THE EFFECTS OF METHOD OF TRAINING, SECONDARY REINFORCEMENT, AND OVERLEARNING ON SINGLE HABIT REVERSAL

By

CHARLES H. ANDERSON

Bachelor of Science
Kansas State College
Pittsburg, Kansas
1961

Master of Science
Oklahoma State University
Stillwater, Oklahoma
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Thesis Approved:

William W. Rambo

Thesis Adviser

Henry L. Sisk

Larry T. Brown

Robert W. Scofield

John E. Susky

J. H. Boggs

Dean of the Graduate College

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CHAPTER I

STATEMENT OF THE PROBLEM

Introduction to Problem

The ultimate objective of the psychology of learning is the specification of the conditions governing acquisition and retention of habits in the human organism. Human beings would make the most satisfactory subjects for investigating learning phenomena, if all desirable controls could be imposed upon them. However, psychologists have had to rely upon investigations of behavior of lower organisms in the hope that this might yield data applicable to their objectives. The utilization of lower organisms in psychological research might seem paradoxical to some not familiar with contemporary psychology. The question is frequently asked, "Why study lower organisms?" It might be pointed out, however, that many psychologists are of the opinion that the question needs no rationalization because the investigation of learning phenomena in lower organisms is itself a legitimate area of scientific investigation beyond any practical application it might have with regard to the solution of human problems.

The use of lower organisms in the study of learning phenomena can be justified by both practical and theoretical reasons. In this context, lower organisms are used as tools or instruments of research.

Many questions regarding learning arise whose answers demand a form of operational or environmental technique to which man cannot be submitted. This occurs in researches requiring application of noxious stimuli and prolonged deprivation of substances required for survival. Researches of the relation of early experience on later behavior require a rigid control of certain variables which cannot be imposed on human subjects. In these and other instances lower organisms are the tools by which various parameters are studied. Which organism is used in such researches is determined primarily by practical and economic considerations.

Theoretical reasons specify the use of lower organisms in learning research. Theoretical questions regarding the operation of chemical or hormonal factors, brain mechanisms, and other physiological processes and their implications are of major significance for the psychologist interested in learning phenomena. It is conceivable that after exploration and analysis of the learning of lower organisms the psychologist may be able to make an intelligent guess as to the learning of human beings. The following is concerned with a problem of theoretical interest to learning psychologists for experimental investigation.

The Problem

The problem has its background in the current psychological literature concerning the effects of overlearning upon single habit reversal in the rat. The procedure for investigating habit reversal entails training an organism to make a discrimination response, approach responses to stimulus complex X being reinforced and approach responses to a stimulus Y being extinguished. Upon reaching acquisition criterion the reinforcement is changed to Y and the organism must then learn approach responses to Y and extinguish approach responses to X. Overlearning consists of extended training beyond the initial acquisition criterion. The typical overlearning-habit reversal experiment has consisted of comparing two groups of subjects. One group, the control group, is reversed immediately upon reaching acquisition criterion. The second group, the overlearning group, is reversed after receiving a specified number of training trials beyond the acquisition criterion. The finding that the overlearning group learns the habit reversal significantly faster than the control group has been referred to in the literature as the "overlearning reversal effect (ORE)."

Early investigators reported that the overlearning groups reverse significantly faster than the control groups in both visual and position discrimination tasks. More recent experimental findings have not consistently reported that overlearning facilitates single habit reversal. The literature at this point suggests that there is a greater probability of obtaining ORE in visual discrimination tasks than in position tasks; however, the conditions responsible for the occurrence or non-occurrence of the ORE in both visual and position tasks have not been specified.

The purpose of this research was to investigate experimentally some conditions under which the ORE might occur in simple discrimination situations. Specifically, the purpose of this research was to investigate the importance of three variables to single habit reversal in the rat. These variables were: (1) method of training, (2) secondary reinforcement, and (3) overlearning.

Method of Training: Single habit reversal was investigated using two methods of training; a brightness method of training and a cue-correlated position method of training. In brightness discrimination tasks the organism must learn to respond to the lighter or darker discriminandum to receive reinforcement. The cue-correlated position method consists of having visual cues (brightness) correlated with positional cues in a two-choice situation. The organism must learn a positional response to receive reinforcement.

Secondary Reinforcement: A number of investigators, e.g., Skinner (1938), Saltzman (1949), and Miles (1956) have shown with various organisms that under certain conditions an originally neutral stimulus can acquire reinforcing properties. Hull (1943) states that cues closely and consistently associated in time with a reinforcing state of affairs acquire reinforcement value. The general class of such cues have since been referred to as secondary reinforcers. Secondary reinforcers such as approval, money, prestige, and many others are of unquestioned importance in directing much learning by humans. The mechanism of secondary reinforcement is difficult to analyze in human learning because of the long and complicated history through which it develops.

In discrimination situations secondary reinforcement has two chances to operate: (1) If the correct and incorrect responses terminate in similar goals, differing only in the presence or absence of primary reinforcement, the incorrect response is secondarily reinforced. This should make the discrimination harder for the organism to master than one in which the goal situations are different. (2) If the cue identifying the correct choice has some of the same properties as the goal to which it leads, the positive discriminandum would be a secondary reinforcer and would attract behavior through its incentive function. This investigation was designed to assess the effect on habit reversal of receiving a secondary reinforcing stimulus at the goal when an incorrect response occurs during acquisition as against entering an empty goal box on an incorrect response.

Overlearning: As defined previously, overlearning consists of extended training beyond acquisition criterion. It is apparent that there are many instances in which human behavior is influenced by the overlearning variable. For example, in human verbal learning situations overlearning has been shown to produce less retroactive inhibition; i.e., it reduces the negative influence that learning of one task may have upon the subsequent recall of a previously learned task.

In order to assess the effects of overlearning upon single habit reversal, half of the subjects in this research was reversed immediately upon reaching acquisition criterion. The other half was given fifty overlearning trials before being reversed to the previously negative discriminandum.

Importance of the ORE

Empirical knowledge concerning ORE is important for several reasons: (1) Data from overlearning-reversal studies may help to bridge the gap between the continuity and non-continuity positions with respect to the learning function. The continuity view holds to the position that the learning process is gradual; the non-continuity view has maintained that the learning process is insightful or sudden. Reversal data have demonstrated that practice improves discrimination reversal learning to the point that reversals are solved in one trial. This general finding suggests that learning becomes insightful as a result of abilities developed with practice. (2) Habit reversal with its emphasis on shifting of responses, is a useful analytic technique for studying habit interference--the negative influence that formation of one simple habit may exert upon the subsequent formation of a second habit. In more practical human situations the negative influence occurs when responses learned in one situation are opposite, antagonistic, or unsuitable to those needed in a new situation. For example, Americans in certain foreign countries find it difficult to change from a left-hand drive in traffic that moves on the right to a right-hand drive in traffic that moves on the left; old habits are a handicap in such situations. (3) Since overlearning has been shown to facilitate the subsequent learning of an incompatible response in certain situations, specification of the conditions under which this occurs would enhance our knowledge of transfer phenomena. Transfer occurs when certain elements are common to both the old and new stimuli. Where the similarity of old and new is great, the amount of transfer will be comparably great. Knowing how to drive one type of automobile makes it easier to drive another.

Where overlearning has been found to facilitate reversal a number of explanations have been put forth to explain the ORE. Reid

(1953) has emphasized the learning of a "discriminating response" which makes the subsequent reversal easier. D'Amato and Jagoda (1961) have developed a conflict theory of reversal learning where learning of certain avoidant tendencies assume a major role in ORE. Learning of attentional responses that ensure the organism will attend to the relevant cue during reversal has been considered important by Mackintosh (1965).

Summary

A problem was proposed that has its background in the literature concerning the effects of overlearning upon habit reversal in the rat. Investigation of this problem will provide answers to the following questions:

(1) What are the relative effects of the brightness discrimination method of training and the cue-correlated position method of training upon habit reversal in the rat?

(2) What is the effect on habit reversal in the rat of receiving a secondary reinforcing stimulus at the goal box when an incorrect response occurs during the acquisition of a discrimination response as against the effect of entering an empty goal box?

(3) What is the effect of extending training beyond criterion on habit reversal in the rat?

(4) What are the interactive effects of method of training, secondary reinforcement, and overlearning on habit reversal in the rat?

CHAPTER II

REVIEW OF THE LITERATURE

Preliminary Considerations

Early researches concerned with the ORE concentrated upon testing theoretical explanations of the ORE put forth by Reid (1953). More recently research efforts concerning ORE have taken on a more empirical orientation; that is, attempts have been made to isolate the variables responsible for the occurrence of the ORE. This review will be organized around the type of training procedure utilized, since this appears to be a variable importantly related to the ORE.

Empirical Data Relevant to Investigating the ORE

The ORE and Brightness Discrimination Tasks: The first research that clearly demonstrated the ORE was performed by Reid (1953). Three groups of rats were trained to make a black-white discrimination response in a Y-maze. Upon reaching acquisition criterion one group was reversed immediately, and the other two groups were given 50 and 150 overlearning trials respectively. The group receiving 150 overlearning trials learned the reversal more rapidly than did the subjects of the other two groups. To account for these findings Reid hypothesized that overlearning ensured that the subjects would continue to look at or orient toward the relevant stimuli during reversal. The previous finding that overlearning facilitates reversal was soon confirmed by Pubols (1956) in both brightness and spatial discrimination tasks involving a Y-maze. An explanation similar to Reid's was given to the findings.

Capaldi and Stevenson (1957) tested a prediction from reinforcement theory; namely, that a greater number of reinforcements during acquisition would result in greater resistance to extinction and consequently slower reversal learning. The more highly reinforced group reversed significantly faster than the other two less frequently reinforced groups, thus confirming the ORE. Their results were interpreted in terms of the hypothesis that rate of extinction is a function of the degree to which the pattern of reinforcement is changed on the reversal from the original training problem.

