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THE EFFECTS OF OVERTRAINING ON REVERSAL AND NONREVERSAL SHIFTS IN FAST AND SLOW LEARNERS

A DISSERTATION

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BY

ARTHUR WAYNE VINEY

Norman, Oklahoma

1964

THE EFFECTS OF OVERTRAINING ON REVERSAL AND NONREVERSAL SHIFTS IN FAST AND SLOW LEARNERS

APPROVED BY

DISSERTATION COMMITTEE

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THE EFFECTS OF OVERTRAINING ON REVERSAL AND NONREVERSAL SHIFTS IN FAST AND SLOW LEARNERS

CHAPTER I

HISTORY OF THE PROBLEM

Kendler and Kendler (1959) have suggested the possibility that children who are fast learners have developed mediational responses appropriate to a discrimination learning situation while slow learners have failed to develop such responses. Kendler and Kendler investigated this possible difference in fast and slow learners by testing both types of learners in reversal and nonreversal shift discrimination problems.

A reversal shift problem is one in which a formerly positive cue becomes negative and a formerly negative cue becomes positive. A nonreversal shift problem is one in which a new dimension (ND) is introduced or a previously irrelevant dimension (ID) becomes relevant. Despite the fact that previous investigators have paid scant attention to the distinction between nonreversal shift (ND) and nonreversal shift (ID), this distinction is necessary for understanding and applying theoretical formulations and it will be used throughout this paper. A negative cue in a reversal shift problem is one which is consistently nonreinforced. A cue from an irrelevant dimension is one which lacks consistency of association with reward and nonreward. In the usual discrimination problem position is an irrelevant cue. Even though position may receive random 50% reinforcement it is nevertheless irrelevant to the solution of the discrimination problem.

Kendler and Kendler (1959) demonstrated that kindergarten children who are fast learners learn a reversal shift faster than a nonreversal shift (ID) while slow learners learn a nonreversal shift (ID) faster than a reversal shift. Utilizing a control group consisting of nonreversal shifts (ND) it was demonstrated that there were no differences between fast and slow learners. Specifically, Kendler and Kendler utilized three dimensions which consisted of height, brightness, and geometric shape. The specific discriminanda for height and brightness consisted of two tall and two short metal tumblers. One of each height was black and the other was white. The specific discriminanda for geometric shape consisted of a diamond shaped cookie cutter and a circle shaped cookie cutter. A reversal shift consisted of reversing from tall to short or short to tall or from black to white or white to black. Nonreversal shifts (ND) consisted of transferring from the diamond or the circle (shape) to either height or brightness. In either case, the transfer was to a dimension which had not been previously present. Nonreversal shifts (ID) consisted of transferring responses from height to brightness when brightness had been previously present but irrelevant or from brightness to height when height had been previously present but irrelevant. For example, a subject might be confronted with a tall black tumbler and a short white tumbler on one trial and a short black tumbler and a tall white tumbler on the next trial. If brightness was relevant, then the subject learned to ignore height. In the critical test trials, however, height (the previously irrelevant dimension) became relevant. With these kinds of problems, Kendler and Kendler found that, for slow learners, both types of nonreversal shifts were faster than a reversal shift while, for fast learners, a nonreversal shift (ID) was slower than a reversal shift or a nonreversal shift (ND). Figure 1 illustrates the results of the Kendler

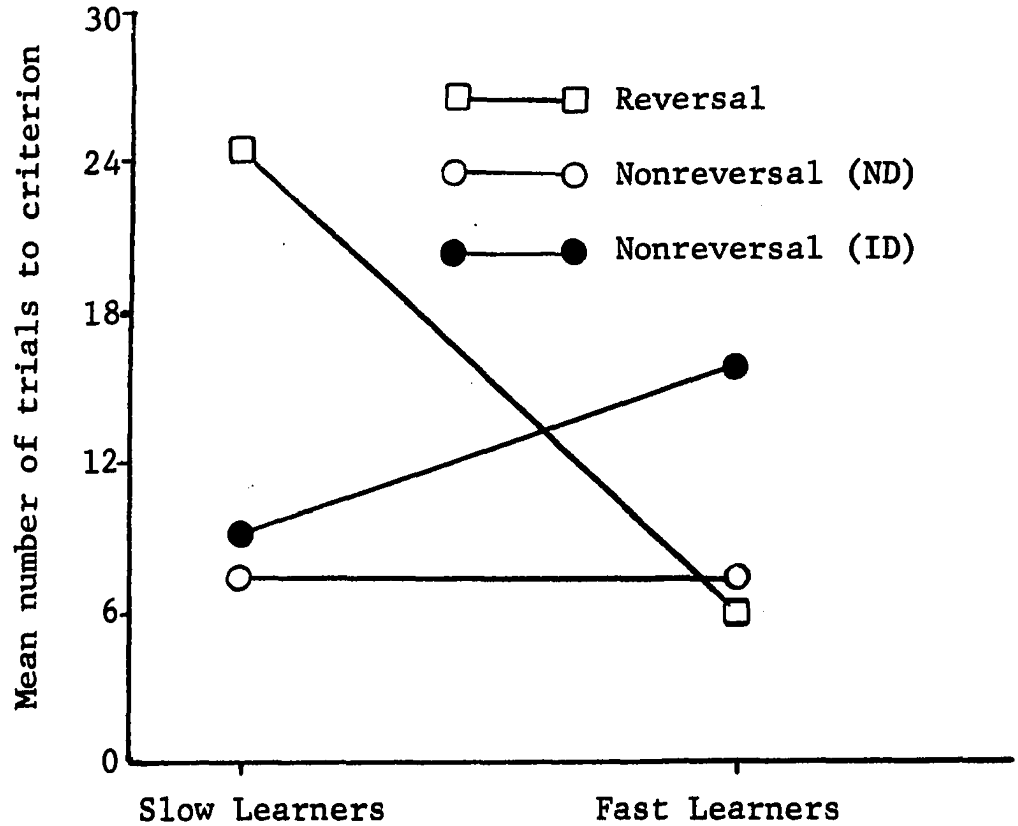

Fig. 1. Mean number of trials to criterion for fast and slow learners in three different kinds of discrimination shift problems in the 1959 Kendler and Kendler study.

and Kendler study.

The fact that slow learners are slower on a reversal shift problem than on a nonreversal shift problem seems in keeping with a straightforward single-unit S-R theory such as that of Spence (1936). Spence would predict slower transfer on a reversal shift than on a nonreversal shift, because in the reversal shift situation the formerly positive cue must be extinguished to a point which is below the position of the formerly negative cue before significant habit strength can be attached to the formerly negative cue. A nonreversal shift (ID), according to Spence, would be faster than a reversal shift because a formerly irrelevant cue has not been associated with reward or nonreward on a consistent basis. Such a cue therefore, is available for conditioning faster than a negative cue which has been consistently nonrewarded. A nonreversal shift (ND) should also be faster than a reversal shift because a new cue should be available for conditioning faster than a formerly negative cue. The predictions of Spence's theory have been confirmed not only by the slow learners in the aforementioned experiment by Kendler and Kendler, but also by Kelleher (1956) who used albino rats in discrimination problems.

The fact that fast learners learn a reversal shift faster than a nonreversal shift (ID) does not seem consistent with a single-unit S-R theory such as that of Spence. Single-unit theorists such as Hull and Spence have, of course, warned of the possibility that their theories may not be applicable to the realm of higher mental operations which involve language and possible covert symbolic mediational processes. The fact that fast learners learn a reversal shift faster than a nonreversal shift (ID) seems to require an alternative to the explanation offered by single-unit S-R theory. Other evidence also points to the need for alternative explanations. For example, Kendler and D'Amato (1955) demonstrated a faster rate for reversal shifts than for nonreversal shifts in a concept formation study in which college students learned a card sorting task. Kendler and D'Amato accounted for their results by means of a mediational S-R explanation. According to this explanation, "a reversal shift should occur at a more rapid rate than a nonreversal shift because at the completion of the learning of the first concept, the symbolic cues appropriate to the second concept were available to Ss in the reversal shift groups" (Kendler & D'Amato, 1955, p. 169). The nonreversal shift would be slower than the reversal shift because there are no internal symbolic cues which can be attached to the previously irrelevant dimension. The formation of a symbolic cue might develop in the following manner. Let us say that there are two stimulus components, e.g., black and white, which compose one dimension (brightness) of a discrimination problem. The overt response may be attached to the positive stimulus, say white. There is, however, an implicit response which carries with it both components of the dimension. It is as if there is, in addition to the overt response to the positive stimulus, a covert response to the dimension brightness. When black and white are reversed, the presence of the covert symbolic response will facilitate learning even though the overt response is attached to the "wrong" stimulus. These symbolic cues are not available, however, in a nonreversal shift because a new dimension or a previously irrelevant dimension is introduced. Therefore, a reversal shift should be faster than a nonreversal shift where such mediational processes are in operation. In effect, the focusing processes of mediation serve to "gate out" stimuli not related to the relevant dimension.

