THE OVERTRAINING REVERSAL EFFECT AS A FUNCTION OF ATTENDING TO THE RELEVANT ATTRIBUTE

by

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STATEMENT BY AUTHOR

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sep 2, 1968

Date

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF ILLUSTRATIONS

ABSTRACT

The purpose of the current experiment was to investigate the effect of difficulty in a discrimination task on the overtraining reversal effect (ORE). Two hypotheses were made: (1) the probability of obtaining the ORE would increase when the relevant stimulus dimension in a discrimination problem was relatively obscure (Hard Problem) during initial trials, and (2) the probability of obtaining the ORE would decrease if the relevant dimension was perceptually obvious (Easy Problem). Forty-eight university students served as volunteer Ss. Each S received training on one of two successive discrimination problems (Easy or Hard Problem). Four treatment groups with 12 Ss each were formed: criterion training--Easy Problem (Group A), overtraining--Easy Problem (Group B), criterion training--Hard Problem (Group C), and overtraining--Hard Problem (Group D). All responses from Ss were tape-recorded. No ORE was found with the Easy Problem. A significant ORE was not obtained with the Hard Problem but trends toward one were indicated. The significance of these findings and their implications were examined and discussed.

INTRODUCTION

For two decades now, there has been a great amount of experimental research and investigation directed toward evaluating the effects of postcriterion training or overtraining on the rate of acquisition in discrimination reversal problems. Some investigators have found that overtraining on a discrimination task tends to facilitate learning with respect to the reversal of the original problem. This facilitation is usually manifested in the form of a significant decrement in the number of trials to reversal acquisition. In effect, overtrained subjects have been observed to solve the reversal of a discrimination problem at a faster rate than subjects trained just to a preset criterion. This effect has been labelled the overlearning reversal effect (ORE).

Recently, there has been some controversy concerning whether or not the ORE should be designated as an "overlearning" phenomenon. One inconvenience of the term "overlearning" is that it is ambiguous since it is difficult to say when learning becomes overlearning (Sperling, 1965; Hergenhahn, 1966). Of a more practical significance, "overlearning" suggests that once a subject has overlearned or mastered a task, he should not, theoretically, make any more errors in performing that task whereas the term

"overtraining" does not seem to carry this implicit assumption. A subject may have received extensive training on a task, such as a rotary-pursuit problem, but this does not imply that he has mastered this task perfectly since his performance may still be subject to future errors. Finally, learning may involve some type of internal processes which are manifested in the subject's performance while training connotes a more external, observable, experimenter-controlled operation. In the majority of discrimination reversal experiments, it appears that investigators have been primarily interested in whether the subject makes the correct response to the appropriate stimulus. In other words, they have been interested in the observable performance of the subject as influenced by controlled training procedures.

From the preceding notions, the term "overtraining" appears to be less ambiguous and cumbersome than "over-learning" when describing the events which occur in the discrimination reversal type of experiment. Hence, throughout the remainder of this paper, ORE will refer to the "overtraining reversal effect."

Spence (1936, 1937, 1952) considered discrimination learning to be a cumulative process in which there is a continuous increment in the strength of the "excitatory tendency" of a particular stimulus cue or the tendency of this stimulus cue to evoke from the subject a response of

approaching it. More specifically, the excitatory tendency of the positive stimulus cue, in a discrimination problem, is strengthened through the successive reinforcement of appropriate approach responses to it. In contrast, the excitatory strength of the negative stimulus cue is weakened or inhibited because responses to it result in non-reinforcement. Thus the subject learns to orient toward and approach the stimulus complex containing the positive cue. In this sense, the subject is not responding to the entire stimulus configuration as a whole but rather is selectively responding to one element within that complex, the positive cue. In essence then, Spence's paradigm is a two-process model of discrimination learning involving both a reinforcement and inhibition principle.

Increment in habit strength, or the strength of the excitatory tendency of the positive stimulus cue if viewed in terms of the Spence paradigm of discrimination learning, is assumed to be a function of the number of reinforced trials (Hull, 1943). With each reinforced trial, not only does habit strength increase but the resistance of this habit to subsequent extinction through nonreinforcement is likewise increased. Thus in regard to discrimination reversal learning, the subject receiving extensive over-training on a particular task, as opposed to a criterion trained subject, might be expected to display a slow acquisition rate for the reversal of this same task. This

result could be expected since both habit strength and resistance of the habit to extinction have been built up to a high level with respect to the original task.

However, Reid (1953) found just the opposite effect. Similar to Spence, he has suggested that in discrimination learning, a subject learns "to discriminate a specific set of stimuli within the total stimulus complex [p. 107]." In addition to this discrimination response, a subject also learns to respond appropriately to the set of stimuli in which the positive stimulus element is embedded. Reid labels the latter a discrimination of choice or a choice response. In effect then, discrimination learning is viewed as a two-process or two-stage phenomenon in which a subject acquires: (1) a choice discrimination, suggesting an overt or directly observable response of the organism to the positive test stimulus; and (2) a response of discriminating, a more covert attention or orienting type of response toward the positive stimulus element.

Reid indicated that evidence for such a two-process theory of discrimination learning could be provided in a situation where subjects displayed faster reversal learning as a function of extensive overtraining on the original problem. To demonstrate this assumption, he trained rats on a black-white discrimination task in a Y-maze. Rats that received extensive overtraining were found to require significantly fewer trials in which to acquire the correct

response in the reversal problem than did the criterion trained animals. Reid accounted for this finding by stating that the postcriterion trained subjects had a greater opportunity to develop a discriminating (attending) response than did the animals trained just to criterion.

With the foregoing reasoning, Reid is suggesting a differential rate of development for each of the processes within his two-stage discrimination learning model. Initially, a more rapid build-up occurs in the choice discrimination (overt response) over the response of discriminating (attending activity) since the former is temporally closer to the reinforcing event; reinforcement being contingent on the occurrence of this response. With prolonged training, the discriminating response is strengthened, the temporal distance between it and the presentation of reinforcement being diminished, thereby providing rapid learning of a reversal problem. At the end of criterial training on the other hand, the choice response is stronger, having been developed to a higher level, than is the discriminating response. Criterion training thus results in slow reversal acquisition because in addition to the formation of a new and appropriate choice response, the response of discriminating must be effectively strengthened to the point of functional utility during reversal training. In reversal acquisition following overtraining however, only one of the two previously mentioned processes has to be altered and

that being the establishment of an appropriately different choice response; the discriminating response being functionally effective due to postcriterion training.

In the same article, Reid presents Spence's explanation of this overtraining reversal effect (ORE) which is based on the idea of position habit strengths. Spence believed that subjects reaching criterion on the original problem still possess differential position habit strengths. As a result, criterion trained subjects experience habit interference on the part of the stronger position habit during reversal learning thus impeding reversal acquisition. Overtraining is said to equalize these position preferences, thereby neutralizing any interference effects, resulting in rapid reversal acquisition.

