16
10	21	M	All	9	14	21	17
11	21	F	All	14	16	22	20
12	20	M	All	12	17	19	17
13	21	F	All	21	21	22	18
14	19	F	All	11	15	16	12
15	18	F	All	14	20	18	20
Means:	19.5					17.8	16.8
Medians:	19					18	17

TABLE XXIII

INDIVIDUAL SUBJECT DATA FOR CONDITIONING PERFORMANCE IN THE 25 PER CENT CONSTANT COLOR GROUP

S	Age	Sex	Color Used	"Yeses" in Blocks of 24 Trials 1st	2nd	3rd	Total Number of Correct Responses in Last 24 Trials
1	19	F	Y	1	4	3	17
2	19	F	Y	9	9	6	14
3	18	M	Y	12	9	6	14
4	19	F	Y	3	6	12	14
5	19	M	Y	8	9	7	17
6	20	F	R	3	5	6	14
7	24	M	R	8	8	9	15
8	19	M	R	10	9	10	12
9	27	M	R	6	7	8	16
10	19	F	R	7	8	7	16
11	19	F	G	4	5	4	14
12	20	M	G	9	10	12	12
13	18	F	G	5	4	9	13
14	19	F	G	9	9	9	15
15	23	M	G	14	14	13	13
Means	20.1					8.0	14.4
Medians	19					8	14

TABLE XXIV

INDIVIDUAL SUBJECT DATA FOR CONDITIONING PERFORMANCE IN THE 25 PER CENT CHANGING COLOR GROUP

S	Age	Sex	Color Used	"Yeses" in Blocks of 24 Trials 1st	2nd	3rd	Total Number of Correct Responses in Last 24 Trials
1	21	M	All	12	10	11	14
2	18	M	All	9	10	7	17
3	21	M	All	2	6	5	17
4	20	M	All	12	12	12	12
5	20	F	All	0	4	5	13
6	18	F	All	6	6	4	16
7	18	M	All	7	12	12	16
8	31	M	All	6	11	9	15
9	19	M	All	7	13	7	17
10	19	F	All	8	5	4	16
11	24	M	All	13	10	7	17
12	21	F	All	6	13	8	16
13	19	F	All	12	9	10	14
14	20	F	All	11	13	12	16
15	19	F	All	3	8	8	16
Mean:	20.5					8.0	15.4
Median:	20					8	16

TABLE XXV

INDIVIDUAL SUBJECT DATA FOR CONDITIONING PERFORMANCE IN THE 25 PER CENT CONSTANT COLOR AND CONSTANT VERBALIZATION GROUP

S	Age	Sex	Color Used	"Yeses" in Blocks of 24 Trials 1st	2nd	3rd	Total Number of Correct Responses in Last 24 Trials
1	23	F	G	15	11	10	14
2	20	F	G	9	5	3	17
3	22	F	R	6	7	5	17
4	23	M	R	9	7	7	17
5	24	M	Y	7	4	6	16
6	24	M	G	6	7	7	13
7	20	F	G	7	3	6	16
8	21	F	R	6	8	5	13
9	20	F	Y	9	12	8	16
10	24	M	Y	8	11	5	17
11	22	F	Y	10	9	10	14
12	26	M	Y	7	7	9	16
13	22	M	R	9	6	9	13
14	24	F	R	8	4	4	15
15	23	M	G	5	9	8	16
Means:	22.5					6.8	15.3
Medians:	23					7	16

TABLE XXVI

INDIVIDUAL SUBJECT DATA FOR CONDITIONING PERFORMANCE IN THE 25 PER CENT CHANGING COLOR AND CHANGING VERBALIZATION GROUP

S	Age	Sex	Color Used	"Yeses" in Blocks of 24 Trials 1st	2nd	3rd	Total Number of Correct Responses in Last 24 Trials
1	23	F	All	4	5	4	16
2	24	M	All	8	7	10	14
3	19	M	All	6	7	6	14
4	19	F	All	8	7	8	16
5	18	F	All	9	6	5	15
6	20	M	All	11	9	9	15
7	21	F	All	10	7	5	17
8	21	M	All	9	9	11	15
9	26	M	All	11	10	11	11
10	19	M	All	13	9	13	11
11	22	M	All	11	8	7	17
12	21	M	All	7	9	10	14
13	20	M	All	6	7	5	19
14	19	M	All	10	7	4	16
15	25	M	All	11	9	10	14
Mean:	21.1					7.8	14.9
Median:	21					8	15