The fact that Kendler and Kendler found no differences between a reversal shift and a nonreversal shift (ND) for fast learners may reveal more of the nature of mediational processes. It will be remembered that a nonreversal shift (ID) maintains elements of the previously relevant dimension in the second task or critical test situation. These elements may trigger the mediation mechanism so that its response slows down the learning of the new dimension. In a nonreversal shift (ND) the subject is confronted with a new set of cues so there is nothing present to trigger the mediation mechanism which was utilized in the first discrimination task. Thus, the previously useful mediation mechanism should not retard the learning of the new task. A nonreversal shift (ND), therefore, should be faster than a nonreversal shift (ID).

The point of major importance which should be stressed is that single-unit S-R theory and mediational S-R theory make differential predictions with respect to reversal and nonreversal shifts and it has been demonstrated that rats and kindergarten children who are slow learners and nursery school children (Kendler, Kendler, & Wells, 1960) learn in accord with the predictions of a single-unit theory, while college students and kindergarten children who are fast learners learn in a manner which is more consistent with the predictions of mediational S-R theory. A reasonable conclusion might be that both theories are correct. That is, fast learners have developed mediational processes and slow learners are still in the process of acquiring such processes.

The present study was designed to investigate further the differences between fast and slow learners with respect to discrimination problems. Basic to any further investigation of differences between fast and slow learners, however, is a consideration of the amount of preshift training. This is especially important because of the findings of recent studies (Capaldi & Stevenson, 1957; MacKintosh, 1962; MacKintosh, 1963; Pubols, 1956; Reid, 1953) that the amount of preshift training is a matter of considerable consequence in accounting for the results of discrimination studies. The general finding has been that overtraining on a discrimination problem will facilitate the learning of the reversal of that problem. This finding has led to a good deal of recent theorizing which we will presently review. There is apparently good reason to believe that some other learning takes place during overtraining. If we assume with Kendler and Kendler that there is a basic difference between fast and slow learners with respect to the development of mediational processes, then it may be possible that overtraining might have different effects upon the different types of learners or that overtraining might provide the slow learners with a mediational response. In effect, it may be that a study of the relative effects of overtraining upon fast and slow learners would shed more light on the specific nature of the learning processes of both types of learners.

Before elaborating upon the details of the present investigation, a brief review of the effects of overtraining upon discrimination reversals is in order. It should be observed that the data and perhaps the theories of the effects of overtraining upon reversal and nonreversal shifts are limited to the behavior of lower organisms.

Reid (1953) demonstrated more rapid learning of reversal shifts for rats after an excessive amount of overtraining in a simple Y maze discrimination problem. It would appear that faster learning of a reversal shift after overtraining would present some difficulty for Spence's theory since overtraining results in increased habit strength for the positive stimulus thereby increasing its resistance to extinction. Spence, however, in a personal communication to Reid, explained the results by a logical extension of his theory. Spence accounted for the results in terms of differential position habit strengths in the criterion and overtraining groups. That is, criterion groups may have stronger position biases than overtrained subjects. It should be remembered that position is an irrelevant cue which has received random 50% secondary reinforcement. Overtraining provides for further equalization of position biases. Thus, overtrained subjects face the reversal of a simple discrimination problem with less position preference and are more likely to respond to the to-be-learned discrimination without position biases. Reid offered an alternative explanation of his results. He said that

> as a rat learns to make a specific choice discrimination, he is also learning a response of discriminating, i.e., learning to respond to a set of stimuli of which the specific stimulus is a member (Reid, 1953, p. 107).

This explanation is similar to the "vicarious trial and error" phenomenon reported by Muenzinger (1938) and Tolman (1939). Reid points out, however, that his theory is different from VTE in that "VTE designates 'the hesitating, looking back-and-forth sort of behavior,' while the response being described is a clear-cut 'looking at' one stimulus card, 'looking at' the other stimulus card, and immediately making a response to the correct card" (1953, p. 110). Reid goes on to point out that "learning to discriminate" is a slower process than learning to respond to a specific stimulus. Overtraining, therefore, provides opportunity for the development of "learning to discriminate." "Learning to discriminate" is slower than learning a response to an absolute stimulus value because there is greater delay of reinforcement for the discriminating response than for the response to the absolute stimulus value. Reid is not specific about the form of the curve for "learning to discriminate," but his general explanation may be conceptualized by reference to the curves in Fig. 2. The negatively accelerated curve in Fig. 2 refers to the increasing habit strength for the positive stimulus while the

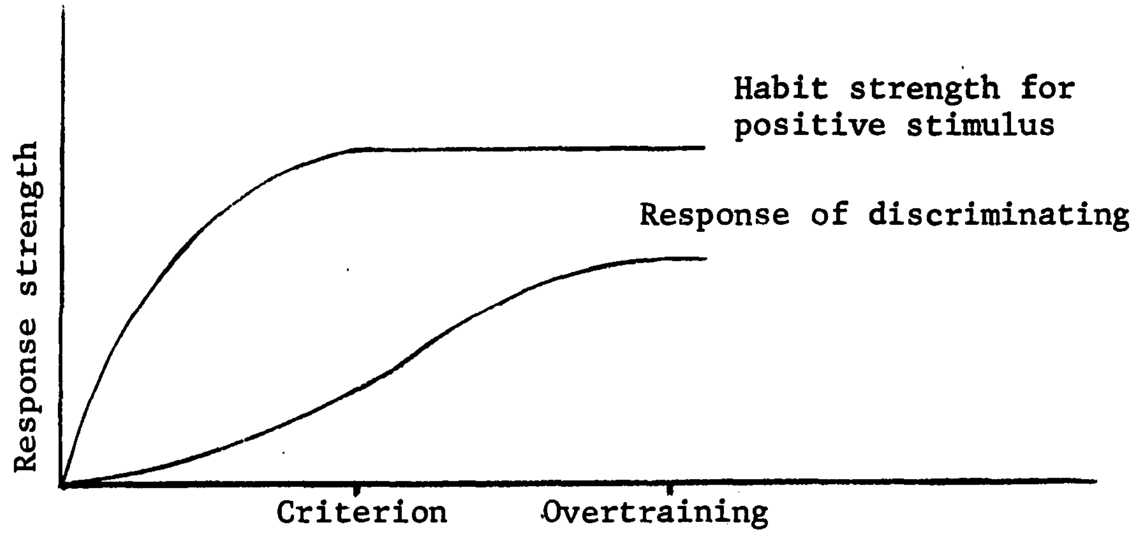

Fig. 2. Theoretical curves for learning to respond to an absolute stimulus value and "learning to discriminate."

S-shaped curve refers to the learning of a "response of discriminating." It can readily be observed that there should be large differences in resistance to extinction for the "response of discriminating" depending upon level of training. In criterion groups there is little acquired habit strength for the "response of discriminating." Therefore, a reversal shift is guided simply by the extinction of the response to the formerly positive stimulus and the acquisition of habit strength to the formerly negative stimulus. In overtraining, however, there is an increment in habit strength of the "response of discriminating" and this response is now more resistant to extinction. The presence of the "response of discriminating" in overtrained subjects should then facilitate the transfer from the formerly positive to the formerly negative stimulus.

Pubols (1956) attempted a test between Reid's theory and Spence's theory. Utilizing the Y alley maze, Pubols essentially replicated Reid's study with the addition of an attempt to introduce position-preference reduction training. If position preferences were controlled and if amount of learning were then not a factor in speed of reversal shifts it would be interpreted as a confirmation of Spence's position. However, an opposite result would favor Reid's explanation. The finding was that, even with position-preference reduction training, subjects still learned a reversal shift faster with overtraining than with criterion training. This finding was interpreted as supporting Reid's position. Pubols was hesitant, however, to say that his results contradicted Spence's theory. He concluded only that "position preferences would have less of an effect than if the reduction training had not been given, and that these results lend additional support to the response of discriminating interpretation" (Pubols, 1956, p. 245).