An interesting theory of two-choice discrimination learning has been set forth by Restle (1955). He postulates that within each discrimination learning trial, the subject observes a stimulus situation which is composed of a set of cues or stimulus dimensions. A cue is regarded as an indivisible entity in the sense that its various parts do not elicit differential responses from the organism. In an operational sense then, a configuration is defined as a cue which is separate from its constituents if a subject can acquire a consistent response to this configuration despite changes in its elements. Restle further states

that cues are either relevant or irrelevant. A relevant cue enables the organism to determine the manner in which reward can be obtained while an irrelevant cue is uncorrelated with reward. The subject's task in a two-choice discrimination problem is essentially to attach appropriate responses to the relevant cues (conditioning) while simultaneously making his responses independent of the irrelevant ones (adaptation). According to Restle then, the two processes operating in two-choice discrimination learning involve the subject's responses being: (1) "conditioned" to the relevant cues, and (2) "adapted" to the irrelevant cues.

Restle indicates that his theory does not apply to reversal learning since the relation between the cue and reward in such a problem is reversed. However, it seems as though the general postulates of this theory can be of value in conceptualizing the operations that may occur in reversal acquisition if one views the relevant cue or stimulus dimension (say color) in a problem as remaining constant but the cue constituents or elements (for example, redness or blackness) as altering in value (either positive or negative). With overtraining then, conditioning of the relevant cue (in this example, color) is strengthened beyond the level obtained with criterion training alone and simultaneously, there is also occurring a more extensive adaptation to the irrelevant cues (say size and shape) in

the stimulus complex of the problem. This postcriterion training, which produces overconditioning to the relevant cue and overadaptation to the irrelevant cue, also increases the extinction resistance of the responses which are directed toward the relevant stimulus dimension and in this manner, leads to significantly rapid reversal learning.

In the first of two experiments, Pubols (1956) replicated Reid's brightness discrimination task and obtained results which supported the latter's finding that overtraining on a visual discrimination problem facilitated acquisition of the discrimination reversal. An ORE was likewise found to follow overtraining on a position discrimination problem in the second experiment.

Pubols views Reid's response of discriminating as the "orientation" of the organism's eyes toward the differential cues within the stimulus complex. This discriminating or orienting response is temporally farther from reinforcement than is the choice response. Each increment in the habit strength of the former will thus be less than that for the latter. In initial trials then, the response of discriminating increases at a slower rate than does the choice response. In the case of criterion trained subjects, an adequate choice response (appropriate response to the positive stimulus) has been formed by the end of training, but an efficiently functioning discriminating response (orienting toward the positive stimulus) has not been

established. With these subjects, appropriate responses may be made during initial reversal trials but the orienting response is not directed toward the relevant cue thus leading to frequent errors, extinction of this response, and slow reversal learning. In contrast, overtraining strengthens and increases the resistance of the discriminating response to extinction thus affording rapid reversal learning in significantly fewer trials.

The course of discrimination reversal learning has been found to vary as a function of procedural differences involved in criterion training (Pubols, 1957). Rats were divided into two groups: (1) a trials criterion group in which each rat was reversed after a certain number of trials had been completed regardless of performance, and (2) a performance criterion group in which each rat was reversed after attaining a performance criterion consisting of a certain number of correctly executed trials. The performance group functioned superior to the trial group on the majority of reversal problems. This difference was accounted for by the fact that rats in the performance group obtained extra experience on the original problems, being in effect overtrained, which facilitated their acquisition of the reversal problems.

Some theorists have focused primarily on the concept of extinction in explaining the occurrence of the ORE. In addition to his idea that the formation of

conditional relations necessarily results from the temporal contiguity of stimulus and response, Estes (1950) indicates that in any behavioral system conditioning and extinction occur concurrently and that these two operations are not separate processes if viewed within this context. Reversal learning thus involves the simultaneous extinction of the originally appropriate response and the conditioning of a new response.

In an experiment where rats learned a black-white discrimination at different levels of training, Capaldi and Stevenson (1957) found an inverse relationship between the degree of original training and the ease of solving the reversal problem. Animals that received the greatest number of training trials learned the reversal problem significantly faster and with fewer errors than minimally trained animals. In other words, "negative transfer on the reversed discrimination decreased as the frequency of reinforcement on the original discrimination increased [p. 197]." Following overtraining, any change in a problem was more readily discriminated and extinction was faster than during earlier stages of learning. In terms of the Capaldi-Stevenson hypothesis then, the rate of extinction is a function of the degree to which the pattern or schedule of reinforcement is changed in the reversal problem as opposed to the original training problem.

In line with the preceding finding, a similar investigation resulted in a differential-rate-of-extinction interpretation of the ORE (Birch, Ison, and Sperling, 1960). After finding the ORE in a discrimination task, they explained the difference between their overtrained and criterion groups as being due to these groups' differential rates of extinction to the previously reinforced cue rather than to the acquisition of appropriate responses to the new positive cue. Overtraining was viewed as facilitating reversal learning because it appeared to result in faster extinction of the formerly correct response.

A somewhat more complex extinction-oriented explanation for the ORE is offered by D'Amato and Jagoda (1961). They maintain that the essential operation in simple discrimination learning is the establishment of avoidance tendencies toward the negative stimulus while the build-up of approach responses to the positive stimulus is secondary. The extinction of avoidance tendencies toward the previously negative stimulus is then a critical factor in reversal learning.

D'Amato and Jagoda go on to say that with post-criterion training, experience with the negative stimulus is essentially terminated resulting in the reduction of avoidance tendencies toward this stimulus. During reversal learning then, the criterion trained subject requires more trials to learn the problem because he must perform two

operations: (1) extinguish avoidance responses to the initially negative stimulus now the positive stimulus, and (2) develop correct approach responses to the positive reversal stimulus. On the other hand having only limited experience with the originally negative stimulus, the post-criterion trained subject possesses a distinct advantage in that he has already extinguished any avoidance tendencies to this stimulus even before reversal trials begin. During reversal learning then, he essentially has only one operation to complete and this involves developing correct approach responses to the positive reversal stimulus. Hence with one less operation to perform, the overtrained subject is able to learn the reversal problem more rapidly than the criterion subject.