Brookshire, Warren, and Ball (1961) reasoned that Reid's (1953) explanation of ORE in terms of a "discriminating response," which facilitates habit reversal should transfer to and facilitate the learning of other discrimination problems. To test this, they investigated the effect of overlearning trials upon intra- and extra-dimensional discrimination tasks. Two groups of subjects, an overlearning and control, were utilized. Half of each group was given training on a position task and half was given training on a brightness task in a T-maze. Half of the group that learned the brightness discrimination was given reversal training while the other half was trained on a position habit. Half of the group of animals that was trained on the position habit was given reversal training while the other half was trained on brightness discrimination. The rats that received overlearning trials on the original problem reversed more quickly than did their respective control groups, thus confirming ORE. However, the rats that were given overlearning trials on one task and then shifted to the other task did no better than their respective controls. Since overlearning didn't facilitate transfer when the dimensions were changed, the investigators suggested that Reid's (1953) hypothesis is an insufficient explanation of ORE.

Mackintosh (1962), also testing Reid's (1953) hypothesis concerning the acquisition of "a discriminating response," gave 3 groups of rats 0, 75, or 150 overlearning trials on a brightness discrimination task using a jumping stand. Half of the subjects from each group was given reversal training and the other half was given training on a gray vertical-horizontal discrimination. The ORE was obtained for the habit reversal conditions, but overlearning produced negative transfer to the new task, thus again contradicting the "discrimination response" hypothesis, since overlearning didn't facilitate discrimination along a new stimulus dimension.

D'Amato and Jagoda (1960) have characterized reversal learning as follows: At the end of discrimination training, approach tendencies are built up to S+ and S- has strong avoidance tendencies associated with it. To reverse the subjects must extinguish approach tendencies to S+, but more importantly must extinguish avoidance tendencies to the S-. In their opinion the extinction of avoidance responses to the S- is by far the most important. Their explanation of ORE is that very few errors are made during the overlearning trials and this termination of experience with S- leads to a reduction in the avoidance tendencies through generalization of approach tendencies from S+.

D'Amato and Jagoda predicted that if subjects were forced to have a number of experiences with S- during the overlearning trials, reversal learning would be impeded rather than facilitated. Equivalently, overlearning should not facilitate reversal learning in a successive discrimination situation, since avoidance of S- is maintained by the very nature of the situation. As a test of the first prediction, D'Amato and Jagoda (1961) gave three groups of rats training on a brightness discrimination problem. One group was reversed immediately upon reaching criterion. A second group was given 200 overlearning trials, 20 per cent of which were forced to S+, and a third group had 20 per cent of its overlearning trials forced to S-. The group that had forced experience with S- reversed slower than either of the other two groups, thus confirming their hypothesis.

Birch, Ison, and Sperling (1960) tested D'Amato and Jagoda's hypothesis that overlearning shouldn't facilitate reversal learning in a successive discrimination, since avoidance of the negative discriminanda is maintained by the very nature of the situation. Rats were rewarded for running to a white platform and extinguished to a black platform. On any trial only one of the platforms was present. After reaching acquisition criterion the original group of animals was subdivided such that one group received reversal immediately, while the other group received overlearning trials and then reversal training. The overlearning group manifested quicker reversal learning than did the control, thus again confirming ORE, but providing evidence contrary to D'Amato and Jagoda's explanation of ORE. Birch et al. suggested in way of explanation that an increasing number of reinforcements does not lead to greater resistance to extinction.

Not all investigators have reported finding ORE with brightness discrimination tasks. Erlebacker (1963), testing the discrimination hypothesis, found no ORE when reinforcement was given under either continuous or partial conditions. It was concluded from the reversal results that at least two factors are required to explain the partial reinforcement effect and the overlearning reversal effect; after 100 per cent reinforcement differences in learning ability are more important; after partial reinforcement the extinction factor is more important. Paul and Havlena (1963) found no ORE under two conditions of delay of reinforcement. D'Amato and Schiff (1965) failed to find ORE in a series of eight experiments despite the manipulation of a number of possible relevant variables. Some of the variables investigated included the intra-trial interval, strain differences, amount of reward, and a more pronounced change between acquisition and reversal training conditions.

The ORE and Position Discrimination Tasks: For a time the ORE appeared to be a rather well-established phenomenon. One of the first indications that it was not a well-established phenomenon came in a series of four experiments by D'Amato and Jagoda (1962). It will be recalled that D'Amato and Jagoda (1961), using a brightness discrimination task, found that forced trials to the negative discriminandum during overlearning retarded reversal learning. The mentioned series of studies was an attempt to extend this finding concerning forced trials to position reversal learning. In addition, a new control group which previous experiments omitted was introduced to control for the time interval filled by the overlearning trials prior to reversal training, since mere delay between the time that acquisition criterion is reached and reversal training begun might influence reversal training. This group's reversal training was simply delayed until the overlearning group started reversal. The results of the first three experiments were comparable; the only significant outcome was that the groups receiving trials forced to the incorrect side learned the reversal slowest. The delay-control group reversed quickest but not significantly so; no ORE was observed. The fourth experiment eliminated the forced trials procedure and had groups which received 0, 200, 400, or 800 overlearning trials. Again even with an excessive number of overlearning trials, no ORE appeared.

Along the same lines, Paul (1965) reports six experimental attempts by D'Amato and Schiff (1962) to reproduce ORE with a position habit in a Y-maze. All six experiments failed to find ORE. Variables manipulated were: (1) Brightness cues were correlated with positional cues in the Y-maze. (2) The cues in the alleys of the Y-maze were made visible during the intertrial interval. (3) The drinking period in the goal box was lengthened. (4) A more distinct change in stimulus conditions was introduced between acquisition and reversal to make the two procedures more discriminable. (5) A transparent door permitted the animals to see the alleys during the starting interval, which was increased in length. More recently D'Amato and Schiff (1964) reported two more studies in which the stimulus complex associated with the position response was manipulated. In experiment 1 a visual cue was correlated with the positional cue. In experiment 2 the stimulus consequences of an incorrect response were made highly discriminable by associating an abrupt change in illumination with an incorrect response. Despite these manipulations ORE did not occur.

Hill, Spear, and Clayton (1962), report three experiments in which ORE failed to occur in position tasks. In one experiment an attempt was made to compare T-maze reversal learning by four groups of rats that received different patterns of overlearning in acquisition. Reversal was fastest for the group receiving no overlearning and for the group receiving all its overlearning trials forced to the correct side. Free-choice overlearning gave somewhat slower reversal, and overlearning with an equal number of forced trials to the two sides gave much slower reversal. In two subsequent experiments which were run to verify the earlier finding that overlearning facilitates reversal the findings were similar to the first experiment; no ORE was found. Because a fixed number of trials rather than training to criterion was given and no control for the handling variable was utilized, Hill and Spear (1963) repeated the previous studies of Hill et al. (1962); again the overtrained group required significantly more trials to reach the reversal criterion than the control group.

Some investigators have been able to obtain ORE with position tasks. It will be recalled that Pubols (1956) and Brookshire, Warren, and Ball (1961) reported ORE with a position task. Capaldi (1963) replicated Pubol's study using a position task and found that the more highly trained group required fewer trials and errors to meet reversal criterion.

The ORE and the Role of Irrelevant Stimuli: It should be mentioned that the previous studies showing ORE trained rats on problems in which irrelevant cues were present; either rats were trained on brightness tasks with positional cues irrelevant or were trained on positional tasks with irrelevant brightness cues. The investigations not showing ORE trained rats on a position task without irrelevant brightness cues.

Clayton (1963) investigated the hypothesis that the difference between the successes and failures with respect to ORE lay in the presence or absence of irrelevant or extramaze cues during acquisition and reversal. Two degrees of learning (moderate vs. overlearning) were manipulated simultaneously with two irrelevant cue conditions (present vs. absent) during acquisition and reversal of position tasks. The discriminanda defining the irrelevant stimulus condition were: (1) the patterns on the goal box doors, (2) a striped plaque on the floor of the choice point, and (3) the location of black curtains hung on the white walls of the experimental cubicle. The findings were in direct contrast to earlier studies with overlearning significantly retarding reversal in two experiments. The findings also suggested that reversal following overlearning is even more difficult in the presence of irrelevant stimuli. Clayton's conclusion was that the difference between successes and failures in producing ORE cannot lie solely on the irrelevant stimulus dimension. In an earlier study (North and Clayton, 1959) it had been found that overlearning facilitated reversal in a form discrimination situation, but that irrelevant stimuli had no influence upon either learning of the discrimination or reversal.

Mackintosh (1963a), testing the notion that overlearning increases the likelihood that subjects will respond to the relevant stimulus dimension, presents further evidence bearing upon ORE and irrelevant stimuli. In each of two experiments, rats were trained on a brightness discrimination (with or without overlearning) and then extinguished either by withdrawing all reward or by training on a new discrimination with the cues of the first present but irrelevant. The results of relearning tests showed that the extent to which habit strengths to S+ and S- had been equalized by extinction trials was directly related to the amount of original learning. Non-overlearning subjects showed a significantly greater tendency than overtrained subjects to respond in the direction in which they were originally trained.

In another experiment bearing on the irrelevant dimension Mackintosh (1963b), trained rats on a brightness discrimination task and reversed them after giving 0 to 150 overlearning trials. For one group only one irrelevant cue was present throughout the experiment. For two other groups the reversal was learned with a second irrelevant cue. In one case the cue had been present during original learning, in the other it had not. When there were two irrelevant cues overlearning was shown to have a greater facilitating effect on reversal than when there was only one, whether or not the second had been present in original learning. Mackintosh suggests by way of explanation that the effect of overlearning is to increase the probability that responses will be controlled during reversal by the relevant stimulus dimension; that is, overlearning ensures that the organism will attend to the relevant stimulus dimension during reversal.

