San Fernando Valley State College

OVERTRAINING AND RELATIVE DIFFICULTY OF TASKS

AS FACTORS IN REVERSAL LEARNING

A thesis submitted in partial satisfaction of the requirements for the degree of Master of Arts in Psychology

by

John Ludwig Louks

July, 1969
The thesis of John Ludwig Louks is approved.

San Fernando Valley State College
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ABSTRACT

OVERTRAINING AND RELATIVE DIFFICULTY OF TASKS AS FACTORS IN REVERSAL LEARNING

by

John Ludwig Louks

Master of Arts in Psychology

July, 1969

Speed of reversal learning was studied as a function of overtraining and number of pairs reversed in 72 male and female college students. S's were trained to criterion on six visual discrimination pairs. Overtraining was provided at 0, 5, 10, or 15 additional sets of six pairs. After overtraining was completed, the correctness of buttons in 1, 4 or 6 pairs was reversed. It was confirmed (.01 level) that an intermediate number of pair reversals is the most difficult task to learn. A probable main effect (.01 level) for overtraining was created, but this is not compelling on its own merits. However, in combination with a significant (.01 level) interaction between quadratic trends, the implication is that the overtraining effect is curvilinear in nature. Intermediate values created the greatest positive transfer effect. Number of pairs reversed was effective independently of overtraining.
However, positive transfer due to overtraining was dependent upon large or small numbers of pair reversals. These tasks are of least difficulty. When overtraining was provided prior to a task of maximum difficulty, negative transfer or no effect were observed.
OVERTRAINING AND RELATIVE DIFFICULTY OF
TASKS AS FACTORS IN REVERSAL LEARNING

John Ludwig Louks

The Overtraining-Reversal Effect (ORE) is the subject of this paper, and it has received considerable investigation since it was initially reported. S's are trained to criterion on an initial stimulus discrimination task. It is sometimes found that facilitation in learning a reversal task results if S's are given additional training on the initial task before the reinforcement contingencies are reversed.

If the ORE is, in fact, a principle of learning, the direct implication is that S learns other things than unitary connections between single stimuli and single responses. A unitary S-R model predicts that the response is directly dependent upon the characteristics of the external stimulus complex. An alternative, mediational, model suggests that the external stimulus achieves some abstract, internal, representation. For instance, this may be verbal or perceptual in nature. This representation of the original stimulus field becomes part of the effective stimulus in learning. The roots of this discussion lie in the disagreements
between two schools of psychology, and their respective learning theories. S-R learning theory emphasizes the overt quality of the stimulus and response in learning; while Gestalt psychology has strongly maintained that higher processes of mediation, and the learning of relationships, are the natural mode of learning for human beings and many animals with phylogenetically advanced brains.

Three theories of the ORE will be discussed in this paper. First, there is the theory of discriminable change, proposed by Capaldi & Stevenson (1957). Secondly, Zeaman & House (1963) proposed an attention hypothesis in explaining the ORE. Finally, Kendler & Kendler (1959, 1962, 1964) propose a mediational model.

Wolff (1967) has reviewed the literature on concept shift and discrimination reversal in human subjects. In that review, he summarizes the evidence for and against a number of theories, including the three to be discussed here.

Capaldi & Stevenson (1957) maintain that increased discriminability of the stimuli results from extra practice on a task. During overtraining (OT), correct responses receive continuous reinforcement, while incorrect ones are not being emitted. Thus, the responses which were correct during the initial training are incorrect in reversal learning. Since they were on a
schedule of continuous reinforcement, those responses extinguish at a more rapid rate for overtrained S's than for the criterion trained group. As S receives an increasing number of OT trials, he is able to discriminate the reinforcement contingencies with ever greater precision. When reversal learning begins, he is able to distinguish this shift in the reinforcement contingencies more clearly than an S who is only criterion trained. This hypothesis has received support from the finding (Iwahara & Sugimura, 1960) that as S's were given a greater number of OT trials, they had a greater tendency to notice the reversal shift. However, this theory cannot account for Wolff's (1967) conclusion that OT differentially facilitates visual and position tasks with rats. Wolff suggests that discriminable change probably plays a part in the ORE, but that other factors, such as attention, are operating as well.