More complex, or in some cases cognitively oriented, interpretations of the ORE have been offered. Bruner, Mandler, O'Dowd, and Wallach (1958) state that effective or positive transfer occurs when "learning becomes 'generic-ized' or recoded into a principle that can be applied to a new instance of the principle [p. 612]." They further assert that such recoding is enhanced by overtraining. This generic recoding occurs most effectively when acquisition and overtraining take place under moderate drive conditions (in this case food deprivation). In this situation, effective transfer occurs in that the organism is able to apply the generic principle it has learned in the

original problem to the reversal problem and in this way, is able to gain positive savings in terms of a reduced number of trials to reversal acquisition if the principle is relevant. However, when high drive conditions persist after reversal, no positive savings occur suggesting some negative transfer. The preceding assumptions were empirically verified in this study.

Harlow (1959) has observed that rhesus monkeys which form a discrimination learning set also demonstrate facility in forming a discrimination-reversal learning set. According to his error factor theory, successful discrimination and discrimination-reversal learning requires suppression of positional, differential cue, and response-shift error factors. However, the learned inhibition of a fourth error factor, stimulus perseveration, is not positively transferred from original to reversal learning, the former training producing a high object preference which must be overcome in the reversal phase.

Harlow goes on to explain that original discrimination learning and reversal learning are not antithetical processes. In terms of error factor inhibition or suppression, the two are more identical than opposite and increased efficiency in learning the reversal follows logically from overtraining on a similar (original) problem.

A more cognitively oriented explanation of the ORE has been proposed by Kendler and Kendler (1964). Within

their framework, adult human concept learning does not operate on a single unit S-R theory wherein the external stimulus is viewed as being directly connected to the overt response. Rather, the Kendlers maintain that in adult human concept learning "a mediational mechanism is required which assumes that the external stimulus evokes an implicit response which produces an implicit cue that is connected to the overt response [pp. 589-590]." This mediational hypothesis further assumes that the principles which operate in observable S-R relationships also function in these implicit stimulus and response events.

In the single unit S-R model, as viewed by Kendler and Kendler, the subject tends to respond to the concrete face value of the stimuli (for example, to the redness or blackness, triangularity or squareness, largeness or smallness). Operating within the mediational model however, the subject theoretically attends and responds to the more abstract dimensions (such as color, shape, or size) within a stimulus complex. Postcriterion training affords the opportunity for the subject's attending response to become strengthened and directed toward the more abstract and relevant stimulus dimension in the problem. This allows for rapid reversal learning since the overtrained subject is able to use the same mediating response during reversal training, having only to acquire a new overt response. In contrast, criterion subjects are thought to focus primarily

on the more concrete stimulus cues, as overtrained subjects may do in initial trials, not having sufficient opportunity to abstract out the relevant stimulus dimension in order to form an effective mediating response. For the criterion subjects then, reversal learning progresses slowly.

Within the same general area, a number of recent investigators have focused on the organism's attentiveness to or ability to analyze the relevant dimension within a stimulus complex as being the most important factor accounting for the occurrence of the ORE. Sutherland (1959) and Sutherland and Holgate (1966) stipulate that there are two processes involved in discrimination learning: (1) learning to attend to the relevant cue, and (2) learning the appropriate choice response. An organism possesses a number of sensory "analyzers" each of which analyzes only one aspect of a stimulus situation. The initial strength of an analyzer appears to be determined by the conspicuousness of the analyzed cue.

In learning a discrimination problem, a subject must switch in the appropriate sensory analyzer which detects the differences between the relevant and irrelevant dimensions of a stimulus complex. Once this has been accomplished, appropriate responses are then attached to the outputs of this analyzer. According to Sutherland, overtraining tends to strengthen the relevant analyzer without producing a corresponding increase in the strength

of the overt choice response. During reversal, the relevant analyzer is retained while the original response is extinguished and a correct new one is acquired. Throughout reversal trials, responses to irrelevant cues are minimized through the retention of the relevant analyzer. Criterion training does not provide enough opportunity for the relevant analyzer to become sufficiently strengthened and therefore it is extinguished early during reversal training. This requires that both a re-establishment of this analyzer as well as the learning of a new choice response be accomplished thus resulting in slow reversal learning.

Mackintosh (1962) essentially agrees with Sutherland's "analyzer" explanation of the ORE. According to Mackintosh, what appears to happen during overtraining is that the subject develops a greater probability of responding to the relevant cues and thus learns the reversal faster since the probability of responding to the irrelevant cues is simultaneously weakened. In essence, post-criterion training strengthens the relevant analyzer and perseverates its use during reversal learning.

In addition however, Mackintosh (1965a) has found that the ORE seems to occur only when the relevant dimension involved in the discrimination stiuation is not a perceptually dominant one for the species of organism being used as the subject. If the relevant dimension is dominant,

no ORE is obtained. To illustrate this idea, Mackintosh has found that in a simultaneous brightness discrimination problem overtraining appears to facilitate reversal learning in rats but not in chicks. He attributes this result to the fact that the brightness dimension is probably a more dominant perceptual cue for chicks, on account of their higher visual acuity, than for rats. Hence, overtraining does not serve to strengthen the already dominant brightness analyzer in chicks as it does in rats.

In a review of the role of attention in animal discrimination learning, Mackintosh (1965b) indicates that a subject learns to attend to the relevant stimulus dimension in a discrimination problem and to ignore (adapt to) the irrelevant dimensions. In order for a subject to perform efficiently on a discrimination task then, there must be a high probability for him to attend to the relevant cue and given he is attending, a high probability of his selecting this positive stimulus. In essence, overtraining contributes to rapid reversal learning by steadily intensifying the subject's attending to the relevant dimension.

Sitterley and Capehart (1966) account for the ORE by stating that overtraining serves to narrow down the cue population thus eliminating a large number of possible solutions to the problem. Rapid reversal learning results because overtrained subjects are thereby better able to

notice the change in reward contingencies at the onset of reversal training.

A similar approach is taken by Hergenhahn (1966) who specifies that the function of overtraining is to, in a sense, release the subject so that he may freely sample other cues in the stimulus population. Through this extended sampling, the postcriterion trained subject becomes increasingly aware of the relevant and irrelevant cues in the problem. As a result, reversal learning is rapid because any changes in these cues are readily detected and the appropriate responses initiated.

Lovejoy (1966) bases his interpretation of the ORE on a two-stage math model (an extension of Mackintosh's attention theory) which he has devised through the use of computer "stat-rats." Learning to attend to the relevant stimulus dimension and to make the correct choice response comprise the two stages of discrimination learning.

According to Lovejoy, the probability of attending to the relevant stimulus dimension increases at a slower rate than does the probability of making the correct choice response. For criterion subjects, the probability of attending is less than that of making the correct choice response when reversal training begins resulting in their ceasing to attend to the relevant dimension. Postcriterion training tends to equalize the probabilities of attending and making the correct choice response. In reversal

training then, overtrained subjects possess a higher probability of attending to the relevant stimulus dimension having only to learn a new choice response while criterion subjects must not only learn the appropriate choice response but must also develop a functional attending response.