Summary and Conclusions of Empirical Data Relevant to Investigating the ORE

Analysis of Findings: The ORE has been reported in brightness discrimination tasks by the following investigators: Birch, Ison, and Sperling (1960), Brookshire, Warren, and Ball (1961), Capaldi and Stevenson (1957), D'Amato and Jagoda (1961), Mackintosh (1962), Pubols (1956), and Reid (1953). Negative findings have been reported in eight experiments by D'Amato and Schiff (1965), and one each by Erlebacker (1963), and Paul and Havlena (1964).

In position tasks positive results have been obtained by Brookshire, Warren, and Ball (1961), Capaldi (1963) and Pubols (1956). Negative results have been reported in three experiments by D'Amato and Jagoda (1962); six experiments by D'Amato and Schiff (1962), two experiments by D'Amato and Schiff (1964); three by Hill, Spear, and Clayton (1962); and in one by Hill and Spear (1963).

In situations investigating the influence of irrelevant stimuli the ORE has been reported by Mackintosh (1963a). Negative results have been reported by Clayton (1963), Clayton and North (1959), and by Mackintosh (1963b).

From an examination of the findings the ORE is more likely to occur in brightness discrimination tasks than in position tasks and situations involving irrelevant stimuli. In attempting to account for the ORE many different potentially relevant variables have been manipulated; amount of reward, percentage of reinforcement, intertrial interval, delay of reinforcement, and a more pronounced stimulus change between acquisition and reversal to mention some of the more obvious. In all cases ORE failed to appear. Since the critical variables have not been identified no specific statements can be made concerning the likelihood of appearance of ORE under any three of the training conditions utilized. At the present time the greatest need is for research oriented toward isolating the critical variables responsible for the occurrence of the ORE.

Scope of the Present Research: Relative to certain findings in the literature just reviewed the possible importance of secondary reinforcement as a variable critical to the ORE takes on added significance. Many investigators have not reported the experimental sequence following an incorrect response in a two-choice situation. More specifically, the stimulus complex operating in the incorrect goal box has not always been reported. This stimulus complex could be a potential source of secondary reinforcement for the organism upon making an incorrect response. According to reinforcement theory the presence or absence of secondary reinforcing cues in the learning situation should differentially effect the rate of learning in a discrimination situation. Ehrenfreund (1948) has demonstrated empirically that the presence of a secondary reinforcing stimulus in the incorrect goal box in a brightness discrimination task retards the learning of the discrimination. D'Amato and Jagoda (1960) attest to the possible importance of secondary reinforcement in relation to the ORE in their theoretical explanation of the ORE. They contend that the development of avoidance tendencies toward the negative stimulus is an important factor in establishment of a discrimination, and reversal learning requires the extinction of this avoidance tendency. Further, any event that acts to reduce avoidance tendencies should impede learning the original discrimination, but facilitate reversal.

Consideration of D'Amato and Jagoda's (1960) theoretical explanation of ORE and Ehrenfreund's (1948) finding that learning was retarded by the presence of a secondary reinforcer in a brightness discrimination task gives rise to the following prediction concerning the secondary reinforcement variable: the effect of receiving a secondary reinforcing stimulus in the incorrect goal box during acquisition of a discrimination response will retard learning the original discrimination, but facilitate the subsequent habit reversal, since presumably approach responses are to an extent maintained to the negative discriminandum by the operation of the secondary reinforcer. It is possible that the successful demonstration of the ORE by many investigators could be accounted for by the interaction of secondary reinforcement with overlearning; that is, overlearning might have facilitated reversal because avoidance of the negative stimulus had been reduced by the presence of a secondary reinforcer during acquisition.

The primary purpose of this research is to provide evidence concerning the importance of the secondary reinforcement variable to the ORE in primarily brightness discrimination tasks. If it can be demonstrated that secondary reinforcement is a variable importantly related to overlearning in facilitating reversal, one proposal for future research might be to describe this relationship in more functional terms. This would involve specification of the shape of the function which relates levels of secondary reinforcement to levels of overlearning to facilitate habit reversal. From this relationship one could predict the optimal values for each variable necessary for habit reversal facilitation.

CHAPTER III

METHOD

Experimental Sample

The subjects were 48 naive, male, hooded rats of the Long Evans strain, 80 - 100 days of age at the start of the experiment, and were obtained from Rockland Farms, Rockland, New York.

Apparatus

The experiment was conducted in a room rather uniform in lighting and texture, and contained a minimum of extra-maze cues and auditory distractors. All subjects were wheeled to the experimental room on a portable rack, which held their individual cages.

The experiment proper was performed with a single unit, wooden T-maze with white and black interchangeable arms. A floor plan of the apparatus appears in Appendix A. The entire maze consisted of a 5" x 4" x 9" gray start box, a 5" x 4" x 8½" gray runway, and two arms that measured 5" x 4" x 22". The different compartments were separated by swinging doors which closed behind the subject as it entered the next compartment. The doors were also arranged so as to prevent retracing or correction of a response. Black and white curtains placed 9" from the terminal ends of the arms blocked the subject's view of the food cup before the swinging door closed behind it. The food cup was a clear glass furniture coaster, $2\frac{1}{2}$" in diameter. Noyes standard 45 mg pellets served as the reinforcement on a correct trial. The entire running surface and the top of the maze were covered by $\frac{1}{4}$" hardware cloth. The maze was illuminated by a 25 watt bulb located 4' above the choice point. During preliminary training gray arms or goal boxes with gray curtains were used.

Experimental Design

The experimental design was a 2 x 2 x 2 factorial arrangement of treatments. The three variables manipulated were: (1) method of training (brightness discrimination method and cue-correlated position method), (2) secondary reinforcement (secondary reinforcement and non-secondary reinforcement), and (3) overlearning (0 trial overlearning and 50 trials overlearning). A schematic representation of the design appears in Table I.

Procedure

Adaptation: Upon arrival at the laboratory the subjects were placed on 23-hour food deprivation. For the next four days the subjects were fed five 45 mg pellets in gray goal boxes at the same time as their experimental session was to be scheduled. Immediately after this experience each S was given one hour access to laboratory chow in its home cage. Water was available in the home cages at all times. The 23-hour food deprivation schedule and the one hour daily feeding session were also employed during the subsequent acquisition and reversal conditions. This initial adaptation period served two

TABLE I

SCHEMATIC REPRESENTATION OF THE EXPERIMENTAL DESIGN

Brightness method	0 trials overlearning	Non-secondary reinforcement
		Secondary reinforcement
	50 trials overlearning	Non-secondary reinforcement
		Secondary reinforcement
Cue-correlated method	0 trials overlearning	Non-secondary reinforcement
		Secondary reinforcement
	50 trials overlearning	Non-secondary reinforcement
		Secondary reinforcement

purposes: (1) handling the subjects while placing them into gray goal boxes and returning them to their home cages facilitated taming, and (2) the subjects learned to accept the pellets which were to be given later as reinforcement in the experiment.

Pretraining: The major purpose of the pretraining was to establish the food cup as a secondary reinforcer. The procedure used to accomplish this was similar to that used by Ehrenfreund (1948). On the first day following the adaptation period each subject was given four forced trials to the gray arms of the T-maze; two trials forced to the left arm and two trials forced to the right arm. In order to accomplish the forced responding to the desired arm the swinging door of the alternate arm was simply locked so that the subject could not enter. On each trial the subject was rewarded with two pellets from the glass coaster. For the next four days each subject was given five rewarded trials each day, all forced either to the left or right arm of the maze. Thus, at the termination of pretraining, each subject had 24 rewarded trials forced equally often to both arms of the maze. The forcing procedure was used in an attempt to equalize any position preference of the subjects. Since the glass food cup was associated with eating during this training session, it should have acquired an increment in reinforcing properties.

Acquisition and reversal: The 48 subjects were initially assigned at random to the eight treatment combinations and received pretraining, and 30 acquisition trials. At this time, however, the experiment was terminated and all subjects were placed on an ad lib feeding schedule for seven days. It was felt that termination of the experiment at this time was warranted in order to insure healthy subjects for the completion of the project. Upon resuming the experiment six subjects each were reassigned at random to the eight treatment combinations in order to control for any position and brightness preference acquired during the initial 30 acquisition trials.

The experiment was conducted in two parts. The first part consisted of training subjects in the brightness discrimination group and the second part involved training subjects in the cue-correlated position group. For the subjects trained to make a brightness discrimination, a response to the black discriminandum was positively reinforced for half of the subjects and a response to the white discriminandum was reinforced for the other half of the subjects. This was deemed necessary to control for any brightness preferences of the subjects. The positions of the white and black arms were varied from trial to trial according to predetermined schedules taken from Gellerman (1933) to control for position and alternation patterns.

For the subjects trained to make positional responses it was randomly determined that right-white or right-black was reinforced for half of the subjects and left-white and left-black for the other half of the subjects. Again, this was necessary to control for brightness and position preferences.

All subjects were given 15 massed trials per day. A trial for each subject consisted first of being placed in the start box. Pushing under the start door allowed the subject to run to either arm of the maze with no correction permitted. If the subject chose the correct arm, two pellets were in the glass food cup. On all correct trials the subject was permitted to remain in the goal box 5-10 seconds or until the pellets were ingested. After being removed from the goal box an intertrial interval of approximately 20 seconds followed before the subject was again placed in the start box for another trial. Upon completion of all 15 trials each subject was returned to his individual cage to await feeding.

For the secondary reinforcement group an empty food cup, identical in all other respects to the one found in the correct goal box, was present on each trial. The subjects of the non-secondary reinforcement groups entered an empty goal box. Subjects of both groups were permitted to remain in the goal box 5-10 seconds before being taken out to await the start of the next trial. The preceding description of events on an incorrect trial constituted the manipulation of the secondary reinforcement variable during the acquisition series.

All subjects were trained to a criterion of nine out of ten correct trials with the last five correct. Upon reaching acquisition criterion the subjects of the 0-trial overlearning groups began reversal-training immediately following the last acquisition trial. Subjects of the 50-trial overlearning groups were given 50 post criterion training trials at the rate of 15 trials per day before being reversed to the previously negative stimulus. Reversal training was continued until all subjects had reached a criterion of nine out of ten correct trials with the last five successively correct. The procedure during overlearning and reversal was identical to that during acquisition except that an empty food cup was never present in the incorrect goal box.