Zeaman & House (1963) have proposed an attention hypothesis in order to explain the ORE. A stimulus is assumed to possess several dimensions, and S may only attend to one at a time. When an observing response for one of the dimensions is elicited, it either leads to direct reinforcement if it is the appropriate dimension, or direct extinction if it is the incorrect dimension. When an observing response is followed by reinforcement, it leads to the indirect extinction of the
other irrelevant dimensions. The change in strength of an observing response due to direct and indirect reinforcement, or extinction, is proportional to its current strength. Thus, the theory would predict that when S's initial probability of responding to the appropriate dimension is low, his improvement towards criterion performance will be slow. When his initial probability of responding to the appropriate dimension is high, S will rapidly attain criterion performance.

A mediational model of reversal learning has been proposed by Kendler & Kendler (1959, 1962, 1964). According to his theory, S develops covert verbal mediators during training. These abstractions provide a comparison, or criterion, against which he can test the current reinforcement contingencies. As S receives OT, his verbal mediators become more precisely defined. When a change in reinforcement occurs, he will have a greater likelihood of detecting it than will an S who has not received OT.

The ORE was initially reported for rats (Reid, 1953) on a color discrimination task. Reid gave criterion trained rats 0, 50, or 150 OT trials prior to reversal. The group which had received the maximum amount of OT had required the least number of trials to master the reversal task. In reversal learning, the stimuli are the same as in original learning, but the correctness of
each is reversed. This positive transfer effect may be partially accounted for by elements of the stimulus or response which are common to both tasks. Once having mastered the first task, the S has also acquired a portion of the associations which are necessary for reversal learning. This would be true, however, even if no OT were given. In this respect, the CRE is similar to other examples of positive transfer. However, overtraining enhanced the positive transfer effect due to the presence of similarity between tasks. The overtrained group improved more than the criterion trained group.

The ORE is a complex phenomenon. It is dependent upon several parameters, including drive level, age and learning speed. Bruner, Mandler, O'Dowd and Wallach (1958) deprived rats of food for 12 or 36 hours during overtraining. After overtraining, but prior to reversal learning, S's were deprived of food for 12 or 36 hours independently of the first deprivation. This provided four possible deprivation combinations. S's were trained on a L-R-L-R problem in a 4-unit T maze, and were then given 0, 20, or 80 OT trials. S's were tested on a reversal task (R-L-R-L). Positive transfer occurred when either the overtraining, or the transfer learning, took place under moderate drive. However, high drive level during both sections of the experiment prevented
positive transfer from occurring. Rigidity of response created by the high drive level was offered as an explanation for the findings by the author.

All of the studies cited in this paper conform to a basic form. S's were trained to criterion on an initial stimulus discrimination task, and were then trained to criterion on a second, related task. Most of the studies provided a portion of their subjects with some degree of overtraining. In studying transfer effects, the second task may take one of several forms. When the second problem is identical to the first, but the correctness of some of the stimuli is reversed, the task is referred to as a reversal shift problem. Other types of response shift tasks have also been studied, usually when several dimensions are used. It is possible, for example, to vary two dimensions of a stimulus, such as size and color, simultaneously. In an extradimensional shift problem, often referred to as a nonreversal shift, subjects are trained on one dimension during the first task, with the other being irrelevant. In the second task the same stimuli are used, but the second dimension is reinforced, rather than the first dimension. An intradimensional shift problem is one in which S's learn a second problem using the same dimension as the one which was reinforced on the first problem.
Paul (1965) has reviewed the literature on reversal shifts for rats, and has concluded that there exists a greater likelihood of finding the ORE in visual discrimination problems than in spatial discriminations. Since the ORE has been reported for different ages, sexes, and strains of rats, Paul concluded that these variables were not of crucial importance. In Sperling's review of the rat literature (1965a, 1965b) she draws the conclusion that the ORE is not a general principle of learning for rats, but rather, the result of limited and specific conditions. An analysis was made of many studies using similar designs which showed contradictory results. The total amount of reward in visual discrimination tasks was seen by Sperling as being an important determiner of the ORE in rats.