APPENDIX E

TABLES OF EXTINCTION DATA FOR ALL SUBJECTS

TABLE XXVII

INDIVIDUAL SUBJECT DATA FOR EXTINCTION PERFORMANCE IN THE 75 PER CENT CONSTANT COLOR GROUP

S	Total "Yeses" in Extinction	Response Strength in Per Cent	Trials to Extinction Criterion	"Yeses" in Blocks of 12 Extinction Trials 1	2	3	4	5	6
1	9	15.0	13	8	1	0	0	0	0
2	18	37.5	22	12	6	0	0	0	0
3	6	11.7	8	6	0	0	0	0	0
4	4	7.0	6	4	0	0	0	0	0
5	10	17.5	10	9	0	1	0	0	0
6	5	9.7	10	5	0	0	0	0	0
7	6	9.5	11	6	0	0	0	0	0
8	3	4.7	3	3	0	0	0	0	0
9	8	12.0	9	8	0	0	0	0	0
10	6	9.5	10	5	0	1	0	0	0
11	5	9.2	8	5	0	0	0	0	0
12	14	23.3	54	7	3	1	2	1	0
13	39	81.2	72	4	12	9	6	4	4
14	6	9.5	36	3	2	1	0	0	0
15	10	17.5	16	8	1	0	1	0	0
Means:	9.9	18.3	19.2						
Medians:	6	11.7	10						

TABLE XXVIII

INDIVIDUAL SUBJECT DATA FOR EXTINCTION PERFORMANCE IN THE 75 PER CENT CHANGING COLOR GROUP

S	Total "Yeses" in Extinction	Response Strength in Per Cent	Trials to Extinction Criterion	"Yeses" in Blocks of 12 Extinction Trials					
				1	2	3	4	5	6
1	17	56.6	17	7	3	1	1	3	2
2	5	9.2	7	5	0	0	0	0	0
3	4	7.3	9	4	0	0	0	0	0
4	11	22.8	18	6	1	0	2	1	1
5	10	16.6	41	5	2	2	1	0	0
6	72	150.0	72	12	12	12	12	12	12
7	5	8.7	6	5	0	0	0	0	0
8	6	10.0	7	6	0	0	0	0	0
9	3	8.3	14	1	2	0	0	0	0
10	11	17.4	22	8	3	0	0	0	0
11	6	9.0	15	5	1	0	0	0	0
12	4	7.0	3	3	1	0	0	0	0
13	3	4.5	3	3	0	0	0	0	0
14	6	12.5	8	4	0	0	0	2	0
15	6	11.1	31	3	2	1	0	0	0
Means	11.2	23.4	18.2						
Medians	6	10.0	14						

TABLE XXIX

INDIVIDUAL SUBJECT DATA FOR EXTINCTION PERFORMANCE IN THE 25 PER CENT CONSTANT COLOR GROUP

S	Total "Yeses" in Extinction	Response Strength in Per Cent	Trials to Extinction Criterion	"Yeses" in Blocks of 12 Extinction Trials					
				1	2	3	4	5	6
1	4	44.3	6	4	0	0	0	0	0
2	12	66.6	25	6	5	1	0	0	0
3	9	50.0	25	6	2	1	0	0	0
4	9	25.0	35	2	3	3	0	0	1
5	8	38.0	33	3	2	3	0	0	0
6	5	27.6	11	3	0	1	1	0	0
7	7	25.8	16	6	1	0	0	0	0
8	9	30.0	50	5	0	1	1	1	1
9	4	16.6	7	4	0	0	0	0	0
10	21	100.0	72	5	6	3	5	1	1
11	2	16.5	6	2	0	0	0	0	0
12	18	50.0	53	6	5	4	2	1	0
13	6	22.2	19	4	2	0	0	0	0
14	10	37.0	25	6	1	1	1	0	1
15	19	48.6	20	9	7	0	0	0	3
Means	9.5	39.8	26.8						
Medians	9	37.0	25						