Seven subjects were discarded during the experiment: one due to an eye infection, two for failure to acquire the initial discrimination, and four for failure to respond during reversal training. The criterion for rejection was failure to enter one of the arms of the maze within three minutes after leaving the start box for five consecutive daily sessions.

Two dependent variable measures were recorded to assess the effects of the manipulated variables: (1) the total number of trials taken to attain the reversal criterion, and (2) the number of errors made in reaching the reversal criterion. An error was defined as entrance into the incorrect arm of the maze.

CHAPTER IV

RESULTS

This section consists of four parts: the first describes the preparation for the analyses of the manipulated variables; the second gives the results of the analysis of the transformed errors and total trials to criterion in acquisition; the third describes the results of the analysis of the transformed errors occurring in reversal training; the last presents the findings relevant to the total number of trials to attain reversal criterion. The raw data used in the analyses appear in Appendix B. For convenience in referring to the various treatment combinations the following abbreviations will be utilized: method of training (M), brightness discrimination method of training (BMT), cue-correlated position method of training (CMT), overlearning (OL), non-overlearning (NOL), secondary reinforcement (SR), and non-secondary reinforcement (NSR).

Preparation for the Analyses

The statistical analyses of the percentage of errors and total trials to criterion occurring in acquisition and reversal were conducted by means of the analysis of variance. The F-test of the analysis of variance assumes that the treatment variances are equal and normally distributed in the population. The assumption of homogeneity of variance was tested using the method developed by

Hartley appearing in Winer (1962). The hypothesis of non-homogeneity of variance was not rejected by this test for either the error or trial data in both acquisition and reversal.

A one-way classification analysis of variance was performed on the acquisition data to assess if any differences existed among the four sub-groups for each method of training to acquisition criterion. For the reversal data an unweighted-means analysis of variance described by Winer (1962) was necessary since there were unequal cell frequencies due to the discarding of seven subjects during the experiment. The sums of squares attributed to the manipulated variables were partitioned by means of two-way tables and subsequent investigations of the interactions were carried out by further F-tests of the simple effects. A difference was considered to be significant if the F ratio reached or exceeded the critical value required for the .05 level of significance.

The percentage of error for each subject was computed by adjusting for the total number of trials taken to obtain reversal or acquisition criterion; that is, the proportion of errors to the total number of trials taken to attain reversal or acquisition criterion were converted to percentages. This was performed to account for any two subjects making the same number of errors, but taking a different number of trials in attaining either criterion. The percentage of errors was subsequently subjected to an arc-sine transformation before the analysis of variance. Since percentages tend to be distributed rectangularly the arc-sine transformation is commonly used to normalize and equalize variances of distributions (Steel and Torrie, 1960).

Analysis of the Acquisition Data

The analyses of the acquisition data were deemed necessary in order to show that any differences in reversal learning were not a reflection of differences existent during acquisition training. The mean-transformed errors of the four sub-groups for each method of training appear in Table II. The analysis of variance for differences in errors among the four sub-groups to acquisition criterion appears in Table III. No significant differences existed among the four groups for either method of training. For the BMT, ($F = 2.95$; df 3/15) and for the CMT, $F(3,18) = 1.70$.

The observed total number of trials to acquisition criterion of the four sub-groups for each method of training appear in Table IV. The analysis of variance for differences in learning the original discrimination for the BMT and CMT appears in Table V. The trials data were in agreement with that of the error data for both methods of training; namely, no significant differences existed among the four sub-groups within each method of training to acquisition criterion. For the BMT group, ($F = <1$; df 3/15) and for the CMT group, $F(3,18) = 1.21$.

Analysis of the Transformed Errors in Reversal

The mean-transformed errors for the eight treatment combinations appear in Table VI, and the results of the unweighted-means analysis of variance appear in Table VII. Inspection of Table VII shows significant F values for the following effects: (1) A, method of training ($F = 51.24$; df 1/33); (2) BC, OL x SR interaction.

TABLE II

MEAN TRANSFORMED ERRORS TO
ACQUISITION CRITERION

Cue-correlated position method				Brightness discrimination method			
Group 1	Group 2	Group 3	Group 4	Group 1	Group 2	Group 3	Group 4
25.87	21.60	34.07	28.73	32.06	35.34	42.21	30.12

TABLE III

ANALYSIS OF VARIANCE OF THE TRANSFORMED ERRORS TO ACQUISITION CRITERION FOR THE BMT AND CMT

BMT

Source of Variation	Degrees of Freedom	Mean Square	F
Total	18	---	---
Treatments	3	132.84	2.95
Error	15	45.02	---

CMT

Source of Variation	Degrees of Freedom	Mean Square	F
Total	21	---	---
Treatments	3	184.96	1.70
Error	18	107.88	---

TABLE IV

MEAN NUMBER OF TRIALS TO
ACQUISITION CRITERION

Cue-correlated position method				Brightness discrimination method			
Group 1	Group 2	Group 3	Group 4	Group 1	Group 2	Group 3	Group 4
23.33	21.20	33.66	21.40	41.80	38.40	59.60	45.25

TABLE V

ANALYSIS OF VARIANCE OF THE TOTAL TRIALS TO ACQUISITION CRITERION FOR THE BMT AND CMT

BMT

Source of Variation	Degrees of Freedom	Mean Square	F
Total	18	---	---
Treatments	3	434.05	<1
Error	15	467.73	---

CMT

Source of Variation	Degrees of Freedom	Mean Square	F
Total	21	---	---
Treatments	3	201.07	1.21
Error	18	166.04	---

TABLE VI

MEAN TRANSFORMED ERRORS TO
REVERSAL CRITERION

Cue-correlated position method				Brightness discrimination method			
Non-secondary reinforcement		Secondary reinforcement		Non-secondary reinforcement		Secondary reinforcement	
0 Trials	50 Trials	0 Trials	50 Trials	0 Trials	50 Trials	0 Trials	50 Trials
37.90	38.60	37.10	40.02	49.60	44.48	46.51	52.61

TABLE VII

ANALYSIS OF VARIANCE OF TRANSFORMED MEAN ERRORS IN REVERSAL

Source of Variation	Degrees of Freedom	Mean Square	F
A. Method of training	1	990.90	51.24***
B. Overlearning	1	13.41	---
C. Secondary Reinforcement	1	20.29	1.05
AB	1	4.35	---
AC	1	12.35	---
BC	1	114.25	5.91*
ABC	1	53.23	2.75
Error	33	19.34	---

Harmonic mean = 5.06

* .05
*** .001

Inspection of the means of Table VI reveals that subjects of the CMT group made significantly fewer errors in reversal than subjects of the BMT group. This finding was not entirely unexpected as the CMT offers the organism two cues, brightness and position, as against one in the BMT.

The profile of the mean errors of the OL x SR interaction appears in Figure 1. The analysis of this source of variation was conducted by analysis of variance of the simple effects; that is, the difference between the two levels of SR was tested at each level of the OL variable. The results of this analysis appear in Table VIII: (1) Subjects of the NOL-SR group made fewer errors in reversal learning than those corresponding subjects of NOL-NSR group; however, this difference was not significant ($F = < 1$; df 1/33); (2) Subjects of the OL-NSR group made significantly fewer errors in reversal learning than subjects of the OL-SR group ($F = 5.96$; df 1/33). For the overlearning group the effect of receiving secondary reinforcement on an incorrect response during the original discrimination was to retard reversal learning. No other main effect or interaction was significant for the transformed error data.

Analysis of the Total Trials to Reversal Criterion

The observed mean number of trials to attain reversal criterion appears in Table IX for each of the eight groups and the results of the unweighted-means analysis of variance of the trials to reversal criterion are presented in Table X. Table X shows a significant F for the following effects: (1) A, method of training ($F = 124$; df 1/33); (2) AB, M x OL interaction ($F = 6.32$; df 1/33); (3) BC, OL x SR

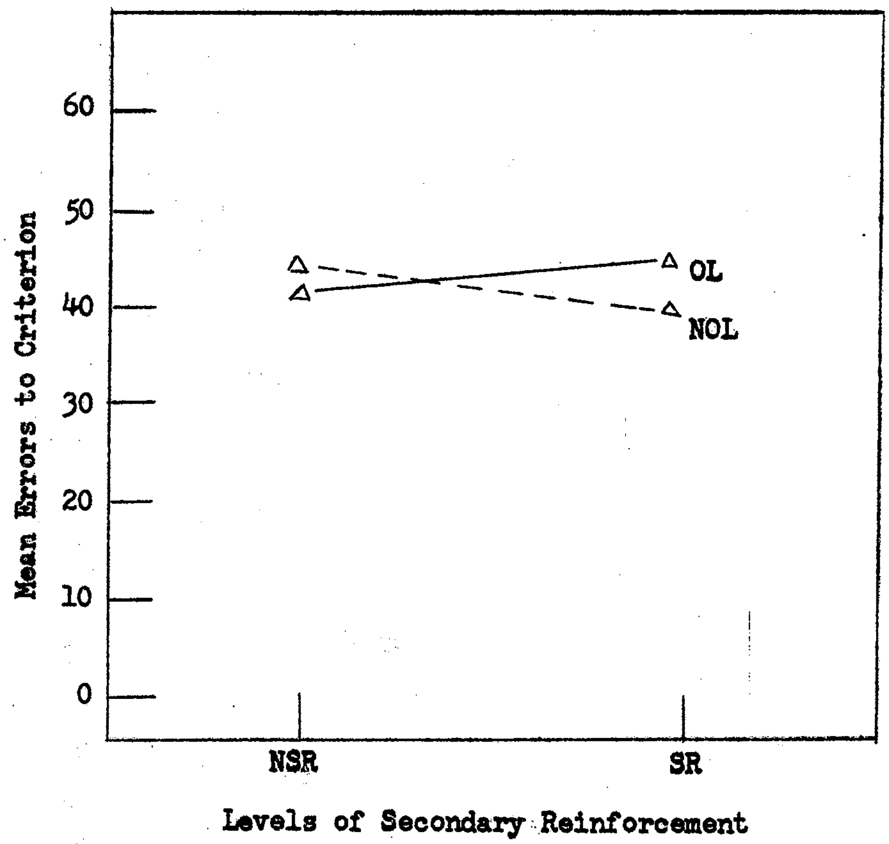


Figure 1. BC Interaction for Transformed Errors

TABLE VIII

ANALYSIS OF THE BC INTERACTION FOR THE TRANSFORMED ERROR SCORES

Source of Variation	Degrees of Freedom	Mean Square	F
C within b_0	1	19.12	---
C within b_1	1	115.36	5.96*
Error	33	19.34	---