Evidence against both Spence's position and Reid's position is offered by Birch, Ison, and Sperling (1960). Instead of the conventional simultaneous discrimination problem, they worked with a successive discrimination problem which rules out position habits altogether. Successive discrimination involves two straight alley runways, one of which terminates with a positive cue and one of which terminates with a negative cue. Animals are run successively in the single-stimulus positive and negative alleys. Gradually, differential running speeds are established and learning criteria are determined by running speeds rather than correct choices. Birch et al. (1960) found that animals overtrained in this successive discrimination situation also learn the reversal of the problem faster than animals not so overtrained. This finding is troublesome for the "response of discriminating" explanation and for the elimination of position habits explanation. Birch's (1961) alternative explanation is essentially motivational rather than associative in nature. He explains the phenomenon in terms of the rg-sg and rf-sf mechanisms.[1] The assumption is that the overtrained group develops a relatively strong rg-sg compared with a group having less acquisition trials on the original discrimination problem. In the reversal phase the formerly positive

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[1]Rg-sg refers to a conditioned fractional anticipatory goal response elicited by runway stimuli. In effect, rg-sg refers to implicit antedating responses evoked by runway stimuli which are associated with goal stimuli. The frustration effects upon the fractional anticipatory responses caused by withholding reward is referred to as rf-sf.

cue is no longer reinforced; this serves to trigger the rf-sf mechanism, and the degree of rf-sf varies directly with the strength of rg-sg. The groups with overtraining, due to their greater rg-sg, have more rf-sf than the lesser trained criterion groups. Hence, due to the greater frustration, the avoidance response to the formerly negative cue is stronger in the overtrained group than in the criterion group.

In a study of simultaneous discrimination, Capaldi and Stevenson (1957) confirmed the results of Reid's and Pubol's studies, but offered a different theoretical interpretation. Capaldi and Stevenson argue that rate of extinction is functionally related to the degree of discrepancies in pattern of reinforcement which occur between acquisition and extinction. Thus, overtraining provides a greater discrepancy between acquisition and extinction conditions providing for easier discrimination between the two conditions. Therefore, with discrimination facilitated by overtraining, a second response is more easily acquired. This theory would predict faster transfer for both reversal and nonreversal shifts with overtraining.

The explanations offered by Birch et al. and by Capaldi and Stevenson seem to be consistent with the findings in both simultaneous and successive discrimination situations.

The explanations offered by Spence and by Reid are apparently limited to a simultaneous discrimination problem. Reid's explanation of "learning to discriminate" could apply to successive discrimination situations only if it were assumed that the subject carried internal symbolic cues appropriate to both stimulus components of the dimension. Discrimination processes would therefore be internal symbolic processes carried out in the absence of the appropriate external stimuli. At least only one component of the dimension is present in a successive discrimination problem and the "learning to discriminate" explanation would necessarily have to be extended to say that the other stimulus component would be present symbolically in order for a "response of discriminating" to occur.

Harlow (1959) accounts for overtraining effects by means of an error-factor theory. Harlow lists four persistent sources of error in discrimination problems. These sources include: stimulus perseveration, differential cue (ambiguity as to whether a reward is for an object or a position), response shift (a strong tendency to respond to both stimuli in an object discrimination problem), and position habit errors (consistent responses to right or left regardless of the position of the correct object). Harlow maintains that the result of overtraining is to reduce the effects of these error sources. This explanation is similar to Spence's position but more elaborate. Harlow's explanation and his learning set data indicate that both reversal and nonreversal shifts (ND) are facilitated by overtraining.

Another type of explanation of the relationship between reversal shifts and overtraining has been offered by Goodwin and Lawrence (1955) and Sutherland (1959). These investigators claim that two learning processes may be involved in learning discrimination problems. One learning process is to a set of stimuli or to a dimension; the other process is the establishing of preferences to various stimuli within the set. The better the learning to the set of stimuli the easier it would be to change preferences. Sutherland, as quoted by MacKintosh (1962), indicates that

> the two processes are, first the switching in of an analyzing mechanism specific to a given stimulus dimension, and, second, the attaching of responses to the outputs of the analyzer. The better the first process is learned (as a result of overtraining), the more likely rats are to keep on responding to the relevant cues after reversal, the less likely they are to respond to irrelevant cues, and the faster they will learn the reversal (1962, p. 555).

A brief summary of the explanations of the effects of overtraining upon reversal shifts indicates several types of explanations. The first type stresses the further weakening of irrelevant cues or errors (Spence, as quoted by Reid, 1953 and Harlow, 1959). The second type of explanation stresses the increasing discrepancy between acquisition and extinction caused by overtraining (Capaldi & Stevenson, 1957) or the resulting increases in frustration as a function of overtraining (Birch, 1961). The third type of explanation stresses the idea that other learning processes are occurring during overtraining such as "learning to discriminate" (Reid, 1953), responding to a dimension or set (Goodwin & Lawrence, 1955), or the switching in of an analyzing mechanism (Sutherland, 1959).

Since the effect of overtraining upon discrimination is a fairly recent area of investigation, time has not permitted the development of critical experiments to test the different explanations. It should be noted that all of the explanations predict faster reversal shifts with overtraining; however, differential predictions may be derived from some of the explanations with respect to the effects of overtraining upon nonreversal shifts. If reversal shifts are faster with overtraining because of a more firmly switched-in analyzer mechanism such as suggested by Sutherland, then overtraining would hinder a nonreversal shift since a more firmly switched-in analyzer mechanism would be appropriate only to one dimension, and a new dimension or a previously irrelevant dimension could not be handled by the analyzer. If, on the other hand, reversal shifts are faster with overtraining because of an increasing response independence from irrelevant cues (Spence) or error factors (Harlow), then a nonreversal shift (ND) should be facilitated by overtraining since the subject would face the new task with greater equalization of position factors, less response shift, etc. These theories, however, predict slower transfer for a nonreversal shift (ID) with overtraining because the previously irrelevant dimension which is now relevant was more thoroughly "gated out" as a function of overtraining; hence, it would be increasingly difficult to build up new response strength to an error which has been more completely eliminated by overtraining.

In an important experiment, MacKintosh (1962) studied the effects of overtraining upon reversal and nonreversal shifts (ND). It was found that overtraining facilitates the learning of a reversal shift and inhibits the learning of the nonreversal shift (ND). MacKintosh (1963) also found that overtraining retards the learning of a nonreversal shift (ID). The 1963 results are not particularly troublesome because, in the view of the present author, all of the theories predict such results. The 1962 study, however, presents some problems. The findings were interpreted as supporting the operation of an analyzer mechanism such as that proposed by Sutherland. MacKintosh felt that his findings were inconsistent with explanations such as Spence's, Harlow's, or Reid's. The present author agrees that the MacKintosh findings are inconsistent with Spence's and Harlow's explanations, but it is doubtful that the study contradicts Reid's explanations. Indeed, such findings would seem to support Reid since "learning to discriminate" is limited to the relevant dimension and is learned more completely with overtraining. The introduction of a new dimension would result in increasingly negative transfer as a function of overtraining.

In addition to the aforementioned interpretational problem in the MacKintosh study there was a methodological problem which may disqualify the data as a test of Harlow's and Spence's explanations. The discrimination apparatus was a modified Lashley jumping stand painted a flat grey. Reversal shifts were made on a brightness discrimination involving black and white cards. Nonreversal shifts were made by switching from brightness to horizontal-vertical stripes which were painted a flat grey, providing little contrast between the nonreversal shift cues and the rest of the environment. Since most of the environment was grey, it is not unlikely that grey stimuli were progressively "gated out" and weakened for discrimination purposes, especially in the overtrained groups. Thus, the horizontal-vertical dimension was contaminated by the fact that it was painted a flat grey the same as the rest of the environment. A dimension of a fundamentally different nature would have provided a better test. As it stands, the study could not be cited as providing evidence against Spence's and Harlow's explanations since irrelevant grey stimuli may have been progressively "gated out," hence, more difficult to respond to in the critical test situation.