Lovejoy further assumes, as does Mackintosh, that when the relevant stimulus dimension in a discrimination problem is perceptually obvious, then the probability of the subject attending to it is high. When the probability of attending is initially high in such a situation, no ORE is found because the subject learns the reversal about as rapidly as the original problem. On the other hand, in a situation where the relevant stimulus dimension is relatively obscure thereby lowering the initial attending probability connected with it, the latter probability becoming strengthened through postcriterion training, an ORE is usually obtained.

As is evident from the foregoing account, most ORE studies have been conducted on animals with few experiments involving humans. The purpose of the present investigation is to determine whether or not the Mackintosh-Lovejoy attentional hypothesis can account for the appearance of the ORE in a simple discrimination task using adult human subjects.

In keeping with Lovejoy's model, the hypotheses for this study are: (1) the probability of the ORE appearing increases if the relevant stimulus dimension in a discrimination problem is relatively obscure during initial trials, and (2) the probability of the ORE appearing decreases if the relevant stimulus dimension in a discrimination problem is perceptually obvious or dominant during initial training trials.

METHOD

Subjects

Ss were 56 university students in introductory and upper-division psychology courses. However, 8 Ss had to be voided. Seven Ss were voided due to procedural errors, and one S never learned the problem which was presented to him. Of the remaining 48 Ss, 22 were males and 26 were females. The rounded mean age for all Ss was 20 years with a range from 17 to 35 years.

Stimuli

Geometric figures mounted on white, unlined, 3 X 5 inch index cards served as the stimuli. Depending on the treatment condition, these figures could be varied in four dimensions: shape, triangle or square; color, red or black; position on the card, left or right; and distance apart on the card, close or far.

The stimulus cards were divided into two groups: one in which the relevant dimension was considered to be perceptually obvious (Easy Problem), and one where the relevant dimension was relatively obscure (Hard Problem). With regard to the Easy Problem, shape and color were the stimulus dimensions used; color was held constant thus making shape the relevant dimension. In this case, either

a red isosceles triangle with a base of 1 inch and 1-1/8 inch sides or a red 1 inch square appeared on each stimulus card. In the Hard Problem, both a triangle and a square appeared simultaneously on each stimulus card. Shape, color, distance, and position were the dimensions varied in this problem with the latter three being relevant. The figures were the same size as those used in the Easy Problem. In terms of distance, the figures on a card (Hard Problem) were defined as being close together when there was 1 inch between them and as being far apart when there were 2 inches separating them.

Both problems involved a concept which Ss were to learn. In the Easy Problem, the concept to be learned in the initial trials was "triangle" which changed to "square" during reversal training. During original training on the Hard Problem, the concept to be acquired was "when a black figure is on the right, the two objects are close together." In reversal trials, the concept was just the opposite "when a red figure is on the right, the two objects are far apart." Each problem contained an equal number of positive and negative examples of the concept to be learned.

Apparatus

Stimulus cards were displayed on a fixed-base screen apparatus which was composed of a rotating horizontal platform on top of which was attached a vertical

section. The horizontal platform of this apparatus was 15 X 21-1/2 inches while the vertical section was 12 X 21-1/2 inches and was fixed perpendicular to the platform dividing the latter into two equal halves lengthwise. Both sections of the apparatus were painted gray. On each side of the screen, stimulus cards were placed on an inclined plane, painted flat black, which was fastened to the horizontal platform and the vertical section. This apparatus was then mounted on a small stand with a metal post running up through the center of the horizontal platform into the vertical section thus allowing rotation of the complete screen. The screen was located on a small table placed between S and E.

A tape recorder was used to register the responses of all Ss. These responses were later transcribed verbatim onto specially prepared data sheets.

Training

Criterion and overtraining were the two levels of practice used in the present experiment. Criterion training consisted of 8 correct responses out of 10 while 18 correct responses out of 20 constituted overtraining. In effect, postcriterion trained Ss received 100% overtraining in that they were given a total of 10 additional trials.

Groups

There were two main treatment groups of 24 Ss each. One group received the Easy Problem and the other group was trained on the Hard Problem. Both of the main groups were further subdivided into a criterion and overtraining group. In all, four treatment groups with 12 Ss in each were formed. Group A received criterion training on the Easy Problem while Group B was given overtraining on the same problem. The treatment condition for Group C was criterion training on the Hard Problem and that for Group D was overtraining on the same problem.

Procedure

On arriving at the experimental room, each S was assigned to one of the four treatment groups according to a cyclic pattern. The first experimental S was assigned to Group A, the second to C, the third to B, and the fourth to D. The fifth S was then assigned to Group A thus beginning the assignment cycle over again.

Once assigned to a particular treatment group, S was then shown the equipment, how it operated, and told that his responses would be recorded during the experiment. After this initial explanation, E then read the following set of instructions to S:

> In this experiment, I am going to show you a number of cards. There will be something about each card that will indicate to you whether or

> not it is an example of a concept I am thinking of. If you think that a certain card is an example of the concept, you are to respond by saying "yes." On the other hand, if you believe that a particular card does not illustrate the concept, you are to respond by saying "no." On the basis of your response, I will say either "correct" (meaning your response was right) or "wrong" (meaning your response was not correct). In addition, I will ask you to specify that particular element or elements of a card which indicated to you that the card was or was not an example of the concept. There will be no time limit but give me your answer as soon as you can. Remember to look at each card carefully.

Following the instructions, S was verbally presented a sample problem (a card with a dot on it was an example of the sample concept while one without a dot was not). Through the use of this example, S was shown how the stimulus cards were to be displayed, when and how to respond, and what he would be questioned about. Any questions S had were then answered.

Following this instructional period, E placed the screen apparatus in front of S. The initial stimulus card was set in position on E's side of the screen, the tape recorder was turned on, and the screen was then rotated so that S could see the card. While S was looking at the presented stimulus, the next stimulus card was positioned on the opposite side of the screen. Following S's initial response ("yes" or "no"), E gave feedback ("correct" or "wrong") after which he asked S to explain his reasoning as to why he thought the card was or was not an example of the concept he was to learn. Each succeeding trial was begun

as soon as S finished giving his reason for responding a particular way during the preceding trial.

Stimulus cards were presented to S in a random sequence which varied between treatment groups. Consequently, all Ss in a particular treatment group received the same stimulus presentation sequence. The four stimulus presentation sequences were derived from four permutations of an 8 X 8 randomized Latin square design.

RESULTS

Problem Difficulty

The number of trials each S took to reach the prereversal criterion for his particular treatment group is shown in Table 1. Ss trained on the Easy Problem required an average (Group A scores plus Group B scores) of .17 trials to reach prereversal criterion while Ss who were given the Hard Problem took an average (Group C scores plus Group D scores) of 6.54 trials.