* .05

TABLE IX

MEAN NUMBER OF TRIALS TO REVERSAL CRITERION

Cue-correlated position method				Brightness discrimination method			
Non-secondary reinforcement		Secondary reinforcement		Non-secondary reinforcement		Secondary reinforcement	
0 Trials	50 Trials	0 Trials	50 Trials	0 Trials	50 Trials	0 Trials	50 Trials
22.66	30.80	21.50	28.60	68.70	47.80	51.40	59.25

TABLE X

ANALYSIS OF VARIANCE OF MEAN NUMBER OF TRIALS TO REVERSAL CRITERION

Source of Variation	Degrees of Freedom	Mean Square	F
A. Method of training	1	9583.08	124.00***
B. Overlearning	1	4.58	---
C. Secondary Reinforcement	1	47.97	---
AB	1	488.44	6.32*
AC	1	2.53	---
BC	1	468.30	6.06*
ABC	1	542.63	7.02*
Error	33	77.28	---

Harmonic mean = 5.06

* .05
** .01
*** .001

interaction ($F = 6.06$; df 1/33); (4) ABC, M x OL x SR interaction ($F = 7.02$; df 1/33).

The profile means of the M x OL interaction appear in Figure 2. The analysis of this source of variation was conducted by analysis of variance of the simple effects; that is, the difference between the two levels of OL was tested for each method of training. This analysis is presented in Table XI. Inspection of the profile means show: (1) The CMT-NOL group required fewer trials than the CMT-OL group to attain reversal criterion, however this source of variation was not significant ($F = 3.80$; df 1/33); (2) Subjects of the BMT-OL group took fewer trials than the corresponding BMT-NOL group to reversal criterion, although the difference was not significant ($F = 2.58$; df 1/33). In this instance overlearning facilitated reversal, as has been frequently reported for the BMT in the literature, but not significantly.

Presented in Figure 3 are the profile means of the OL x SR interaction. Analysis of the difference between levels of SR for the two levels of OL is summarized in Table XI. In viewing the profile means the following relationships are evident: (1) The NOL-SR group reversed significantly faster than the NOL-NSR group ($F = 5.28$; df 1/33). In this instance, discounting the method of training, secondary reinforcement during acquisition facilitated the subsequent reversal in the absence of overlearning experience. (2) The OL-NSR group required fewer trials to reversal criterion than the OL-SR group, but this source of variation was not significant ($F = 1.40$; df 1/33).

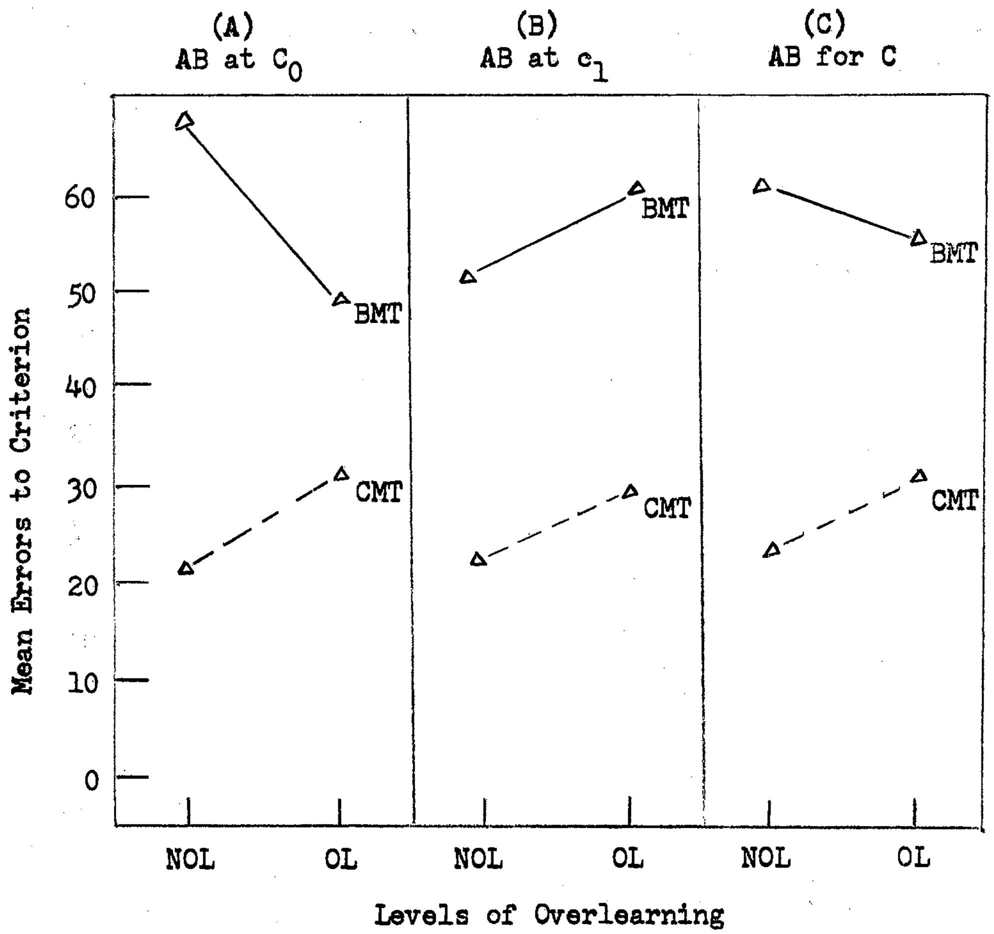


Figure 2. AB Interaction for Total Trials to Reversal Criterion

TABLE XI

ANALYSIS OF AB AND BC INTERACTIONS FOR THE TOTAL NUMBER OF TRIALS TO REVERSAL CRITERION

AB INTERACTION

Source of Variation	Degrees of Freedom	Mean Square	F
B in a_0	1	293.78	3.80
B in a_1	1	199.24	2.58
Error	33	77.28	---

BC INTERACTION

Source of Variation	Degrees of Freedom	Mean Square	F
C within b_0	1	408.04	5.28*
C within b_1	1	108.23	1.40
Error	33	77.28	---

* .05

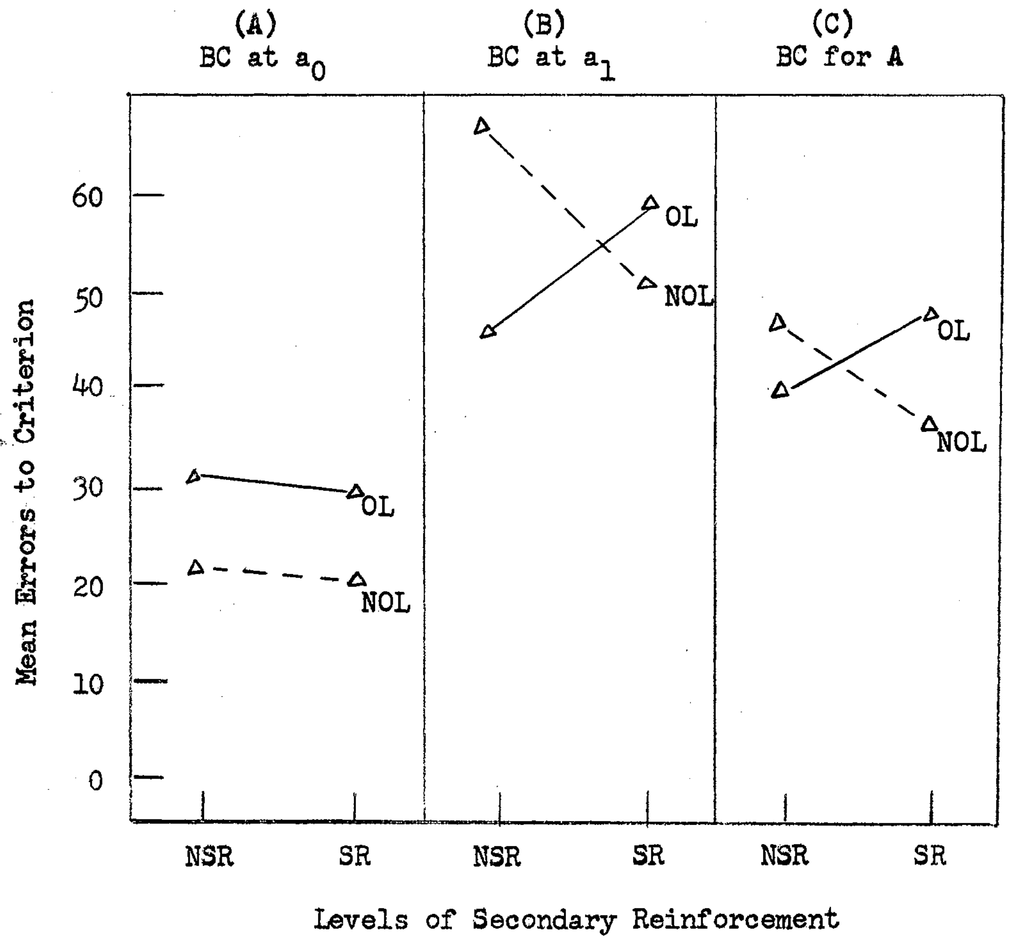


Figure 3. BC Interaction for Total Trials to Reversal Criterion

It should be recalled that the foregoing analysis of the simple effects of the OL x SR interaction for the total trials to reversal criterion does not agree exactly with that of the OL x SR interaction for the transformed errors, although the findings are in the same direction. In addition the over-all analysis for the trials to reversal criterion revealed more significant sources of variation than the transformed error data. Most investigations have reported closer agreement between the errors and trials to reversal, however, in this investigation essential agreement did not occur possibly for the following reasons: (1) Any two subjects could make approximately the same number of errors in learning the reversal, but take a different number of trials; (2) Subjects could take approximately the same number of trials to reversal criterion but commit a different number of errors. Hence, it is not surprising that there were absolute differences between means greater in magnitude for the errors in some comparisons and in others a difference in magnitude greater for trials to reversal criterion. Individual differences in eliminating position preferences and exploratory tendencies can possibly account for any failure of the two analyses to agree closely in this investigation.