It should also be noted that the results of the MacKintosh study, to the extent that they represent true effects, are limited to lower organisms. If Kendler and Kendler are correct in assuming fundamental differences between fast and slow learners with respect to the development of mediational responses, it appears that the results of a study like the MacKintosh study might be different for fast than for slow learners. On the other hand, it appears possible that the effect of overtraining is to provide the slow learner with some mechanism (a mediational process) which the fast learner acquires with much greater speed.

CHAPTER II

PROBLEM

The purpose of the present study was to attempt a further investigation of the effects of overtraining upon reversal and nonreversal shifts (ND) and possible differences between fast and slow learners with respect to the shift and training variables. The present study did not include nonreversal shifts (ID) because there does not seem to be a great deal of disagreement about what the effects of overtraining would be upon this type of shift.

The present study consisted of a 2 x 2 x 2 factorial design with two levels of training, reversal and nonreversal shifts, and fast and slow learners. Differential predictions from the various theories outlined in Chapter I are as follows:

1. The only theory appropriate to fast and slow learners is that of Kendler and Kendler. It predicts the initial position of these two kinds of learners in the

criterion groups. Fast learners should respond in a similar manner to reversal and nonreversal shifts, while slow learners should learn a reversal shift at a slower rate than a nonreversal shift because they respond in accord with the predictions of single-unit S-R theory.

2. The most straightforward and clearcut predictions concerning the effects of overtraining are made by Spence's and Harlow's theories. That is, the effects of overtraining should facilitate transfer for both reversal and nonreversal shifts provided the second task is not more difficult than the first. Presumably, fast learners should benefit more from overtraining than slow learners since they should eliminate errors at a faster rate.

3. Differential predictions for reversal and nonreversal shifts may be derived from theories such as Reid's, Sutherland's, and Goodwin and Lawrence's. Such theories predict negative transfer for nonreversal shifts with overtraining. Overtraining should produce positive transfer for reversal shifts. These predictions are based on the idea that an analyzer mechanism more firmly focused by overtraining and appropriate to only one dimension will serve to facilitate transfer from one cue to another only within the relevant dimension. However, if a new dimension is introduced as the

second task, the presence of the analyzer should retard learning of the new task. Presumably, a fast learner should be more retarded by the effects of overtraining in a nonreversal shift situation than a slow learner since the analyzer mechanism should be more firmly focused for a fast learner. For the same reason, a fast learner should learn a reversal shift faster with overtraining than a slow learner.

4. A logical extension of Kendler and Kendler's mediational hypothesis would seem to agree with a theory such as Sutherland's rather than one such as Harlow's with respect to the effects of overtraining upon fast and slow learners. It would appear that the effects of overtraining upon mediational processes should be to facilitate the learning of a reversal shift and further retard the learning of a nonreversal shift. Presumably, the mediation mechanism is specific to one dimension and increased practice with that dimension should facilitate changing cues within the dimension. Mediation processes, however, would be inappropriate to a new dimension and therefore inhibit the nonreversal type transfer. The amount of inhibition should be a function of the amount of preshift training. If Harlow's predictions were confirmed this would seem inconsistent with Kendler and Kendler's position. Figures 3-6 provide further elaborations of the various predictions.

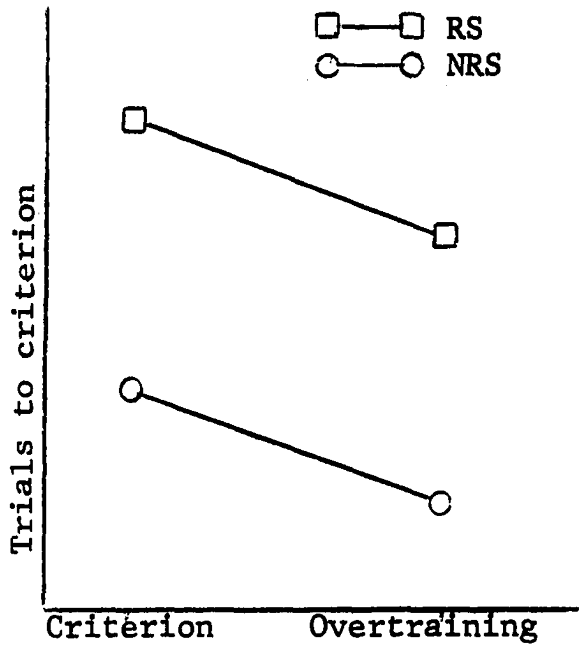

Fig. 3. Effects of overtraining upon slow learners according to prediction 2.

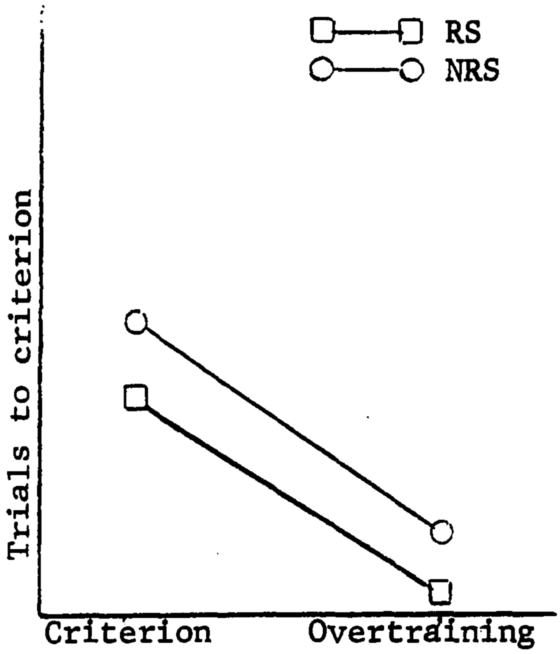

Fig. 4. Effects of overtraining upon fast learners according to prediction 2.

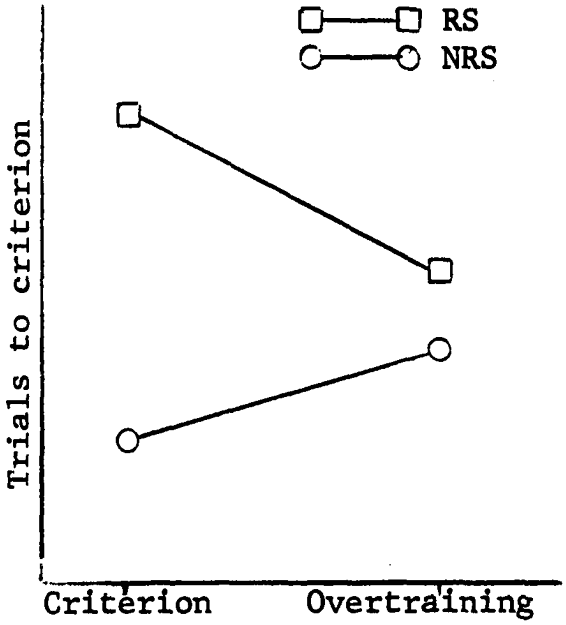

Fig. 5. Effects of overtraining upon slow learners according to predictions 3 and 4.

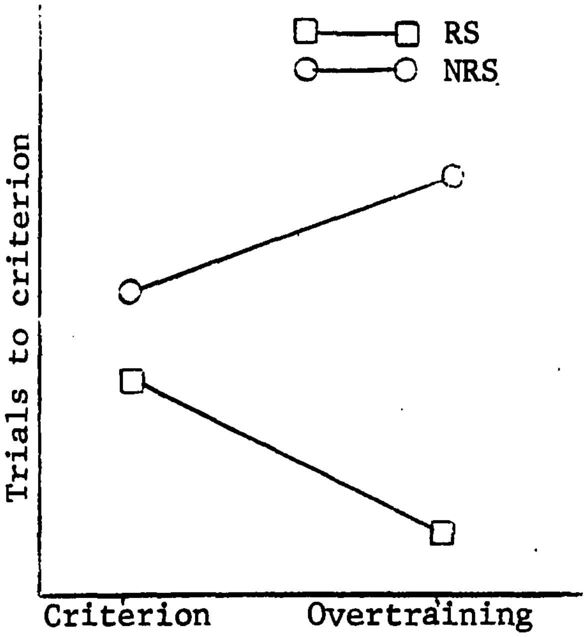

Fig. 6. Effects of overtraining upon fast learners according to predictions 3 and 4.