In order to determine whether or not the Hard Problem was in fact more difficult to learn than the Easy Problem, an F test for homogeneity of variance was performed using the values reported in Table 1. The resulting F was 153.48 with 23/23 df which was significant at the .005 level. Since the equal variance assumption was not met, neither an analysis of variance nor a t test was performed on Table 1 data. However, a nonparametric technique was used. A significant difference ($H = 22.33$, 1 df, $p < .001$) was obtained with a Kruskal-Wallis one-way analysis of variance by ranks. Thus, all Ss who were trained on the Easy Problem reached prereversal criterion at a significantly faster rate than did Ss who were given the Hard Problem, thereby indicating that the latter problem was more difficult to learn than the former.

Table 1

Number of Trials Each Subject Required to Reach the Prereversal Criterion of His Treatment Group

	Easy Problem		Hard Problem	
Subject	Group A	Group B	Group C	Group D
1	3	0	0	4
2	0	0	0	3
3	0	0	3	30
4	0	0	13	6
5	0	0	0	4
6	0	1	3	2
7	0	0	10	24
8	0	0	0	2
9	0	0	9	6
10	0	0	9	17
11	0	0	2	0
12	0	0	0	10
$\bar{X}$	.25	.08	4.08	9.00

The preceding findings are graphically illustrated in Figure 1 which shows the mean number of trials to pre-reversal learning for criterion (CR) and overtrained (OT) Ss in each of the two problem groups.

Reversal Data

With regard to reversal learning, Table 2 sets forth the number of trials each S took to reach the reversal criterion in his particular problem group.

An F test for homogeneity of variance ($F = 1.16$, 23/23 df, $p > .05$) was computed for the Easy versus the Hard Problem reversal data contained in Table 2. Since the equal variance assumption was thus met, a two-way analysis of variance (Fixed Model) was computed using the data in Table 2. As seen from Table 3, no significant results were found with the two-way analysis of variance.

Although a significant ORE was not obtained with the Hard Problem ($t = 1.46$, 22 df, $p > .05$), trends (Figure 2) in the hypothesized directions were found. Considering the Hard Problem, overtrained Ss given this task tended, generally, to learn the reversal concept faster than criterion trained Ss. In contrast, overtrained Ss were somewhat slower in learning the Easy Problem reversal in terms of mean number of trials than were the criterion trained Ss. However, this difference was primarily due to one S's (S 3 in Group B) performance. This S required

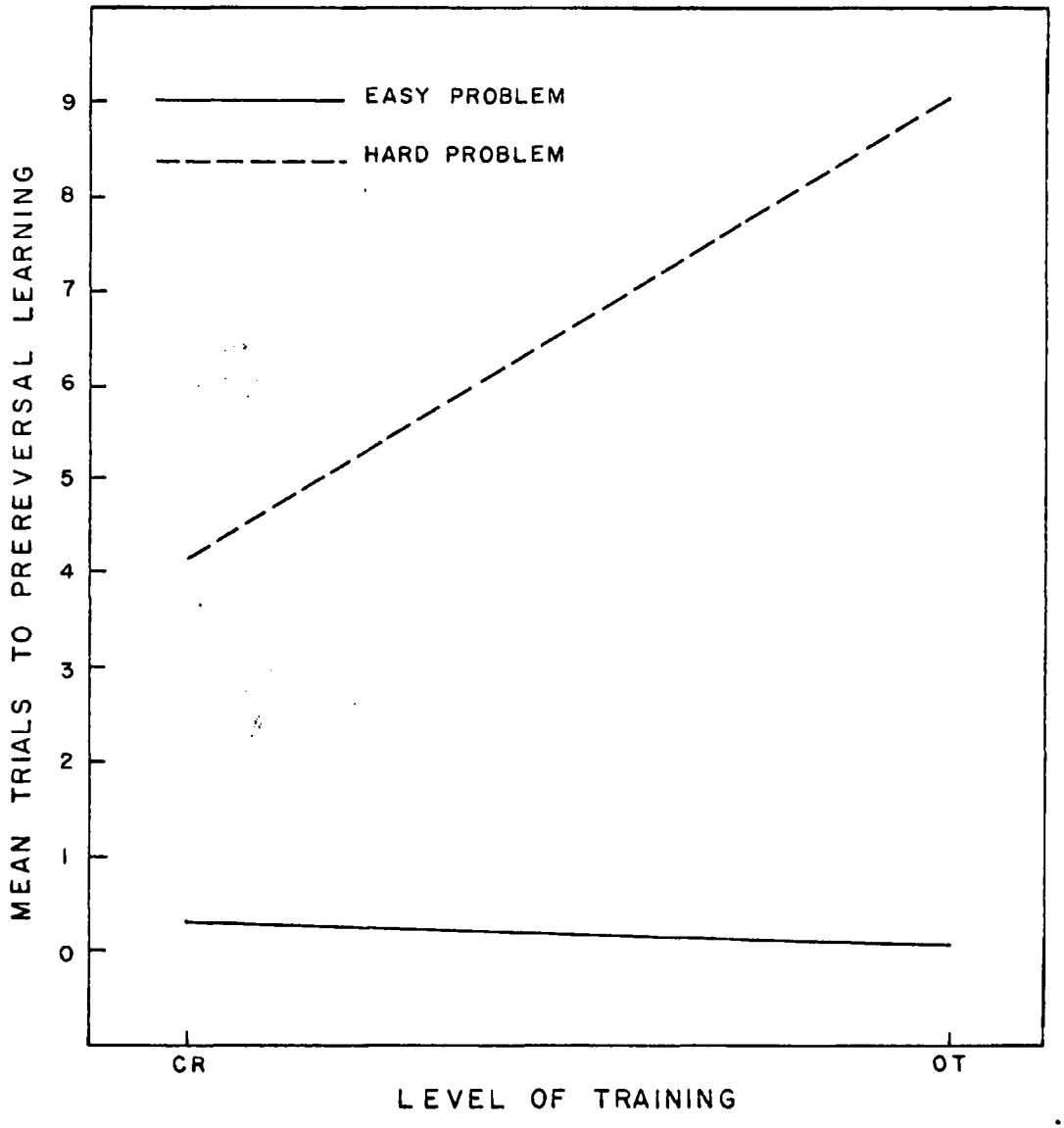

Fig. 1. Mean number of trials to prereversal learning in all treatment groups.