Analyses of the M x OL x SR interaction generally confirm and extend the findings of the first-order interactions for the trials to reversal. These analyses were conducted by comparing the various levels of the first-order interactions at the levels of the third variable; that is, components of AB were compared at levels of C, BC at levels of A, and AC at levels of B. The summary of the analysis of variance of the M x OL x SR interaction occurs in Table XII.

TABLE XII

ANALYSIS OF THE ABC INTERACTION FOR THE TOTAL NUMBER OF TRIALS TO REVERSAL CRITERION

Source of Variation	Degrees of Freedom	Mean Square	F
a_0 c_0 at B	1	167.64	2.17
a_1 c_0 at B	1	1055.41	13.66**
a_0 c_1 at B	1	127.56	1.65
a_1 c_1 at B	1	155.90	2.02
Error	33	77.28	---
b_0 c_0 at A	1	5242.31	67.84**
b_0 c_1 at A	1	2261.82	29.27**
b_1 c_0 at A	1	731.17	9.46**
b_1 c_1 at A	1	2376.73	30.75**
Error	33	77.28	---
a_0 b_0 at C	1	3.39	---
a_1 b_0 at C	1	714.07	9.24**
a_0 b_1 at C	1	12.25	---
a_1 b_1 at C	1	331.68	4.29*
Error	33	77.28	---

* .05
** .01

The following significant sources of variation emerged: (1) An inspection of the profile means of Figure 4a and Figure 4b shows that the BMT-NSR-OL group reversed significantly faster than the corresponding BMT-NSR-NOL group ($F = 13.66$; df 1/33). This finding supports and extends the number of investigations reporting a facilitative effect of overlearning upon habit reversal in a brightness discrimination task. (2) Subjects of the BMT-NOL-SR reversed significantly faster than the BMT-NOL-NSR group ($F = 9.24$; df 1/33). The effect of secondary reinforcement during the original learning of a brightness discrimination without subsequent overlearning was to facilitate reversal learning. So far as the writer is aware similar findings have not been reported previously by other investigations in the area of habit reversal. In addition, the foregoing provides support for the explanation of reversal learning put forth by D'Amato and Jagoda (1960). (3) Subjects of the BMT-OL-NSR group reversed significantly faster than the BMT-OL-SR group ($F = 4.29$; df 1/33). The foregoing relationships are depicted in Figure 2a and Figure 2b. The effect of secondary reinforcement in this instance was to retard reversal learning with the BMT and overlearning experience. This finding was contrary to the prediction generated from D'Amato and Jagoda's (1960) theoretical explanation of reversal learning; namely, that OL and SR would interact to facilitate reversal learning. (4) Inspection of the profile means of Figure 3a and Figure 3b shows that regardless of the particular OL x SR treatment combinations, the CMT led to significantly faster reversal than the BMT. This finding supports most reported literature; namely, the ORE is infrequently found with position discrimination tasks.

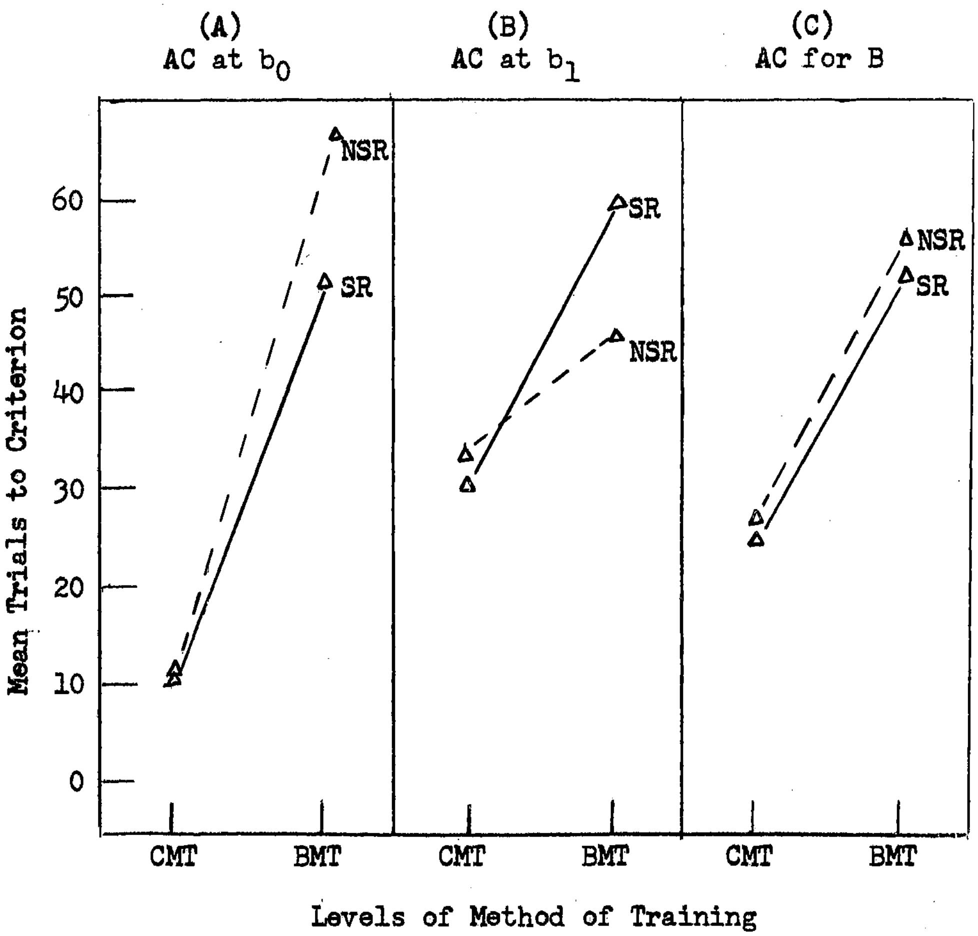


Figure 4. AC Interaction for Total Trials to Reversal Criterion

CHAPTER V

DISCUSSION

The major purpose of this research was to investigate the effects of method of training, overlearning, and secondary reinforcement upon habit reversal in the rat. The most noteworthy aspect of the findings relevant to the major purpose was with respect to the M x OL x SR interaction for the total trials to reversal criterion. Analyses of the M x OL x SR interaction for the trials to reversal criterion revealed that subjects of the BMT x NSR x OL group took significantly fewer trials to attain reversal criterion than the corresponding BMT x NSR x NOL group. The effect of fifty overlearning trials upon the BMT-NSR group was to facilitate reversal to the previously incorrect discriminandum. That this effect was not due to differences reflecting acquisition training is supported by the finding that these groups did not differ significantly in total trials taken to attain the original acquisition criterion. Although the foregoing component of variation of the M x OL x SR interaction for the error data was not significant, inspection of the mean errors reveals that the corresponding group receiving overlearning made fewer errors in learning the reversal. The foregoing confirms the findings of other investigators (Capaldi and Stevenson, 1957; D'Amato and Jagoda, 1961; and Reid, 1953) in the area of habit reversal: overlearning facilitates habit reversal in a brightness discrimination task, where the ORE is most firmly established.

Investigators in the area of habit reversal have put forth several hypotheses which might serve as an explanation for the reported ORE. (1) Subsequent practice in making the discrimination during the overlearning may facilitate the learning of the reversal habit. Reid (1953) and Pubols (1956) suggest that this could be mediated by an acquired observing response--a response very similar in ways to that of "vicarious trial and error" reported by Muenzinger (1938) and Tolman (1939). It is different in that VTE refers to "the hesitating, looking back-and-forth sort of behavior" whereas the observing response is described as "looking at" one discriminandum and immediately making a correct response; thus, organisms are better prepared to "pay attention" to the relevant cues. (2) The long series of reinforcements during overlearning could possibly make a change in the conditions easier to discriminate and thus make reversal learning easier; that is, overlearning makes it easier for organisms to recognize that acquisition has ended and extinction and reversal have begun. This explanation has been put forth by Capaldi and Stevenson (1957). (3) During overlearning very few errors are made and because of this reward may reduce through generalization the tendency to avoid the incorrect discriminanda and facilitate approach to those discriminanda when they become correct. This explanation is given by D'Amato and Jagoda (1961). (4) Mackintosh (1965) has put forth an attention explanation of the ORE. According to this position "overlearning increases the probability of attending to the relevant cue during reversal without causing a corresponding increase in choice response strength. The result of this is that overtrained subjects extinguish their choice responses while still attending to the relevant cue, whereas non-overtrained subjects extinguish their tendency to attend to the relevant cue before fully extinguishing choice responses." It can be seen from the above that there is no shortage of theoretical explanations for the ORE; however, there is no reason to believe at this stage of development that one is better than the others. Perhaps Mackintosh's (1965) point is well taken that any decision between alternative explanations must be in terms of the differences in daily reversal scores between overtrained and non-overtrained subjects. For example, Mackintosh states that the occasional failure to obtain the ORE in brightness tasks could be because the irrelevant spatial cue was not a dominant one, or that some factor was increasing resistance to extinction in overtrained subjects. An inspection of the daily reversal scores would decide between these alternatives.