A difference appears to exist between the performance of older children and adults, on the one hand, and younger children and lower animals, on the other. For example, Tighe (1964) used monkeys as subjects and compared their speed in learning reversal shift and nonreversal shift problems. Infant, adolescent and adult monkeys all learned a nonreversal shift faster than they had learned a reversal shift. Similarly, it has been shown that nursery school children learn a nonreversal shift problem faster than they learn a reversal shift (Kendler, Kendler & Wells, 1960). In another study,
(Kendler, Kendler & Learnard, 1962) the developmental discrepancy for human subjects was demonstrated as the range of ages was extended. Children were found to demonstrate different preferences for solving optional shift problems at different ages. Five age levels of subjects were used, the range being from three years to ten years. Stimuli consisted of cards on which two variables, size and brightness (black or white), varied at once. S's were initially trained on one of the variables, with the other one being irrelevant. They were presented with test stimuli after two phases of initial training were completed. This phase allowed response in terms of a nonreversal shift or a reversal shift to be correct. The proportion of subjects responding in terms of reversal shifts, rather than nonreversal shifts, increased in each successively higher age group. That is, younger S's more frequently chose to respond to the previously irrelevant dimension, or inconsistently to both dimensions, while older S's chose to respond to the previously incorrect cue of the relevant dimension. Kendler, Kendler & Learnard interpret this as the development of mediation with increasing age in humans.

Eimas (1966) studied the relationship of OT to type of shift. Half of his kindergarten and second grade S's received 100 OT trials on a stimulus discrimination
problem, while the other half was only criterion trained. S's learned intradimensional shifts faster than they learned extradimensional shifts after original learning. Extra experience led to a greater improvement on shift learning for intradimensional shift tasks than it did for extradimensional shift tasks. It should be noted, however, that even though extradimensional shift learning was the least similar to the original task, subjects who received OT also improved on that task. However, this improvement was less than that of overtrained S's who learned intradimensional shift problems.

In a study of kindergarten children (Kendler & Kendler, 1959) no difference was found to exist due to the effects of OT or type of shift. However, when analyzed according to fast and slow learners on the visual discrimination problem, it was found that fast learners mastered a reversal shift with greater speed than they learned a nonreversal shift. Slow learners were able to learn the nonreversal shift faster than the reversal shift. Thus, slow learning and lower developmental level were associated with speed of nonreversal learning, while faster learning and higher developmental level are associated with ease of reversal shift learning. Together, these findings have been taken as support for a mediational, or abstracting process involved in reversal shift learning.
Further evidence supports a hypothesis of differential facilitation of reversal learning by OT. House & Zeaman (1962) trained retardates to a 90% criterion of performance on a visual discrimination task, and then gave them 125 OT trials. Following this training, they presented one of three tasks to be learned: reversal shift, intradimensional shift, or extradimensional shift. Reversal shifts were learned as easily as intradimensional shifts, and both were easier to learn than extradimensional shifts.

The OT variable was extended to three levels in a study involving reversal shifts, intradimensional shifts and extradimensional shifts (Furth & Youniss, 1964). Higher levels of OT caused greater differentiation between the speed of learning the three types of shift problem. The degree of OT has a greater effect in facilitating reversal shift learning than it does on intradimensional shift learning and extradimensional shift learning. The explanation given for this is that OT develops a dimension-specific response, which is less well established after only criterion training. This explanation is compatible with the findings (Furth & Youniss, 1966) that reversal shifts and intradimensional shifts were learned with comparable speed. If OT helped to reinforce a dimension-specific response,
then it would be most appropriate to consider the total amount of trials of training in the given stimulus context.

In another study, Blank (1966) investigated size sorting in nursery school children and then tested them on a reversal shift problem and on an extradimensional shift problem. Subjects were divided into three groups. One group was undertrained; that is, they were informed of the solution before they had solved the problem. The second group was informed of the solution and then given 20 OT trials. The third group was allowed to work until they had solved the problem. There was no relationship between degree of OT and ease of extradimensional shift learning. Instead, however, an inverse relationship was found between number of trials in training and number of trials to reversal learning. Blank suggests that the ORE is due to the total number of trials in training, rather than simply the number of OT trials.