CHAPTER III

METHOD

Subjects

The subjects were 64 female kindergarten children taken from two elementary schools in Midwest City, Oklahoma. The schools were located in similar middle class socioeconomic areas. The mean age of the subjects was 72.4 months with a range of from 65 to 80 months. Two subjects were eliminated because of failure to learn.

Apparatus

The apparatus (Fig. 7) consisted of a one inch flat unpainted piece of plywood 12 inches wide and 18 inches long. This board was divided lengthwise by a perpendicular screen which was 12 inches high and 18 inches in length. The base and screen were mounted on a swivel device making it possible to turn the apparatus in a 360 degree circle. On one side of the apparatus were two ¾ inch depressions six inches apart in which a token reward, consisting of a marble, could be placed. The depressions were felt lined for the purpose of minimizing any possible auditory cues. When the side of the apparatus containing the depressions was turned toward the experimenter, the token reward was placed in one of the

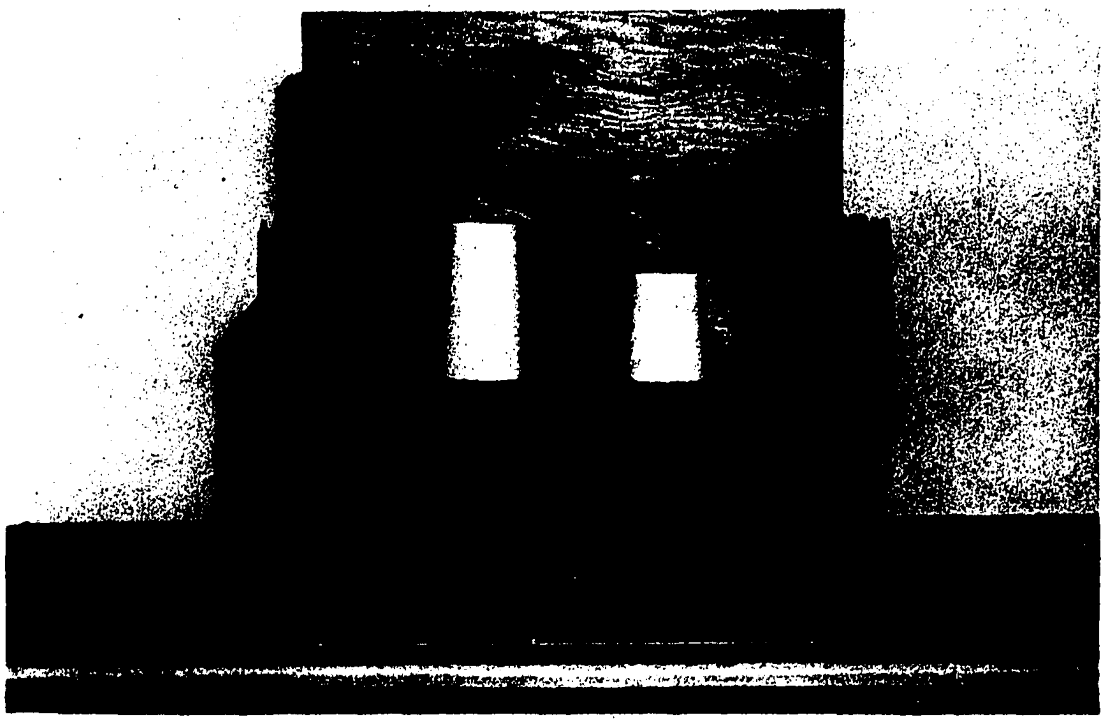

Fig. 7. Photographic reproduction of the apparatus.

depressions and was then covered with one of the discriminanda (to be described below). The 12 x 16 perpendicular board served to screen the experimenter's actions so as to minimize any possible position cues. After the token reward and the discriminanda were in their appropriate places, the apparatus was turned 180 degrees so as to face the subject, who was sitting directly in front of the experimenter.

One of the dimensions was shape. The specific discriminanda were a wooden disc three inches in diameter and a three inch wooden square. The other dimension was height. The specific discriminanda were a metal tumbler six inches high and another four inches high. All discriminanda were painted white.

Procedure

Subjects were run individually in a small quiet room. When a subject arrived at the experimental room, he was greeted by the experimenter, who attempted through informal conversation to create a friendly and relaxed atmosphere. The conversation was eventually directed toward the discrimination apparatus and a large collection of prizes (to be described shortly). Subjects were given the following instructions:

> We are going to play a game and your job is to try and find a hidden marble. You see these two places cut in the board? (At this point the experimenter referred to the two depressions in the base of the apparatus.) I am going to place a marble in one of these and cover both of them with these two objects (here the experimenter pointed to the two discriminanda which were to be used in the initial learning session). Your job is to guess where the marble is hidden. Each time I turn the objects so that they face you, you may choose the one of them under which you think the marble is hidden. The

object of the game is for you to try to get the marble every time. (The foregoing statement was repeated several times throughout the experiment.) When you guess correctly, you may take the marble and place it in this sack (each subject was given a small cloth sack). After the game is over, you may trade the marbles you have won on one of these prizes. (At this point the subject was introduced to a large assortment of candy, cookies, charms, etc.) Remember now, the object of the game is for you to get a marble on every trial. (At this point, subjects were asked if they understood the game or had any questions. Any questions were answered and then the testing procedure was begun.)

Subjects were divided into fast and slow learner groups on the basis of their scores (upper 1/3 and lower 1/3) on the Metropolitan Readiness Tests. Both fast and slow learners were then randomly assigned to one of four test conditions which included: reversal shift-criterion training, reversal shift-overtraining, nonreversal shift-criterion training, and nonreversal shift-overtraining.

In initial training, a given subject might be confronted with a circle-square (shape) combination or a tall-short (height) combination. If a subject was assigned to a reversal shift group, then the critical test problems consisted of a shift from the circle to the square or the square to the circle or from tall to short or short to tall. A nonreversal shift subject who was originally confronted with shape was, in the critical test situation, transferred to height. Likewise, a nonreversal shift subject who was originally confronted with height was, in the critical test situation, transferred to shape. In all, there were four possible arrangements of discriminanda for reversal shift subjects and eight possible arrangements of discriminanda for nonreversal shift subjects. These arrangements included:

Reversal Shift

1. Square to circle
2. Circle to square
3. Tall to short
4. Short to tall

Nonreversal Shift

1. Circle to tall
2. Circle to short
3. Square to tall
4. Square to short
5. Tall to circle
6. Tall to square
7. Short to circle
8. Short to square

Subjects were randomly assigned to these various arrangements. The discriminanda were also randomized with respect to position. However, there was a control for run effects such that if one object occupied one position for three successive trials, it was automatically changed on the fourth trial.

The learning criterion was nine out of ten successive correct choices. This criterion is the same as that utilized in the 1959 Kendler and Kendler study.

Subjects in the overtraining groups were given 100% overtraining before they began the critical tests. Immediately after the completion of the overtraining trials, subjects entered into the critical test conditions without further instructions. Subjects in criterion groups began the critical tests immediately after meeting the original discrimination learning criterion.

The learning criterion for the critical tests was the same as for the original discrimination problems, i.e., nine out of ten successive correct choices.

CHAPTER IV

RESULTS

The original data, consisting of trials to criterion, were characterized by marked heterogeneity of variance. Hartley's F_{max} test resulted in a value of 4018.13. The critical region for F_{max} with eight treatments and seven degrees of freedom in each treatment is $F > 11.8$. The source of the heterogeneity is to be found in the rather large variance differences between reversal and nonreversal problems. This finding is in keeping with a similar finding reported in the 1960 Kendler, Kendler, and Wells article. Heterogeneity was further augmented by the learner (fast-slow) dimension in the present study. For example, slow learners in the criterion reversal shift group displayed a range of from 1 to 98 responses in order to reach criterion. By contrast, all fast learners in the nonreversal shift overtraining condition apparently needed only one trial to solve the problem. If the first trial resulted in an error (no reward) then there was an immediate and systematic response to the appropriate alternative discriminandum. If the first trial was correct, then there was never an attempt to respond to the inappropriate discriminandum. Thus, the range of responses, by contrast with the range in the slow learner reversal criterion group, was extremely narrow, i.e., 0 to 1.

Because of the heterogeneity of variance a log transformation was performed on the original data resulting in considerable reduction of heterogeneity ($\underline{F}_{max} = 13.97$), but the $\underline{F}$ ratio was still within the critical region so another method of analysis was chosen.