Another finding occurring in this investigation in close agreement with the reported literature was that the ORE failed to appear with the CMT. It will be recalled that the CMT consisted of having brightness cues correlated with positional cues. Inspection of the acquisition and reversal scores reveals that this is a relatively easy task for the rat. Further, the simplicity of the discrimination might well be the crucial factor in the failure to find the ORE with the CMT. This would be consistent with D'Amato and Schiff's (1964) failure to find the ORE using the CMT method. At this point Lovejoy's (1965) explanation for failure of ORE to occur with position tasks is well taken. He has pointed out that the ORE depends on non-overtrained subjects ceasing to attend to the relevant cue in reversal. On the other hand if the relevant cue is one the subjects automatically attend to, then non-overtrained subjects should continue to do so during the course of reversal. Rats learn position discriminations rapidly and are generally thought to be predominantly spatially oriented; therefore, it is not surprising that spatial cues are highly preferred by rats, and direct more or less automatically the focus of attention. Under these circumstances the ORE would not be predicted. No doubt the failure to consider the above has led to much confusion in the literature concerning the ORE. Many investigators have claimed that the ORE is an evasive, inconsistently appearing and disappearing phenomenon. Mackintosh (1965) indicates this appears so due to the confusion of the two different types of discrimination tasks---visual and positional.

An additional finding of interest was that the BMT-NOL-SR group reversed significantly faster than the BMT-NOL-NSR group. The effect of receiving a secondary reinforcement cue in the incorrect goal box during acquisition was to facilitate reversal of the BMT-NOL group. D'Amato and Jagoda (1961) have contended that the development of avoidance tendencies toward the negative stimulus is an important factor in the establishment of a discrimination, and reversal learning requires the extinction of this avoidance tendency. Further, any events that act to reduce avoidance tendencies should impede learning the original discrimination, but facilitate reversal. Support is given to this notion for the operation of the secondary reinforcement variable by the observation that the secondary reinforcement group took approximately 20 per cent more trials to attain acquisition criterion than it's respective control, but reversed significantly faster. This suggests that avoidance tendencies were partially reduced to the negative discriminandum by the operation of the secondary reinforcement during acquisition so that the subsequent reversal learning was facilitated.

No support was found for the prediction relating secondary reinforcement and overlearning generated from D'Amato and Jagoda's (1961) explanation of ORE. As previously stated, secondary reinforcement would interact or summate to facilitate reversal. However, the analysis revealed that the BMT-OL-NSR group reversed significantly faster than the BMT-OL-SR group. The effect of secondary reinforcement with subsequent overlearning was to retard reversal. One possible explanation for the above finding is that secondary reinforcement and overlearning neutralized each other with the BMT; that is, the effect of secondary reinforcement during acquisition was to establish an initial response bias for the negative stimulus since acquisition was retarded somewhat for the secondary reinforcement group, but subsequent overlearning operated to equate response biases for the two discriminanda rather than summating to provide an over-all response bias toward the negative or reversal stimulus.

As has been the frequent findings of other investigators, another potentially important variable, secondary reinforcement, has failed to be a critical variable in accounting for the ORE. However, the data of this investigation suggest that if the ORE is to occur in brightness discrimination tasks it must occur in the absence of secondary reinforcing cues in the incorrect goal box during acquisition. It is probable that a preponderance of secondary reinforcing cues in the incorrect goal can account for some investigators failing to find the ORE with brightness tasks. On the other hand, secondary reinforcing cues in the incorrect goal box during acquisition will facilitate habit reversal in the absence of subsequent overlearning presumably because avoidance of the reversal stimulus is reduced by the operation of secondary reinforcement.

Before concluding this discussion on habit reversal, one final point needs to be made. The ORE is a rather paradoxical and dramatic finding and it could be for this reason that research has concentrated on attempting to isolate the critical variables responsible for the ORE. Perhaps research efforts should be directed toward examining the potential differences in the course of reversal learning between over-trained and non-overtrained subjects as has been suggested by Mackintosh (1965). At any rate the conclusion seems warranted that the ORE is a genuine phenomenon, but the set of conditions under which it can be expected to occur cannot be accurately delineated at the present time.

CHAPTER VI

SUMMARY AND CONCLUSIONS

The primary purpose of this research was to provide evidence concerning the importance of the secondary reinforcement variable to the ORE in brightness-discrimination tasks. Taken in its entirety the experiment was designed to provide answers to the following questions:

(1) What are the relative effects of the brightness discrimination method of training and the cue-correlated position method of training upon habit reversal in the rat?

(2) What is the effect on habit reversal in the rat of receiving a secondary reinforcing stimulus at the goal when an incorrect response occurs during the acquisition of a discrimination response as against the effect of entering an empty goal box?

(3) What is the effect of extending training beyond criterion on habit reversal in the rat?

(4) What are the interactive effects of method of training, secondary reinforcement, and overlearning on habit reversal in the rat?

In order to examine these questions six male, hooded rats of the Long Evans strain, 80-100 days of age, were assigned at random to each of the eight cells of a 2 x 2 x 2 factorial arrangement of treatments. In a single unit T-maze with interchangeable black and white goal boxes twenty-four of the subjects received acquisition training under the brightness discrimination method of training and twenty-four received acquisition training under the cue-correlated position method of training. All subjects were given fifteen massed trials per day with an intertrial interval of approximately twenty seconds until a criterion of nine out of ten correct trials with the last five successively correct had been attained. For the secondary reinforcement group an empty food cup, identical in all other respects to the one found in the correct goal box, was present on each incorrect trial. The subjects of the non-secondary reinforcement groups entered an empty goal box on an incorrect trial. Subjects of both groups were permitted to remain in the goal box 5-10 seconds before being taken out to await the start of the next trial. The preceeding description of events on an incorrect trial constituted the manipulation of the secondary reinforcement variable during the acquisition series.

Upon reaching acquisition criterion the subjects of the 0-trial overlearning groups began reversal learning on the same day following the last acquisition trial. Subjects of the 50 trial overlearning groups were given 50 post-criterion training trials before being reversed to the previously negative stimulus. Reversal learning was continued until all subjects had reached a criterion of nine out of ten correct trials with the last five successively correct. The procedure during overlearning and reversal was identical to that during acquisition except that an empty food cup was not present in the incorrect goal box.

The major findings were: (1) Overlearning facilitated the habit reversal of the subjects that learned a brightness discrimination response without benefit of a secondary reinforcing stimulus upon entering the incorrect goal box. (2) Subjects receiving a secondary reinforcing stimulus upon entering the incorrect box during acquisition of a brightness discrimination response and without subsequent overlearning experience reversed significantly faster than their corresponding control group. (3) Subjects not receiving a secondary reinforcing stimulus upon entering the incorrect goal during acquisition of a brightness discrimination response and with subsequent overlearning experience reversed significantly faster than the secondary reinforcement group. (4) Overlearning failed to facilitate the habit reversal of those subjects that learned cue-correlated position responses without benefit of a secondary reinforcing stimulus upon entering the incorrect goal box.

Although a number of explanations were put forth to account for the ORE in this investigation, the major conclusion was that secondary reinforcement is not a critical variable relating to the ORE. The data suggested that if the ORE is to occur in brightness discrimination tasks it must occur in the absence of secondary reinforcement cues in the incorrect goal box during acquisition. On the other hand, secondary reinforcement in the incorrect goal box during acquisition will facilitate habit reversal in the absence of subsequent overlearning. The conclusion seems warranted, that the ORE is a genuine phenomenon, but the set of conditions under which it can be expected to occur cannot be accurately delineated at this time.

BIBLIOGRAPHY

Birch, D., Ison, J. R., & Sperling, Sally E. Reversal learning under single stimulus presentation. J. exp. Psychol., 1960, 60, 36-40.

Brookshire, K. H., Warren, J. M., & Ball, G. G. Reversal and transfer learning following overtraining in rat and chicken. J. comp. physiol. Psychol., 1961, 54, 98-102.

Capaldi, E. J., & Stevenson, H. W. Response reversal following different amounts of training. J. comp. physiol. Psychol., 1957, 50, 195-198.

Clayton, K. N. Reversal performance by rats following overlearning with and without irrelevant stimuli. J. exp. Psychol., 1963, 66, 255-259.

D'Amato, M. R., & Jagoda, H. Effects of extinction trials on discrimination reversal. J. exp. Psychol., 1960, 59, 254-260.

D'Amato, M. R., & Jagoda, H. Analysis of the role of overlearning in discrimination reversal. J. exp. Psychol., 1961, 61, 45-50.

D'Amato, M. R., & Jagoda, H. Overlearning and position reversal. J. exp. Psychol., 1962, 64, 117-122.

D'Amato, M. R., & Schiff, D. Studies in the overlearning reversal effect. Cited by Paul, C. The effects of overlearning upon single habit reversal in rats. Psychol. Bull., 1965, 63, 65-72.

D'Amato, M. R., & Schiff, D. Further studies of overlearning and position reversal learning. Psychol. Rep., 1964, 14, 380-382.

D'Amato, M. R., & Schiff, D. Overlearning and brightness discrimination reversal. J. exp. Psychol., 1965, 69, 375-381.

Ehrenfreund, D. Effects of a secondary reinforcing agent in black-white discrimination. J. comp. physiol. Psychol., 1948, 42, 1-5.

Erlebacher, A. Reversal learning in rats as a function of percentage of reinforcement and degree of learning. J. exp. Psychol., 1963, 66, 84-90.

Gellerman, L. W. Chance orders of alternating stimuli in visual discrimination experiments. J. genet. Psychol., 1933, 42, 207-208.

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

Hill, W. F., & Spear, N. E. A replication of overlearning and reversal in a T maze. J. exp. Psychol., 1963, 65, 317.

Hill, W. F., Spear, N. E., & Clayton, K. N. T-maze reversal after several different overtraining procedures. J. exp. Psychol., 1962, 64, 533-540.