Since most of the studies have employed only single item problems, the number of pairs reversed in a reversal task has not been extensively studied. Wortz & McTee (1965) presented 35 adult males with a panel of six lights. They were lighted in pairs, yielding fifteen pairs in all. S's were required to learn the correct response for each pair during initial learning. Wortz &
McTee were able to reverse the reinforcement contingencies in any number of the fifteen pairs. A curvilinear relationship was found to exist between NPR and speed in reversal learning. Intermediate proportions of items reversed were the most difficult to learn.

In a study of OT and NPR, McCreary (1967) used college students as subjects. They were presented with a panel of four buttons. When these were lighted by two's, there were six possible pairs. Criterion performance on the original task was followed by eight additional presentations of this set of stimuli for half of the S's. In each set, pairs were presented in random order. When OT was completed, the correctness of the response in 1, 3, 4, or 6 of the pairs was reversed. McCreary performed a logarithmic transformation of his data in order to correct for positive skew. He found a significant effect due to both OT and NPR. The relationship between NPR and speed to reversal learning was curvilinear, with an intermediate number of reversals requiring the greatest number of trials to reversal learning. No significant interaction effect was found. The significant main effect was the same as that found by Wortz and McTee.

It was with the intention of extending the number of levels of NPR and OT that this study was undertaken. A more comprehensive estimate of the total relationship between OT and NPR is provided in this manner. The
extended experimental design is more sensitive to interaction effects and also provides a sufficient number of levels of overtraining to yield information concerning a possible curvilinearity of that variable.
METHOD

Subjects

Seventy-two college students served as subjects for the experiment, with an equal number of males and females participating. They were between 18 and 21 years of age. These subjects were obtained from Introductory Psychology classes as part of their course requirement.

Apparatus

Four buttons were presented to the subject on a panel. The buttons were made of clear plastic, one inch square. They were arranged on the panel four inches from each other, in a diamond shape. One each was positioned at the top, bottom, left and right. When E activated a pair of buttons, a light went on behind each one. This provided S with his cue as to which pair required a response. E set a pattern of item correctness with switches prior to each session. One button was always correct in each pair, and one was always wrong. Differential reinforcement of buttons due to pattern was controlled for by setting the pattern in a special way. Two buttons were correct once and two buttons were correct twice. When S pressed the correct button, a light within it was activated, thus illuminating a red "WIN" sign in the button. If the subject pressed the incorrect button, the lights went off and E proceeded to the next pair.
Procedure

S's were seated in front of the panel, one at a time, in a quiet room. E was seated directly opposite S, operating a stimulus presentation mechanism and recording S's responses on a tally sheet. E was screened from S's view in order to eliminate social reinforcers. When S entered the room, E read these instructions: "Be seated in front of the buttons on this panel. Now, look at the buttons in front of you. Two of them will be lighted at a time, and you are to firmly press one of them. For every pair of buttons, one will always be correct, and the other will always be wrong. If you press the correct button, it will briefly flash a "WIN" in red, but if you press the wrong one, the lights will just go off. You are to learn the correct button in each pair." The presentation of stimuli was then begun.

Since four buttons were presented, two at a time, there were six possible combinations of pairs. One trial consisted of all six pairs of stimuli, presented in random order. S's response to each pair was recorded on a tally sheet. Each S was trained to a criterion of two errorless sets of six responses. The tally sheets for each experimental condition were constructed prior to the experiment. Each S was assigned at random to an experimental condition at the beginning of his experimental session.
After having mastered the initial task, the specified number of overtraining trials were given. When overtraining was completed, the correctness of a designated number of pairs was reversed for every S. All S's were then trained to criterion on the reversal task.
RESULTS

A four by three factorial design was employed. Number of pairs reversed (NPR) was represented by 1, 4 or 6 pair reversals (factor 1). OT (factor 2) was represented by 0, 5, 10 or 15 additional trial sets after criterion training. An analysis of variance was performed on trials to criterion for the initial task in order to insure that no difference existed between groups prior to application of the experimental variables. The results of this analysis are summarized in Table I. NPR, OT and interaction effects all yielded nonsignificant F ratios.