A reasonable alternative to the problems created by heterogeneity was to change response measures from trials to criterion to the log of error scores. This change resulted in sufficient reduction of heterogeneity ($\underline{F}_{max} = 9.48$) to permit the use of the analysis of variance. According to Kendler and Kendler (1959), there is substantial agreement between these two measures.[1]

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[1]There is essential agreement in the present study between the analysis of transformed error scores and the analysis based on transformed trials to criterion. The analysis based on trials to criterion, however, did yield a significant learner effect which was not present in the analysis based on error scores.

Table 1 presents a summary of means and variances of untransformed error scores of the various sub-groups, and Table 2 presents the results of the analysis of variance of the transformed data.

Table 1

Means and Variances of Untransformed Error Scores for All Groups

Treatment Groups		Mean	Variance
Slow Learners	Reversal Criterion	13.00	299.25
	Reversal Overtraining	8.62	63.24
	Nonreversal Criterion	2.00	2.00
	Nonreversal Overtraining	3.75	21.69
Fast Learners	Reversal Criterion	3.75	2.44
	Reversal Overtraining	4.12	6.36
	Nonreversal Criterion	4.88	54.61
	Nonreversal Overtraining	1.62	.24

The only significant result is the shift effect (B) indicating the relatively greater difficulty of transfer in reversal shift than in nonreversal shift problems.

The only other _F_ ratio in Table 2 which approaches significance is the one for the learner variable (A).

Table 2

Summary of Analysis of Variance of Log of (Errors + 1)

Source	ss	df	ms	F	P
Learner (A)	.3210	1	.3210	2.74	
Shift (B)	2.3223	1	2.3223	19.83	.01
Training (C)	.0036	1	.0036		
A x B	.2483	1	.2483	2.12	
A x C	.0956	1	.0956		
B x C	.0026	1	.0026		
A x B x C	.2139	1	.2139	1.83	
Error (w)	6.5808	56	.1171		
Total	9.7881	63			

Failure to reach significance here may be partially attributable to the reversed performance of fast and slow learners in the nonreversal criterion groups. This difference is indicated in Table 1.

The training variable was not significant, indicating that 100% overtraining is not sufficient to produce a training effect in kindergarten children.

The insignificant learner x training (A x C) interaction indicated that overtraining did not produce differential effects upon slow and fast learners. There was a slight decrease in the number of errors in the overtraining conditions for both slow and fast learners, but the amount of decrease in errors was about the same for both types of learners.

In a similar manner, overtraining did not produce differential effects upon the two types of shifts. Thus, the shift x training (B x C) interaction also proved insignificant. Again, there were slight decreases in the number of errors for both reversal and nonreversal overtraining conditions, but the amount of decrease was about the same for both overtraining conditions.

The triple interaction in Table 2 falls short of the required significance level, indicating the failure of the training variable to produce differential effects upon the form of interaction of the other two variables.

One expected result that did not materialize was that the shift effect would be more pronounced for slow learners than for fast learners. That is, it was expected that slow learners would show significantly greater differences in performance in the two different shift conditions than fast learners. Such a result would, of course, have produced a significant shift x learner (A x B) interaction. Figure 8 provides a picture of the direction represented by

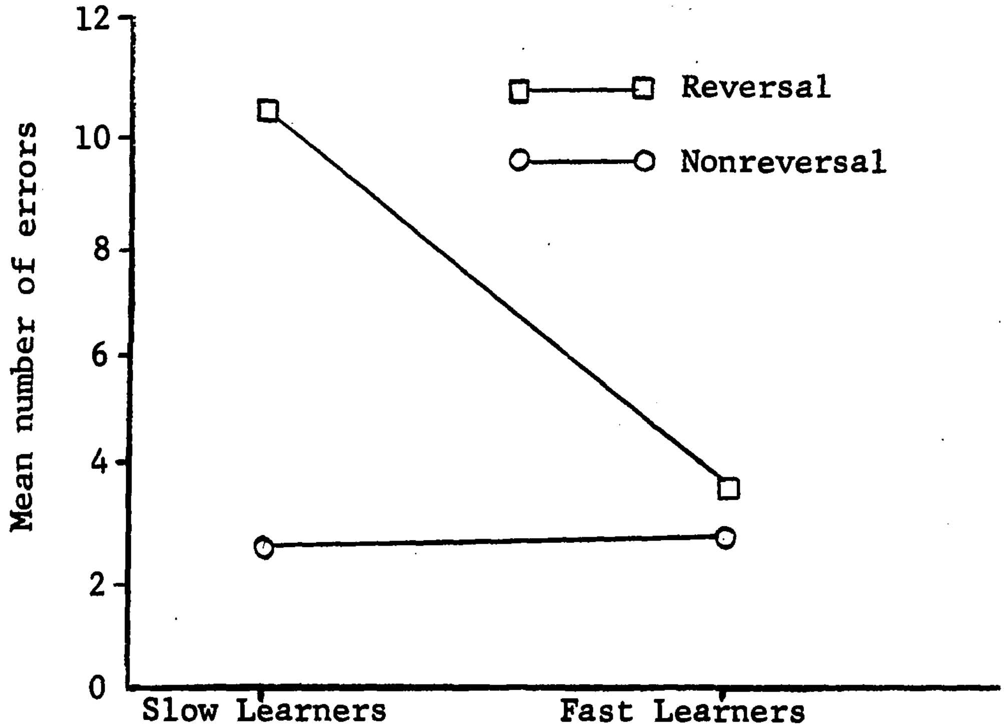

Fig. 8. Mean number of errors of fast and slow learners in reversal and nonreversal problems.

the _F_ ratio for the learner x shift interaction. It should be noted that these results are in the same direction as those reported by Kendler and Kendler (1959). Because of the apparent similarity between the results of the present study and those of the Kendler and Kendler study, it seemed appropriate to conduct a more detailed analysis of the shift x learner interaction. Accordingly, Duncan's (1955) _new multiple range test_ was applied to the 4 means involved in the interaction term. The test indicated that the mean for the slow learner reversal shift condition was significantly larger than any of the other means ($P < .05$).

The differences between fast and slow learners for reversal and nonreversal problems are brought into stronger focus by an examination of transfer scores. These scores consist of the number of errors in original training minus the number of errors in the critical test problems. The mean transfer score for slow learners in reversal problems was -5.00 indicating that the critical problems were learned at a slower rate than the initial problems. All of the other groups showed positive transfer scores indicating faster performance in the critical problems than in the initial problems. Thus, the mean transfer score for slow learners in nonreversal problems was 4.19, for fast learners in reversal problems the mean transfer score was 1.00, and for fast learners in nonreversal problems the mean transfer score was 5.06. The only group showing negative transfer was the slow learner reversal shift group.

Because of the rather large differences in the aforementioned transfer scores, and because such scores are based on the relationship between initial learning performance and performance in the critical tasks, it was decided to conduct a statistical analysis based more directly on transfer performance in hope of providing a more sensitive test of the experimental questions. The analysis consisted of a 2 x 2 x 2 x 2 design with repeated measures for the performance (initial learning and critical task learning) variable. The response measure was, again, the log of error scores. Table 3 presents a summary of the analysis of variance. It should be pointed out that the first part of the analysis ("between subjects") is not particularly useful for the purposes of the study. The second part of the analysis (based on repeated measures), however, is directly relevant to our experimental interests.

The four-way analysis reveals a significant shift (D x B) effect ($\underline{F} = 19.82$, $P < .01$) indicating the relatively greater difficulty of reversal transfer as opposed to nonreversal transfer.

There was also a significant transfer difference between fast and slow learners. The mean overall transfer score for slow learners was -.41, while fast learners showed positive transfer with a mean score of 3.09. The learner x period (A x D) effect in Table 3 indicates that this difference was significant ($\underline{F} = 4.20$, $P < .05$). This result is consistent with that of the analysis based on trials to criterion as indicated in the footnote on page 33.