Lovejoy, E. P. An analysis of the overlearning reversal effect. Cited by Mackintosh, N. J. Selective attention in animal discrimination learning. Psychol. Bull., 1965, 64, 124-150.

Mackintosh, N. J. The effects of overtraining on a reversal and a nonreversal shift. J. comp. physiol. Psychol., 1962, 55, 555-559.

Mackintosh, N. J. The effect of irrelevant cues on reversal learning in the rat. British J. Psychol., 1963, 54, 127-134. (a)

Mackintosh, N. J. Extinction of a discrimination habit as a function of overtraining. J. comp. physiol. Psychol., 1963, 56, 842-847. (b)

Mackintosh, N. J. Selective attention in animal discrimination learning. Psychol. Bull., 1965, 64, 124-150.

Miles, R. C. The relative effectiveness of secondary reinforcers throughout deprivation and habit-strength parameters. J. comp. physiol. Psychol., 1956, 49, 126-130.

Muenzinger, K. F. Vicarious trial and error at a point of choice: I. A general survey of its relation to learning efficiency. J. genet. Psychol., 1938, 53, 75-86.

North, A. J., & Clayton, K. N. Irrelevant stimuli and degree of learning on discrimination learning and reversal. Psychol. Rep., 1959, 5, 405-408.

Paul, C. The effects of overlearning upon single habit reversal in rats. Psychol. Bull., 1965, 63, 65-72.

Paul, C., & Havelena, Joan. Effects of overlearning and spatial delay of reinforcement upon a discrimination reversal. Cited by Paul, C. The effects of overlearning upon single habit reversal in rats. Psychol. Bull., 1965, 63, 65-72.

Pubols, B. H., Jr. The facilitation of visual and spatial discrimination reversal by overlearning. J. comp. physiol. Psychol., 1956, 49, 243-248.

Reid, L. S. The development of noncontinuity behavior through continuity learning. J. exp. Psychol., 1953, 46, 107-112.

Saltzman, I. J. Maze learning in the absence of primary reinforcement: A study of secondary reinforcement. J. comp. physiol. Psychol., 1949, 42, 161-173.

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

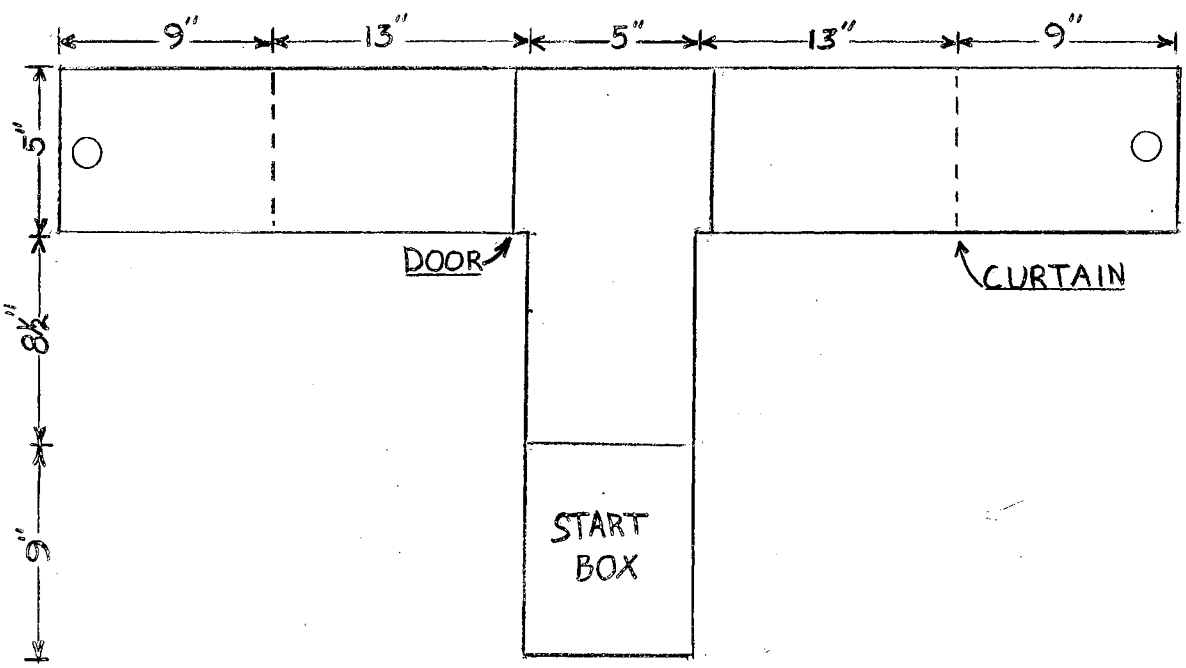
Steel, R. G. D., & Torrie, J. H. Principles and procedures of statistics. New York: McGraw-Hill, 1960.

Tolman, E. C. Prediction of vicarious trial and error by means of the schematic sow-bug. Psychol. Rev., 1939, 46, 318-336.

Winer, B. J. Statistical principles in experimental design. New York: McGraw-Hill, 1962.

APPENDIX A

APPARATUS



APPENDIX B

ACQUISITION RAW DATA

Subject No.	TrT	TC	EC	PE	TE
39	000	20	7	.35	36.27
4	000	22	10	.45	42.13
33	000	32	10	.31	33.83
27	000	12	1	.08	16.43
16	000	10	0	.00	00.00
30	000	44	9	.20	26.56
7	010	25	5	.20	26.56
44	010	23	5	.22	27.97
50	010	10	0	.00	00.00
18	010	13	2	.15	22.79
12	010	35	9	.26	30.66
14	001	11	2	.18	25.10
3	001	39	13	.33	35.06
31	001	36	16	.44	41.55
47	001	22	7	.32	34.45
36	001	56	19	.34	35.67
26	001	38	11	.29	32.58
34	011	20	5	.25	30.00
25	011	22	7	.32	34.45
1	011	13	2	.15	22.79
55	011	11	2	.18	25.10
20	011	41	11	.27	31.31
13	100	68	24	.35	36.27
11	100	57	18	.32	34.45
15	100	57	22	.39	38.65
49	100	12	2	.17	24.35
54	100	15	3	.20	26.56

APPENDIX B - continued

Subject No.	TrT	TC	EC	PE	TE
45	110	60	20	.33	35.06
46	110	45	21	.47	43.28
23	110	17	5	.29	32.58
24	110	25	5	.20	26.56
5	110	45	18	.40	39.23
42	101	50	21	.42	40.40
48	101	88	44	.50	45.00
52	101	58	32	.55	47.87
22	101	44	15	.34	35.67
37	101	58	26	.45	42.13
2	111	45	9	.20	26.56
35	111	68	24	.35	36.27
56	111	10	1	.10	18.44
10	111	58	23	.40	39.23

TrT = Treatment combination*
TC = Trials to acquisition criterion
EC = Errors to acquisition criterion
PE = Per cent of errors to acquisition criterion
TE = Transformed per cent errors

*First digit refers to the level of the method of training variable.
Second digit refers to the level of the secondary reinforcement variable.
Third digit refers to the level of the overlearning variable.

APPENDIX B - continued

REVERSAL RAW DATA

Subject No.	TrT	TC	EC	PE	TE
39	000	20	6	.300	33.21
4	000	17	6	.353	36.45
33	000	23	9	.391	38.70
27	000	27	10	.370	37.47
16	000	19	8	.420	40.40
30	000	30	13	.433	41.15
7	010	28	10	.357	36.69
44	010	33	15	.454	42.36
50	010	29	14	.482	43.97
18	010	24	8	.333	35.24
12	010	40	13	.325	34.76
14	001	18	6	.333	35.24
3	001	25	10	.400	39.23
31	001	32	10	.312	33.96
47	001	23	11	.478	43.74
36	001	13	3	.230	28.66
26	001	18	8	.444	41.78
34	011	22	10	.454	42.36
25	011	29	11	.379	38.00
1	011	23	10	.434	41.21
55	011	41	21	.512	46.26
20	011	28	8	.285	32.27
13	100	73	40	.547	47.70
11	100	68	45	.661	54.39
15	100	69	41	.594	50.42
49	100	67	44	.656	54.09
54	100	64	28	.437	41.38
45	110	62	30	.483	44.03
46	110	62	30	.483	37.35
23	110	63	32	.507	45.40
24	110	30	16	.533	46.89
5	110	46	26	.565	48.73
42	101	57	34	.596	50.53
48	101	66	36	.545	47.58
52	101	57	32	.561	48.50
22	101	44	21	.477	43.68
37	101	33	15	.454	42.36

APPENDIX B - continued

Subject No.	TrT	TC	EC	PE	TE
2	111	58	34	.586	49.95
35	111	71	46	.647	53.55
56	111	60	40	.666	54.70
10	111	48	30	.625	52.24

TrT = Treatment combination*
TC = Trials to reversal criterion
EC = Errors to reversal criterion
PE = Per cent errors to reversal criterion
TE = Transformed per cent errors

*First digit refers to the level of the method of training variable.
Second digit refers to the level of the secondary reinforcement variable.
Third digit refers to the level of the overlearning variable.

VITA

Charles H. Anderson

Candidate for the Degree of

Doctor of Philosophy

Thesis: THE EFFECTS OF METHOD OF TRAINING, SECONDARY REINFORCEMENT, AND OVERLEARNING ON SINGLE HABIT REVERSAL

Major Field: Psychology

Biographical:

Personal Data: Born in Nevada, Missouri, July 2, 1936.

Education: Attended grade school in Nevada, Missouri, and graduated from Nevada High School, Nevada, Missouri, in 1954; received the Bachelor of Science degree from Kansas State College, Pittsburg, Kansas, in 1961; received the Master of Science degree from Oklahoma State University in May, 1963 and completed the requirements for the Doctor of Philosophy degree from Oklahoma State University in May, 1966.

Experience: Graduate teaching assistant, January, 1962 to August, 1965.