Total number of trials to initial criterion performance were not under the control of E, since the trials to criterion measure was used. For this reason, it was necessary to determine the extent of the relationship between speed in learning the original task and speed of reversal learning. A negative correlation (−.58) between trials to initial learning and trials to reversal learning was found. This indicated that subjects who required a greater number of trials to learn the initial task had a moderate tendency to learn the reversal task in fewer trials than subjects who learned the first task faster. Since this variable was not controlled, it was necessary to correct each subject's
<table>
<thead>
<tr>
<th>SOURCE</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>#Pairs</td>
<td>113</td>
<td>2</td>
<td>56.50</td>
<td>1.64</td>
</tr>
<tr>
<td>Reversed</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overtraining</td>
<td>130</td>
<td>3</td>
<td>43.33</td>
<td>1.26</td>
</tr>
<tr>
<td>Interaction</td>
<td>144</td>
<td>6</td>
<td>24.00</td>
<td>0.70</td>
</tr>
<tr>
<td>Error</td>
<td>2069</td>
<td>60</td>
<td>34.48</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>2456</td>
<td>71</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\( F(.01; 2, 60) = 4.98 \)
\( F(.01; 3, 60) = 4.13 \)
\( F(.01; 6, 60) = 3.12 \)
speed in reversal learning for his speed in learning the initial task. Each S's number of trials to criterion on the reversal task was subtracted from his number of trials to criterion on the initial task. A positive difference indicated that a positive transfer effect had occurred. A zero difference is an indication of no experimental effect. Cell means and variances for difference scores are presented in Table II.

Since the purpose of this study was to help clarify the ORE by extending the number of levels of experimental variables, a statistical analysis was desired which would be sensitive to all of the information obtained by this experimental design. A polynomial regression model was adopted (Mendenhall, 1968, p.221). Seventy-two difference scores (y) were obtained, one from each subject. The model equation for each y score may be expressed in terms of a set of regression coefficients, their associated predictor variables, and an error term. Each predictor variable represents a main effect or interaction effect; of course, the number of linearly independent main effects terms for each of the experimental factors are indicated by the degrees of freedom for the factors. There are two degrees of freedom associated with NPR, since there are three levels of that variable. Main effects for NPR may be represented by a first degree term, and a second degree, or quadratic, term. OT has four levels
TABLE III

MEAN DIFFERENCES FOR EACH CELL
(TRIALS TO ORIGINAL LEARNING–TRIALS TO REVERSAL LEARNING)

<table>
<thead>
<tr>
<th>Number of Pairs Reversed</th>
<th>Overtraining</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>5.67</td>
</tr>
<tr>
<td></td>
<td>3.5</td>
</tr>
<tr>
<td>4</td>
<td>0.67</td>
</tr>
<tr>
<td></td>
<td>6.8</td>
</tr>
<tr>
<td>6</td>
<td>0.33</td>
</tr>
<tr>
<td></td>
<td>4.7</td>
</tr>
</tbody>
</table>

* Maximum improvement on reversal task
# Minimum improvement on reversal task

The four cells which represent intermediate experimental effects are not marked with any symbol.

The mean for 0 overtraining is 2.22
The mean for 10 overtraining is 5.39
and three degrees of freedom, so three terms are necessary to fit a curve for the main effects of that variable. They are a first degree term, a second degree term, and a third degree term.

Since two variables are being manipulated, the polynomial regression model must also include a term for each of the possible interactions between main effect terms. The model equation for \( y \) becomes:

\[
y = B_0 + B_1 x_1 + B_2 x_2 + B_3 x_1^2 + B_4 x_2^2 + B_5 x_1^3 + B_6 x_2^3
\]

The estimates of the \( B \) coefficients, \( \hat{B} \), in this equation are not statistically independent of each other. Thus, in order to obtain independent F ratios for each term in the polynomial regression model, it is necessary to replace this model with an alternative parameterization in which the regression coefficients are statistically independent. The \( \hat{B} \) coefficients were not statistically independent because the design matrix, \( (X) \), was not orthogonal. It was possible to transform this matrix into an orthonormal design matrix, \( (U) \), through the Gram-Schmidt orthogonalization process. New, statistically independent regression coefficients, \( \hat{A} \), were obtained by matrix procedures through the following equation:

\[
\hat{A} = (U'U)^{-1} U'Y
\]
The values which were obtained are:

\[
\begin{array}{c}
38.30 \\
-11.51 \\
4.06 \\
26.69 \\
\wedge -11.90 \\
A = 4.69 \\
3.45 \\
-3.48 \\
-.44 \\
3.85 \\
-15.17 \\
-1.78 \\
\end{array}
\]