Table 2

Number of Trials Each Subject Required to Reach the Reversal Criterion of His Treatment Group

	Easy Problem		Hard Problem	
Subject	Group A	Group B	Group C	Group D
1	0	0	0	1
2	0	0	10	0
3	0	21	0	0
4	0	0	1	2
5	0	0	17	4
6	0	0	0	0
7	10	0	3	0
8	0	1	12	0
9	0	0	0	2
10	0	5	0	10
11	0	0	13	0
12	4	0	0	1
$\bar{X}$	1.17	2.25	4.67	1.67

Table 3

Two-Way Analysis of Variance (Fixed Model) of the Number of Trials to Reversal Learning in All Four Treatment Groups

Source	SS	df	MS	F	p
Between Groups:					
Problem (Easy vs. Hard)	25.52	1	25.25	1.07	--
Training (CR vs. OT)	11.02	1	11.02	.46	--
Interaction	50.02	1	50.02	2.10	--
Error (WG)	1049.25	44	23.85		
Totals	1135.81	47			

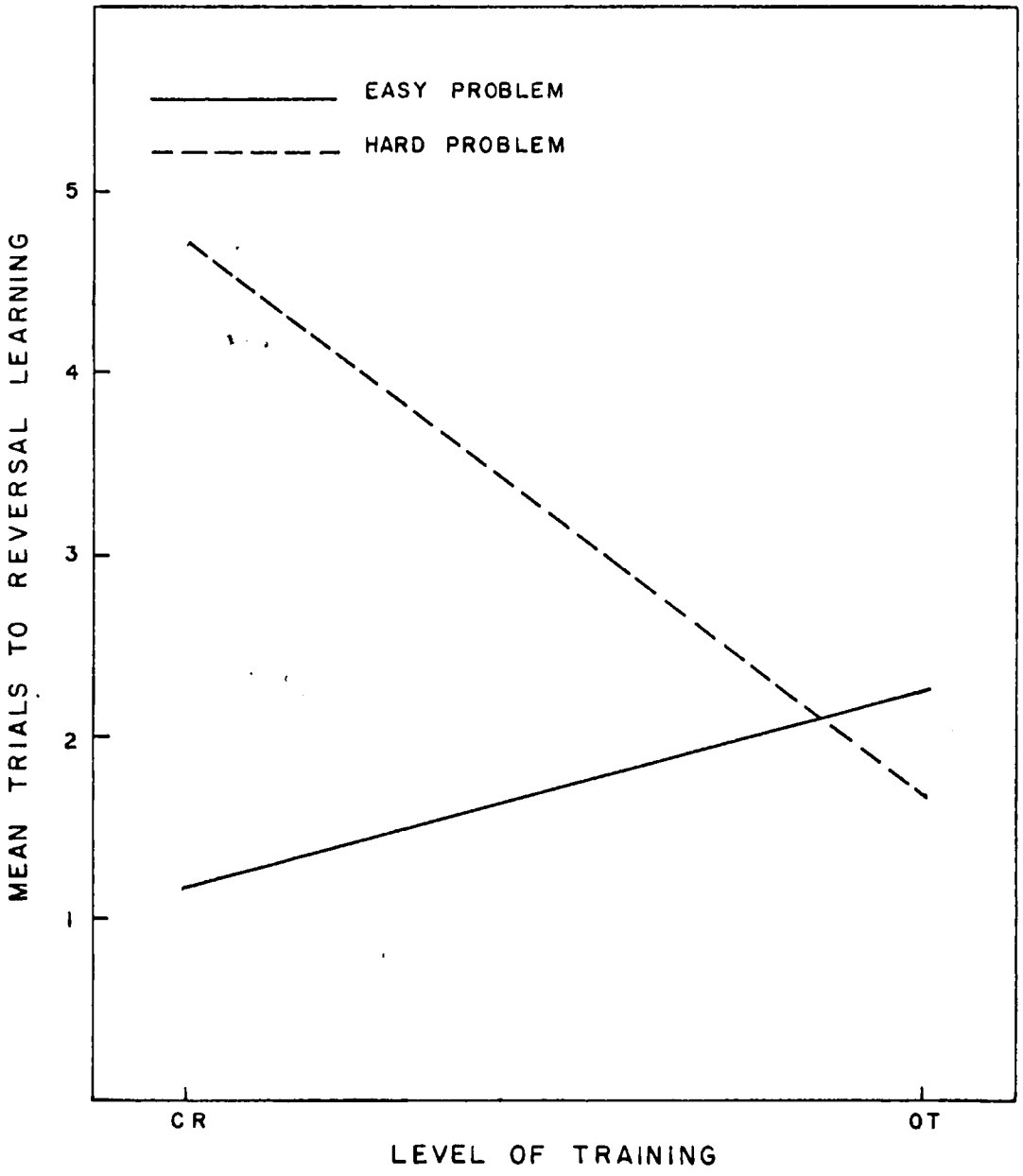

Fig. 2. Mean number of trials to reversal learning in all treatment groups.

significantly more trials to learn the reversal problem following initial overtraining than he needed to learn the original prereversal problem. Furthermore, as can be seen from Figure 2 (and Table 2), the level of training given on the Easy Problem produced essentially no substantial effects with respect to acquisition performance as hypothesized since, on the average, Ss receiving criterion training tended to learn the Easy Problem reversal just as rapidly as postcriterion trained Ss.

Frequencies of Verbalized Hypotheses

The responses each S gave to E's post-trial inquiry--why S thought that a particular stimulus complex was or was not an example of the concept he was supposed to be learning--were classified into hypothesis categories for both the Easy and Hard Problem. In many cases, responses were clear enough so that they were readily classified into one category or another. Ambiguous responses were classified according to the element(s) in each response which appeared to be the most representative or characteristic of a certain category. The hypothesis categories and the resulting frequency distribution for each problem are shown in Table 4.

As can be seen from Table 4, a fairly large variety of hypotheses was offered by Ss in each problem group. However, significantly more hypotheses ($x^2 = 27.66$, 1 df,

Table 4

Frequency Distribution of Hypotheses Verbalized During Prereversal Trials on Both the Easy and Hard Problem

Easy Problem		Hard Problem	
Hypothesis	Frequency	Hypothesis	Frequency
Shape (S)	229	Color + Position (C+P)	222
Color + Shape (C+S)	72	Color (C)	116
No Reason (X)	25	Distance (D)	80
Shape + Color + Position (S+C+P)	15	No Reason (X)	46
Color (C)	11	Position (P)	38
Sequence (Sq)	5	Color + Distance (C+D)	8
Position (P)	3	Color + Position + Distance (C+P+D)	6
Other (O)	2	Position + Distance (P+D)	1
		Size (Sz)	1
Total	362		518

$p < .001$) were offered by Ss in solving the Hard Problem. This result gives further support to the previous findings which indicated that the Hard Problem was significantly more difficult than the Easy Problem.

According to these data (Table 4), the general trend appears to be that S focused on as many aspects of the stimulus situation as possible in attempting to formulate a tentative hypothesis(es) which might eventually lead to the solution of the particular problem which he was confronted with in the treatment conditions.