The most interesting result in Table 3 is the learner

Table 3

Summary of Four-way Analysis of Variance

Source	ss	df	ms	F	P
Between Subjects	7.4648	63	.1185		
Learner (A)	.0365	1	.0365		
Shift (B)	.6875	1	.6875	5.95	.05
Training (C)	.0143	1	.0143		
A x B	.0597	1	.0597		
A x C	.0212	1	.0212		
B x C	.0602	1	.0602		
A x B x C	.1104	1	.1104		
error (b)	6.4750	56	.1156		
Within Subjects	9.3127	64	.1455		
Periods (D)	1.5259	1	1.5259	17.20	.01
C x D	.0015	1	.0015		
B x D	1.7581	1	1.7581	19.82	.01
A x D	.3724	1	.3724	4.20	.05
B x C x D	.1010	1	.1010	1.14	
A x C x D	.0850	1	.0850		
A x B x D	.3974	1	.3974	4.48	.05
A x B x C x D	.1041	1	.1041	1.17	
error (w)	4.9673	56	.0887		
Total	16.775	127			

x shift x period (A x B x D) effect. This result ($\underline{F}$ = 4.48, $\underline{p} < .05$) indicates relatively greater differential effects of the two types of shifts upon slow learners as opposed to fast learners. Thus, the four-way analysis provides further support for mediation theory and the previous findings of the 1959 Kendler and Kendler study.

All of the interactions in Table 3 which relate to the training effect (C) are insignificant, thereby supporting the previous analysis in Table 2 which was based only on error scores in the critical test problems.

CHAPTER V

DISCUSSION

As stated in the results section, the present research lends support to the 1959 Kendler and Kendler study, but the present data also seem to suggest a need for a particular elaboration of the mediation hypothesis. The relationship between the results of the present study and the results of the 1959 Kendler and Kendler study is illuminating. Table 4 provides a direct comparison, in terms of mean number of trials to criterion, of the shift effects for the two studies.

Table 4

Mean Number of Trials to Criterion for the Shift Effect

Kendler and Kendler Study		Present Study	
Group	Trials	Group	Trials
Reversal	15.2	Reversal	12.4
Control Nonreversal (ND)	7.1	Nonreversal	3.6

The shift effect in the Kendler and Kendler study was not statistically significant, but it was in the same direction as that of the present study, which was significant at the .01 level. It will be recalled that single-unit S-R theory predicts that a reversal shift should be slower than a nonreversal shift, and the evidence from the present study supports this prediction. Mediation theory, however, predicts that the difference between a reversal and a nonreversal shift (ND) should be more pronounced for slow than for fast learners. Stated another way, since there should be little difference in performance on reversal and nonreversal shifts for fast learners, the significant shift effect should be attributable largely to the difference in performance for slow learners. This prediction is based on the idea that fast learners, who have developed mediation responses, should solve a reversal shift problem as fast as a nonreversal shift (ND) problem. Slow learners, however, who have not developed mediation responses, should show considerably more negative transfer on reversal shifts than on nonreversal shifts. Once again, a comparison of the present data with the 1959 Kendler and Kendler findings is instructive with respect to an analysis of the interaction prediction. Before making this comparison, one difference between the two studies should be noted. Kendler and Kendler did not have MA scores available so their fast-slow division was determined on the basis of scores above and below the median of trials in the initial learning task. The fast-slow division in the present study, as mentioned earlier, was based on scores on the Metropolitan Readiness Tests. Once again, since Kendler and Kendler used trials to criterion in the critical task as their response measure, the same response measure from the present study will be utilized for comparison of the interaction effects. Figures 9 and 10 present the shift x learner interaction comparisons of the two studies.

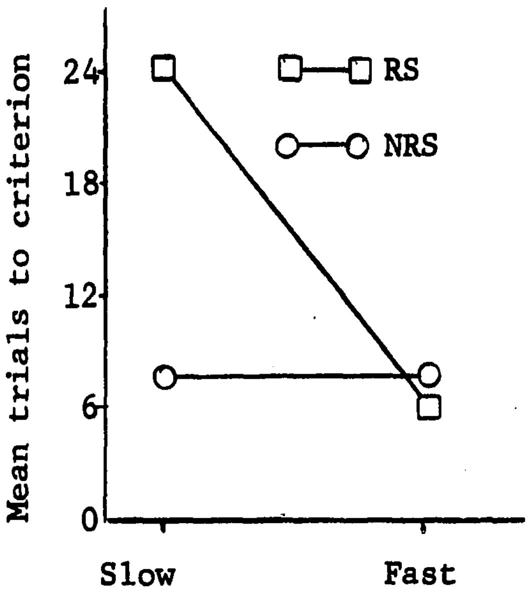

Fig. 9. Shift x learner interaction in the Kendler and Kendler study.

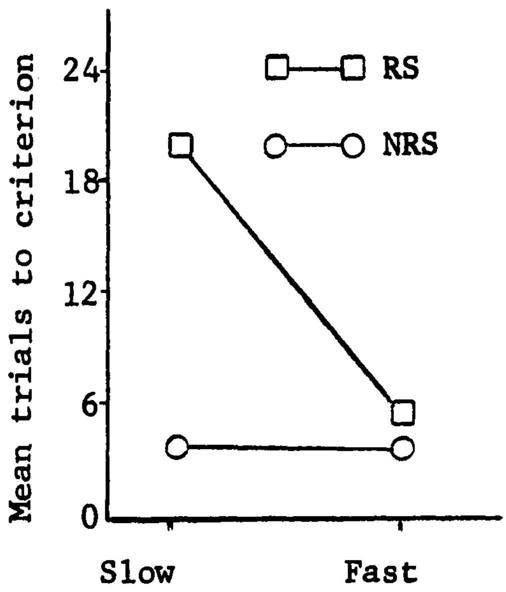

Fig. 10. Shift x learner interaction in the present study.

Examination of Figures 9 and 10 reveals that fast learners, in accord with the predictions of mediation theory, make about the same number of errors regardless of type of shift. Slow learners, however, appear to make more errors in the reversal condition than in the nonreversal condition. These interaction effects proved significant ($\underline{F}$ = 4.00, $P <$ .05) in the Kendler and Kendler study. The similarity of the present findings to those of Kendler and Kendler is indicated by Figs. 9 and 10. That this is more than an apparent similarity is made clear by the significant shift x learner x periods (A x B x D) interaction (page 40) and by the analysis that shows that the number of errors for slow learners on reversal shift problems is greater than for any of the other conditions (page 37). The meaning of the A x B x D interaction is clarified by Figs. 11 and 12. Figures 11 and 12 illustrate rather clearly the negative transfer manifested by slow learners in the reversal shift condition. All other transfer conditions produced positive transfer scores. Thus the present data confirm prediction number one which is based on the conclusion drawn by Kendler and Kendler that slow learners support the predictions of single-unit S-R theory while fast learners support the predictions of mediation S-R theory.

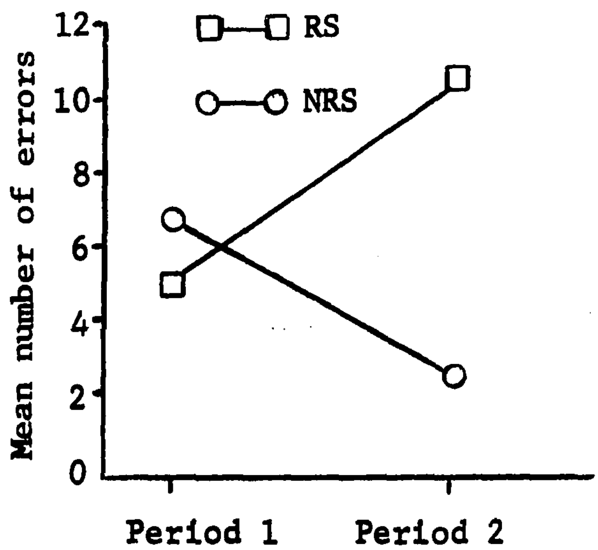

Fig. 11. Period x shift interaction for slow learners.

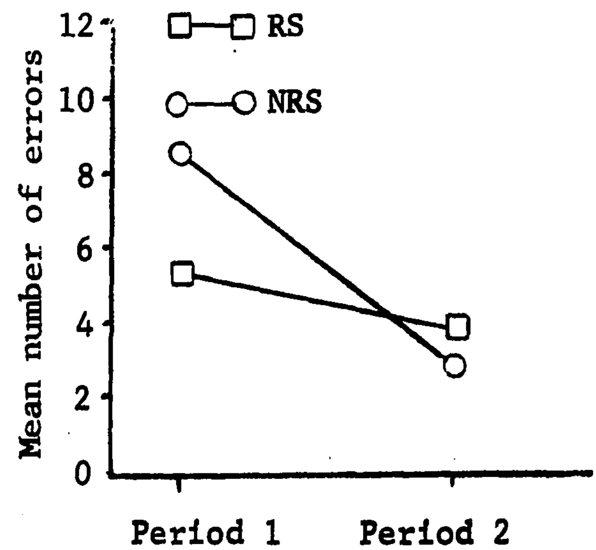

Fig. 12. Period x shift interaction for fast learners.