These coefficients are used in the following alternative model equation:

\[
y = A + A u + A u + A u + A u + A u + A u + e
\]

\[
0 1 1 2 2 3 3 4 4 5 5
\]

\[
+ A u + A u + A u + A u + A u + A u + e
\]

\[
6 6 7 7 8 8 9 9 10 11 11
\]

This equation, and the original model equation, are equivalent to each other, since both predict the same y vector of difference scores. The terms in the alternative model equation represent the same effects, but the regression coefficients and predictor variables have been replaced by transformed values.

The purpose of this alternative parameterization is to provide an independent Sum of Squares for each main effect and interaction effect. The Sums of Squares
were obtained from the following equation:

\[ SS(a_i) = \frac{a_i^2}{u_i'u_i} \]

where \( a_i \) is the regression coefficient for a particular experimental effect, and is found in \( A \). In the denominator of this equation, \( u_i \) is the column of the design matrix \( (U) \) which corresponds to \( a_i \). Since an orthonormal design matrix was used, the inner products of the vectors \( u_i'u_i = 1 \) for all \( i \), and the equation simplifies to:

\[ SS(a_i) = a_i^2 \]

Each of the regression coefficients was squared and appears as a Sum of Squares in Table III. Analysis of variance yielded an \( F \) ratio for each of these sums of squares. It may be seen that the linear effect for NPR just missed significance at the .10 level. The \( F \) ratios for second degree terms are considerably greater than those for first degree trends, which indicates that the effect produced by these variables was primarily curvilinear. For instance, NPR is significant beyond the .01 level and represents a strong experimental variable. It is much more difficult to learn a task in which an intermediate number of pairs have been reversed than one in which a low or high proportion of the pairs have
### TABLE III

ANALYSIS OF VARIANCE SUMMARY TABLE FOR TERMS IN THE POLYNOMIAL REGRESSION MODEL OF Y

<table>
<thead>
<tr>
<th>SOURCE</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>main effects</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$A_{1u1}$</td>
<td>132.34</td>
<td>1</td>
<td>132.34</td>
<td>2.61</td>
</tr>
<tr>
<td>$A_{2u2}$</td>
<td>16.47</td>
<td>1</td>
<td>16.47</td>
<td>.29</td>
</tr>
<tr>
<td>$A_{3u3}$</td>
<td>711.76</td>
<td>1</td>
<td>711.76</td>
<td>14.04 ***</td>
</tr>
<tr>
<td>$A_{4u4}$</td>
<td>141.80</td>
<td>1</td>
<td>141.80</td>
<td>2.80 *</td>
</tr>
<tr>
<td>$A_{5u5}$</td>
<td>22.00</td>
<td>1</td>
<td>22.00</td>
<td>.43</td>
</tr>
<tr>
<td><strong>interaction effects</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$A_{6u6}$</td>
<td>11.93</td>
<td>1</td>
<td>11.93</td>
<td>.24</td>
</tr>
<tr>
<td>$A_{7u7}$</td>
<td>12.11</td>
<td>1</td>
<td>12.11</td>
<td>.24</td>
</tr>
<tr>
<td>$A_{8u8}$</td>
<td>.20</td>
<td>1</td>
<td>.20</td>
<td>.00</td>
</tr>
<tr>
<td>$A_{9u9}$</td>
<td>14.83</td>
<td>1</td>
<td>14.83</td>
<td>.29</td>
</tr>
<tr>
<td>$A_{10u10}$</td>
<td>229.90</td>
<td>1</td>
<td>229.90</td>
<td>4.53 **</td>
</tr>
<tr>
<td>$A_{11u11}$</td>
<td>3.16</td>
<td>1</td>
<td>3.16</td>
<td>.06</td>
</tr>
<tr>
<td><strong>Error</strong></td>
<td>3041.26</td>
<td>60</td>
<td>50.69</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>4337.74</td>
<td>71</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

$F(.10;1,60)= 2.79 *$
$F(.05;1,60)= 4.00 **$
$F(.01;1,60)= 7.08 **
been reversed. This conclusion was drawn by inspecting Figure 1 and Figure 3.