From further inspection of these same data, it appears that both relevant and irrelevant dimensions were focused on as well as aspects of the stimuli which were not originally considered or even perceived by E as possible stimulus variables but which some Ss verbalized in their post-trial reasons, such as: the geometric figure being "glued" instead of "printed" on the card, a small speck or mark on the figure or card, an abstract idea such as "the concept of unity," or the edge of a figure not being "smooth." In the majority of instances, such variables were mentioned within the context of responses that could be readily classified into one hypothesis category or another. But when such an item alone constituted S's response, which occurred very infrequently, this type of response was placed in the "Other" category.

A graphical representation of the distribution of hypotheses offered by Ss during prereversal training on both the Easy and Hard Problem is given in Figures 3 and 4.

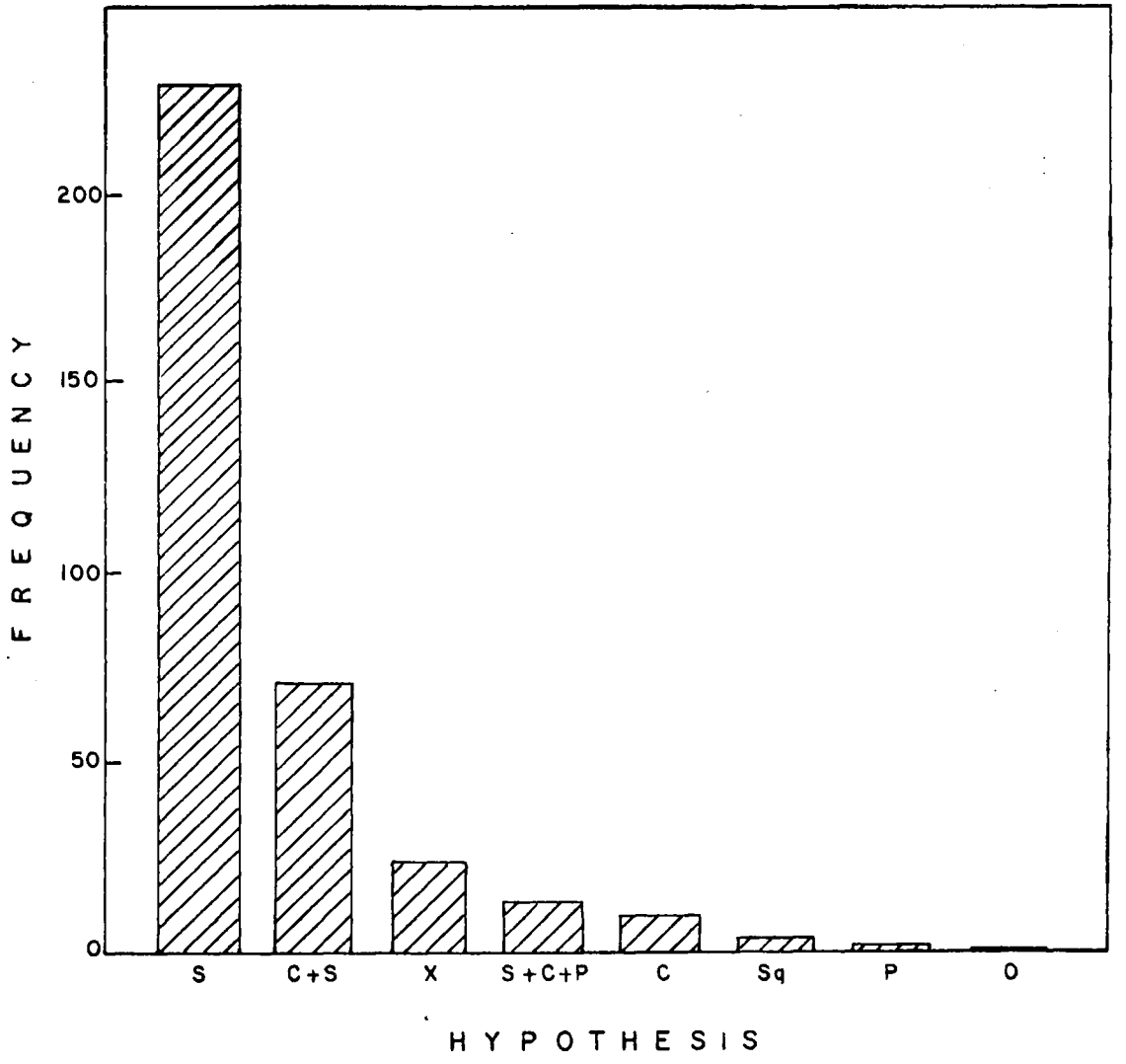

Fig. 3. Frequency of hypotheses verbalized during prereversal trials on the Easy Problem.