TABLE XXX

INDIVIDUAL SUBJECT DATA FOR EXTINCTION PERFORMANCE IN THE 25 PER CENT CHANGING COLOR GROUP

S	Total "Yeses" in Extinction	Response Strength in Per Cent	Trials to Extinction Criterion	"Yeses in Blocks of 12 Extinction Trials					
				1	2	3	4	5	6
1	21	63.6	72	9	4	2	2	2	2
2	6	28.5	15	5	1	0	0	0	0
3	4	26.6	12	4	0	0	0	0	0
4	7	19.4	13	6	1	0	0	0	0
5	11	73.2	37	3	4	1	1	0	2
6	6	50.0	9	6	0	0	0	0	0
7	9	25.0	14	8	1	0	0	0	0
8	23	85.1	22	10	8	0	0	2	3
9	21	100.0	32	10	3	8	0	0	0
10	11	91.5	40	3	3	3	1	0	1
11	7	33.2	31	4	2	1	0	0	0
12	17	70.7	72	4	5	1	1	3	3
13	6	20.0	34	3	2	1	0	0	0
14	13	36.0	19	7	3	0	1	1	1
15	4	16.6	9	4	0	0	0	0	0
Mean:	11.0	49.2	28.7						
Median:	9	36.0	22						

TABLE XXXI

INDIVIDUAL SUBJECT DATA FOR EXTINCTION PERFORMANCE IN THE 25 PER CENT CONSTANT COLOR AND CONSTANT VERBALIZATION GROUP

S	Total "Yeses" in Extinction	Response Strength in Per Cent	Trials to Extinction Criterion	"Yeses" in Blocks of 12 Extinction Trials					
				1	2	3	4	5	6
1	19	63.3	26	9	9	1	0	0	0
2	4	44.4	17	3	1	0	0	0	0
3	9	60.0	39	5	1	2	1	0	0
4	17	81.0	72	6	5	2	1	2	1
5	7	38.9	18	5	2	0	0	0	0
6	15	71.4	40	6	7	1	1	0	0
7	20	111.1	72	6	3	3	3	3	2
8	9	60.0	13	8	1	0	0	0	0
9	7	29.2	26	4	2	1	0	0	0
10	10	66.7	28	6	3	1	0	0	0
11	5	16.7	6	5	0	0	0	0	0
12	12	44.4	20	9	3	0	0	0	0
13	14	51.9	28	6	6	1	0	0	1
14	9	75.0	40	5	2	1	1	0	0
15	15	62.5	21	8	7	0	0	0	0
Mean:	11.4	58.4	31.0						
Median:	10	60	26						

TABLE XXXII

INDIVIDUAL SUBJECT DATA FOR EXTINCTION PERFORMANCE IN THE 25 PER CENT CHANGING COLOR AND CHANGING VERBALIZATION GROUP

S	Total "Yeses" in Extinction	Response Strength in Per Cent	Trials to Extinction Criterion	"Yeses" in Blocks of 12 Extinction Trials 1	2	3	4	5	6
1	4	33.3	23	3	1	0	0	0	0
2	27	90.0	72	6	5	4	5	4	3
3	4	22.2	9	4	0	0	0	0	0
4	13	54.2	40	5	3	4	1	0	0
5	1	6.7	0	0	1	0	0	0	0
6	33	122.2	72	8	10	0	3	1	1
7	14	93.3	17	9	5	0	0	0	0
8	13	39.4	29	5	2	4	0	2	0
9	11	33.3	26	8	2	1	0	0	0
10	21	53.9	72	6	4	5	2	3	1
11	9	42.9	20	7	2	0	0	0	0
12	38	126.7	72	11	7	7	4	4	5
13	5	33.3	13	3	1	1	0	0	0
14	11	91.7	41	5	3	1	1	1	0
15	27	90.0	52	9	10	4	3	1	0
Mean:	15.4	62.2	37.2						
Median:	13	53.9	29						