The effect due to OT is graphically presented in Figure 2. Although main effects due to OT are not as strong as those for NPR, a significant interaction effect (.01 level) was found to exist between second degree trends for OT and NPR. This is an important finding for the ORE, since previous studies have not, characteristically, provided information concerning the interaction between NPR and OT. Wortz and McTee (1965) studied NPR for a similar stimulus discrimination problem, but that study is not appropriate for comparison, since ORE was not included as an experimental variable. McCreary's study (1967) is the most appropriate one for comparison with the present study, since he investigated the effect due to the same variables, on the same type of task, with a similar subject population. In that study, McCreary found significant main effects due to OT and NPR, however, he did not find an interaction effect. This fact will be discussed in the following section.
TRIALS TO CRITERION

"FIG. 1 MEAN NUMBER OF TRIALS TO CRITERION FOR
LEVELS OF PAIR REVERSAL"
"FIG. 2 MEAN NUMBER OF TRIALS TO CRITERION FOR OVERTRAINING GROUPS"
MEAN NUMBER OF TRIALS TO CRITERION 10.50

0 5 10 15 1
0.67 0.00 -2.33 1.17 6
0.33 6.67 4.17
9.33 9.17
5.67

NUMBER OF TRIALS OF OVERTRAINING

4 PAIRS REVERSED

Figure 3 Cell Means
DISCUSSION

An attempt was made to clarify the ORE through two procedures. First, OT was extended to four levels, with NPR represented at three levels. This provided a broader scope of measurement than previous studies had used which was sensitive to interaction effects. Secondly, this design provided a sufficient number of levels of each variable to test for curvilinear effects as well.

At least two studies (Wortz & McTee, 1965; McCreary, 1967) have previously demonstrated the curvilinearity of the NPR effect, which is again confirmed in this study. Intermediate numbers of pair reversals are more difficult for subjects to learn than large or small numbers of pair reversals are.

Three theories of reversal learning were cited in the introduction. The present study has findings which are appropriate, in part, to each of these. Capaldi & Stevenson (1957) suggest that the subject's experience with a discrimination task allows him to progressively differentiate the stimulus array. That theory would predict, in the present study, that an increase in the total number of trials in training would facilitate reversal learning. This prediction is supported by Blank's findings (1966), and also by the finding of a
a moderate, negative correlation between trials to initial learning and trials to reversal learning in the present study.

In Figure 3, it may be noted that S's learn reversal tasks faster for a small or high proportion of pair reversals. This observation is supported by a significant F for the main effect of NPR. The theory of House & Zeaman (1963) predicts this result. Their interpretation would be that during the reversal task, S's have a greater probability of attending to the appropriate cues on a simple task, rather than on a difficult task.

According to Wolff's review (1965), there is little consistent support for the general use of verbal mediation by S's in reversal learning. The finding of a negative correlation between trials to initial learning and trials to reversal learning in the present study would be predicted by the verbal mediation theory of Kendler and Kendler (1959, 1962, 1964). If subjects were employing verbal mediators, a greater number of trials to initial learning would provide an increase in the strength of those mediators. Further support may also be found for a verbal mediation position in the curvilinear effect due to NPR. A verbal mediator, such as "opposite", may be readily applied to a reversal
task in which 100% of the pairs are reversed. Similarly, a verbal mediator, such as "that pair has changed", may be applied when one pair has been reversed. However, an intermediate number of pair reversals allows for no easy application of a single, or simple, verbal mediator, and the subject would rely upon a process other than mediational in learning.