Another interesting result, which is indicated in Table 5, is the relatively higher variability in the slow learner reversal shift condition than in any of the other conditions.

Table 5

Variances of Raw Error Scores for Fast and Slow Learners in Reversal and Nonreversal Problems

Slow Learners		Fast Learners	
Reversal	Nonreversal	Reversal	Nonreversal
186.03	12.61	4.43	30.06

Kendler, Kendler, and Wells (1960) reported greater variability for reversal shifts than for nonreversal shifts and interpreted their results as indicating a possible measure of transitional stages from single-unit S-R responses to mediated S-R responses. The fact that the largest variation appears in the slow learner group does suggest the possibility that these subjects are in the process of transition from single-unit to mediational response modes. Smaller variation occurs in the fast learner reversal shift condition because most of these subjects are responding in a similar mediational S-R manner.

These two findings concerning the learner x shift x period interaction and the larger variation in the slow learner reversal shift condition both seem to indicate support for the predictions of mediation theory. The learner x shift x period interaction offers evidence that the predictions of single-unit S-R theory are limited to the discrimination behavior of lower organisms and children who are still in the initial formative stages of language development. It also seems difficult to account for the larger variation in reversal shift conditions by means of single-unit S-R theory. A possible further test of the predictions of mediation S-R theory would involve a comparison of the relative magnitude of variances of reversal and nonreversal performance of animals, such as rats, with that of kindergarten children. It seems likely that rats would show a smaller difference between variances for the two types of problems than do children.

At the outset of the present chapter it was stated that the present data suggest a need for a particular elaboration concerning the nature of mediation processes. Kendler and Kendler were doubtful that the observed differences between fast and slow learners in performance on reversal and nonreversal shifts represented a difference in general learning ability. Since the present study divided fast and slow learners on the basis of a general abilities test, this would suggest that the availability of mediation responses is related to general learning ability.

Another more important possibility, as indicated by Kendler and Kendler, is that the real difference between fast and slow learners is a reflection of the level of language development and that mediational responses are primarily transformational processes made possible by appropriate verbal devices. In a recent article, Bruner (1964) states:

> In effect, language provides a means, not only for representing experience, but also for transforming it. . . . Not only, if you will, did the dog bite the man, but the man was bitten by the dog and perhaps the man was not bitten by the dog or was

> the man not bitten by the dog. The range of reworking that is made possible even by the three transformations of the passive, the negative, and the query is very striking indeed. Or the ordering device whereby the comparative mode makes it possible to connect what is <u>heavy</u> and what is <u>light</u> into the ordinal array of <u>heavy</u> and <u>less heavy</u> is again striking. Or, to take a final example, there is the discrimination that is made possible by the growth of attribute language such that the global dimension <u>big</u> and <u>little</u> can now be decomposed into <u>tall</u> and <u>short</u> on the one hand and <u>fat</u> and <u>skinny</u> on the other (Bruner, 1964).

None of the predictions (numbers 2, 3, 4) concerning the effects of overtraining was confirmed by the present data. The lack of statistical significance in the training variable and the interactions which involve the training variable, including the triple interaction, could reflect an insufficient amount of overtraining or a need to purify the fast-slow category. A more interesting possibility is that the theories which deal with the effects of overtraining upon reversal and nonreversal shifts account only for the discrimination behavior of inarticulate organisms. The fact that the present data fail to confirm any of the predictions (Birch, Capaldi & Stevenson, Goodwin & Lawrence, Harlow, Reid, Spence, or Sutherland) concerning the effects of overtraining raises a question as to the applicability of the various theories to the discrimination behavior of articulate children who are in the process of developing symbolic mediational responses. The present data suggest that mediational responses are not affected by any learning beyond asymptote. It seems likely that the slow learners in the present study failed to confirm the overtraining predictions because some of them were already too far along in the development of symbolic mediational processes. Partial evidence that slow learners are already in the process of developing mediational responses is offered by the large variability in the slow learner reversal shift condition. More conclusive evidence would seem to depend upon a demonstration of a progressive decrease in number of errors in reversal shifts as a function of increasing age levels. Perhaps overtraining effects could be observed in pre-school or nursery age children who are not as far along in the development of mediational processes as kindergarten children.

CHAPTER VI

SUMMARY AND CONCLUSIONS

Using kindergarten children as subjects, Kendler and Kendler (1959) demonstrated fundamental differences between the performance of fast and slow learners in reversal and nonreversal discrimination problem situations. The general finding was that slow learners perform according to the predictions of single-unit S-R theory (Spence, 1936), while fast learners perform according to the predictions of mediational S-R theory (Kendler & D'Amato, 1955).

The present study was designed to investigate the possible effects of overtraining upon fast and slow learners involved in reversal and nonreversal problem situations. It seemed possible that overtraining might further amplify the differences between fast and slow learners or that it might have an opposite effect by providing the slow learner with sufficient experience with the problem to develop a response mode closer to that of the fast learner.

Several large classes of kindergarten children were divided into fast and slow learners on the basis of scores on the Metropolitan Readiness Tests. Thirty-two subjects were then chosen at random from each classification group. The thirty-two subjects in each (fast-slow) group were then randomly assigned to one of four treatment conditions which included reversal shift-criterion training, reversal shift-100% overtraining, nonreversal shift-criterion training, and nonreversal shift-100% overtraining.

The discrimination problems involved standard (shape-height) dimensions. A reversal shift involved shifting of the positive and negative stimuli within a dimension, while a nonreversal shift involved a change from one dimension to another.

The results which relate to the learner and shift variables provide basic support for the previous findings reported by Kendler and Kendler. There was a significant shift effect (indicating the greater difficulty of reversal transfer) and a significant learner x shift x periods interaction. The learner x shift x period result may be attributed to the fact that slow learners in the reversal shift group showed negative transfer, while all other groups showed positive transfer.

The training variable and the interactions involving the training variable were not significant. The suggestion was offered that learning beyond asymptote does not affect the mediational processes of fast learners. It was further suggested that overtraining failed to produce an effect upon slow learners because too many of them were already in the process of developing symbolic mediational response modes. The latter suggestion was supported by a significantly higher variation in the slow learner reversal condition than in any of the other conditions.

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APPENDIX

ORIGINAL DATA

Table 7

Untransformed Error Scores in Initial Trials for All Groups

	Slow Learners				Fast Learners			
	Criterion		Overtraining		Criterion		Overtraining	
	RS	NRS	RS	NRS	RS	NRS	RS	NRS
	3	3	4	3	3	5	3	3
	3	2	3	3	3	12	6	6
	4	4	4	19	1	16	11	17
	4	3	8	3	6	20	2	7
	4	6	3	5	5	9	3	4
	4	14	4	2	4	4	5	4
	13	37	22	4	8	4	6	5
	6	3	4	2	6	5	9	12
$\bar{X}$	5.12	9.00	6.50	5.12	4.50	9.38	5.62	7.25
σ^2	9.61	125.00	36.50	25.24	4.25	32.48	8.48	20.44

Note: +1 has been added to each score.

Table 8

Untransformed Error Scores in Critical Learning Trials for All Groups

	Slow Learners				Fast Learners			
	Criterion		Overtraining		Criterion		Overtraining	
	RS	NRS	RS	NRS	RS	NRS	RS	NRS
	2	3	5	2	3	24	2	2
	56	1	5	2	3	1	3	1
	6	1	8	2	2	1	2	2
	3	1	17	1	6	2	5	2
	4	5	3	2	6	2	5	2
	5	3	3	2	2	2	2	1
	22	1	26	3	5	6	4	1
	6	1	2	16	3	1	10	2
$\bar{X}$	13.00	2.00	8.62	3.75	3.75	4.88	4.12	1.62
σ^2	299.25	2.00	63.24	21.69	2.44	54.61	6.36	.24

Note: +1 has been added to each score.