The significant main effect due to NPR provides an opportunity to consolidate the mediational theories, attentional theories, and differentiation theories. An attempt will be made to do this by presenting an hypothetical model. In applying these theories to reversal learning, it is profitable to think of the curvilinear effects of NPR as being the result of the similarity of the reinforcement contingencies in initial and reversal learning, and of the simultaneous use of a verbal mediator. It is assumed that the subject follows the simplest procedure which is effectively available to him. Difficulty in reversal learning may be thought of as an increasing function of difference in the reinforcement contingencies between the initial task and the reversal task. Thus, a successively greater percentage of pair reversals leads to fewer responses from the initial task which are appropriate in the reversal task. Reversal learning would be more difficult for 6 pairs reversed than for any other
number if similarity of reinforcement contingencies for the two tasks was the only variable in operation. Simultaneously, another variable, availability of verbal mediation, is hypothesized as being in effect. S is assumed to follow the simplest procedure. Therefore, verbal mediation would be used only when it would make the extinction of inappropriate responses, and the acquisition of new ones through nonverbal processes, an easier task than the acquisition of the same new responses through the use of a mediator. For an intermediate number of pair reversals, there is no simple verbal mediator which could be used to abstract the change in reinforcement contingencies which the subject would observe during reversal learning. However, for the subject whose reversal task consists of a set of stimuli in which reinforcement of responses is 100% reversed, it is a simpler procedure to apply the concept of "opposite" than to learn a new response to each of the six pairs. McCreary's findings (1967), give support to these predictions. In that study, 1, 3, 4 or 6 pairs were reversed for each S. There was no difference between the difficulty of 3 or 4 pair reversals, but each of these was significantly more difficult to learn than 1 or 6 pair reversals was.

No clear confirmation of the ORE was obtained for adult S's in the present study. Cell sample size was
small (n=6). However, if failure to confirm the main effects for OT had been the result of the use of too few subjects in this study, then it would have had a comparable effect on both experimental variables. Reference to Table III confirms that this did not happen.

The significant interaction between the second degree terms, along with the nearly significant second degree OT term, gives reason to suspect that OT is curvilinear in its relationship with reversal learning. The second degree NPR term produced F ratios of .29 and .06 in interaction with the linear and cubic terms for overtraining. By comparison, an F ratio of 4.53 (.05 level) in interaction with the second degree overtraining term suggests that levels of overtraining combine differentially with tasks of different difficulty. Reference to Table II and Figure 3 illustrate this point. Facilitation of reversal learning is implied in cells with positive differences, while interference with reversal learning is indicated by negative differences. A zero in a cell indicates no effect. Maximum values of positive transfer occur where overtraining is at an intermediate level and NPR is at an extreme value. Each of these conditions corresponds to predictions for maximum positive transfer due to each variable. Negative transfer of training occurs for intermediate levels of
NPR, without respect to level of overtraining. The present study provides evidence to the effect that overtraining is effective in facilitating reversal learning only when the task is of a relatively easy nature. If it may be assumed that an increase of the difficulty of a task simultaneously increases an emotional, or drive, component, then a similarity between these findings and those of Bruner, Mandler, O'Dowd and Wallach is observed. They found that overtraining is effective in facilitating reversal learning only for moderate drive levels in rats. The finding of the present study is that overtraining is not effective in facilitating reversal tasks which are highly motivated.

By extending the study of overtraining and number of pairs reversed to a 4X3 design, it has been possible to detect a two-way curvilinear interaction. McCreary's study (1967) used 0 or 8 OT trials. In order to reconcile the differences between the two investigations, it is possible to compare the column means for 0 and 10 overtraining trials in Table II. The mean difference for 0 overtraining trials is 2.22. The mean difference for 10 overtraining trials is 5.39. By comparing these values, it is apparent that the two studies agree on the ORE with respect to direction. It is likely that McCreary found significant effects due to OT since he compared only an intermediate value of that variable with
groups which had received no overtraining. The significant interaction of OT with NPR, along with the finding of agreement between the present study and that of McCreary, suggest that his choice of variables was crucial in his confirmation of the main effects for OT.

The majority of the work on the ORE has used children or animal subjects. Since the present study has presented new findings for college subjects, it would be profitable to extend the basic design and analysis to studies with children and animals. Furthermore, these findings need to be validated or rejected for other problems than the present, pair-wise, position discriminations.

SUMMARY

The findings of the present study imply that an ORE does exist for adult human subjects in a visual discrimination task. The indication is that the ORE is curvilinear in nature for this type of problem. That is, an intermediate amount of OT has a greater facilitating effect on reversal learning than an extreme amount does. However, this effect was found to exist for tasks of low difficulty.
Bibliography