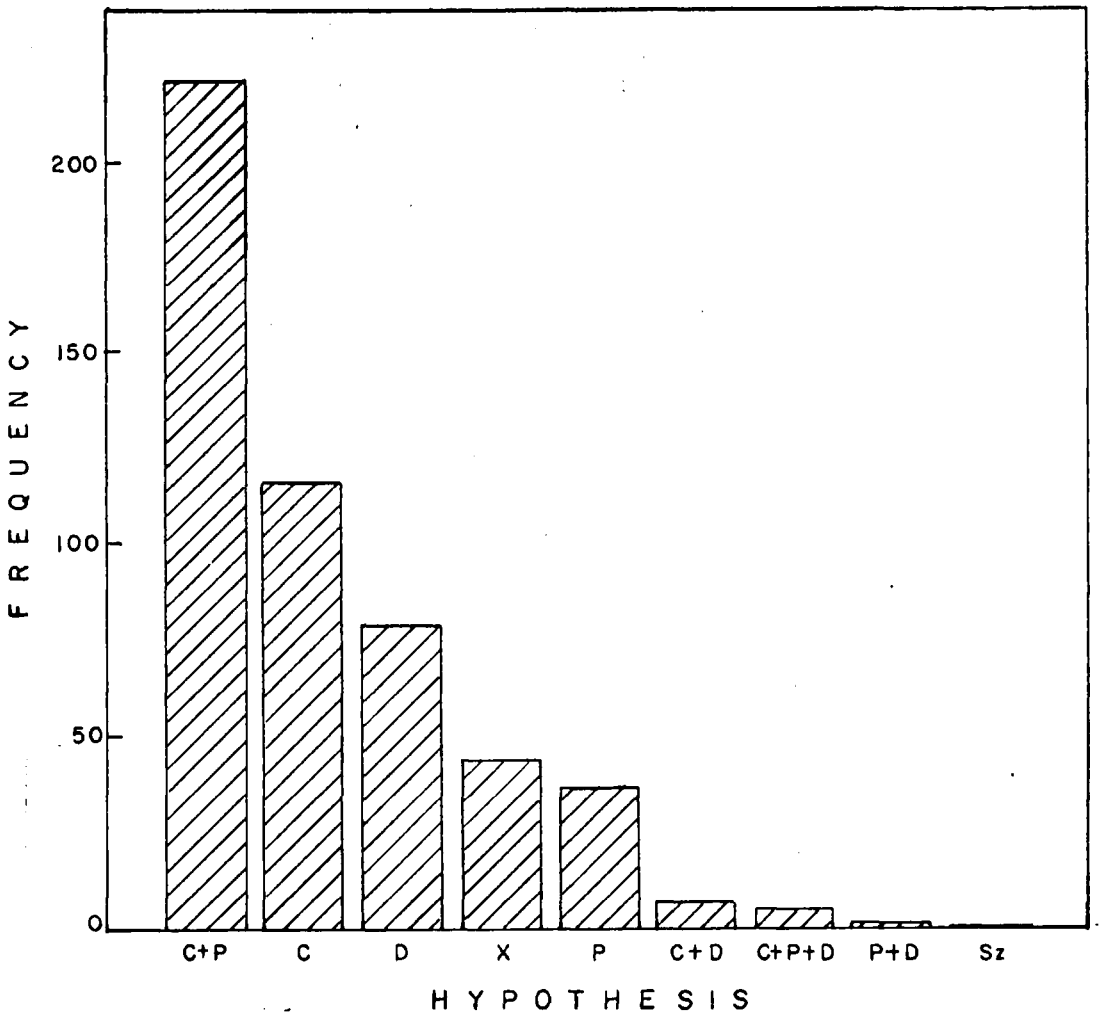

Fig. 4. Frequency of hypotheses verbalized during prereversal trials on the Hard Problem.

DISCUSSION

In retrospect, the two discrimination problems employed in the present investigation were found to be significantly different with respect to difficulty--Ss generally found the Easy Problem less difficult to learn than the Hard Problem. The assumption that no ORE would occur when using a discrimination problem in which the relevant dimension was perceptually obvious to S during initial trials was supported as seen in the results obtained with the Easy Problem (Table 2 and Figure 2). Results obtained with the Hard Problem indicated trends toward an ORE in a discrimination problem where the relevant dimension was initially obscure; however, these results were not statistically significant. As expected, a wider variety and a significantly greater number of hypotheses were generated by the more difficult Hard Problem (Table 4).

In light of these findings, the following questions appear to be appropriate. Why was a significant interaction effect not obtained between the level of training and the type of problem Ss received? Why was a significant ORE not found with the Hard Problem? What are some of the factors which appear to influence the occurrence or absence of the ORE, especially when humans are employed as Ss? In

order to discuss and hopefully to offer some answers to these inquiries and others, five aspects of the present investigation are to be considered and evaluated: the problems used, attitudinal variations among Ss, procedural weakness, training level, and nature of the discrimination task.

Problems

Miller (1959) has found that the relative dominance of stimulus cues or, more accurately, dimensions in a learning situation tend to vary with the age of S thus suggesting the operation of a maturational factor in discrimination learning. For younger children, the position dimension appears to be dominant while with increasing age, simple stimulus configuration then color becomes dominant for the majority of older children.

In conjunction with Miller's findings, the two problems used in the present study were believed, a priori, to be at different levels of difficulty because of the types of dimensions, attributes, and combinations of such used in each problem. The Easy Problem was thought to be less difficult since it contained just two dimensions with one held constant (color) and the other varied (shape). Because of this manipulation of the dimensions, it was assumed that there would be a relatively high initial probability of Ss attending to the relevant dimension in

this problem. Consistent with this approach, the Hard Problem appeared as though it would be more difficult because of the fact that it contained a greater number of variables (color, position, distance, shape) all of which were manipulated. Again, on an a priori basis, it was assumed that the initial probability of Ss attending to the relevant dimension in this problem would be relatively low. An additional irrelevant dimension which was innately present within the structure of both problems but which became evident only after a few Ss were run was that of sequence of stimulus presentation.

The most prominent weakness of this study's Hard Problem was located in its structure in that it was set up in such a way that it could be solved in any one of three ways. During initial trials, S could solve this problem by focusing on either the position of the red figure (left-positive), the position of the black figure (right-positive), or the distance between the two objects (close-positive). As seen from Table 4, a few Ss incorporated all three aspects in their responses, but the majority focused on only one (usually either color or position of the object) in solving the problem. Offering three possible modes of solution may have been one reason why no significant ORE was obtained with the Hard Problem.

However, despite this weakness, Ss took significantly more trials to learn the Hard Problem. Since the

latter problem possessed the same number of irrelevant dimensions (one) as the Easy Problem did, this was not the source of the former's difficulty. On the contrary, more relevant dimensions were added to the Hard Problem thus presenting S with a wider population from which to eventually select out the relevant dimension(s) than was the case in the Easy Problem. The choice process in the Hard Problem was undoubtedly slowed down due to the increased number of alternatives S had to compare and from which he eventually had to choose thus complicating the decision-making process thereby resulting in a decelerated acquisition rate.

Restle (1962) has indicated that the difficulty Ss may encounter in attempting to solve cue learning problems (discrimination learning, concept formation, maze learning) is probably due to their tendency to employ strategies--particular patterns of responses to stimuli--which conflict with the E-defined strategy. In this sense then, cue learning entails more of a selection of strategies by S in solving the problem rather than the formation of strategies as usually assumed. Restle proposes the following three models of strategy selection: one-strategy-at-a-time, all-strategies-at-once, and a-random-sample-of-strategies.

From the nature and content of the verbal responses--as recorded on individual data sheets--offered by Ss in the present experiment, similar operations in

relation to what Restle has described appear to have occurred. Generally, in both the Easy and Hard Problem conditions, Ss seemed to focus on and use one or two attributes (in combination) of a stimulus complex in attempting to solve the particular problem presented. Once S had focused on a dimension or combination of elements which resulted in his receiving "correct" responses from E, he appeared reluctant to relinquish focusing on that aspect of the stimulus complex. Even in the face of "wrong" responses from E during initial reversal trials, S would in many cases persist in focusing on his chosen dimension or element but would eventually alter his overt verbal response until it once again resulted in a "correct" response from E, or else he would focus on another aspect of the stimulus.

The above-described process suggests that the majority of Ss used what Restle designates as the one-strategy-at-a-time model in selecting a plan for solving the problem. Within this model, S selects one strategy which he exercises on each trial. If this strategy leads to positive consequences, S continues to employ it without alteration. However, if the strategy constantly yields negative results, S engages in an exploratory type of behavior where he chooses a new strategy with each succeeding trial and this process continues until S perceives consistent positive results.

In essence, Ss appeared to perceptually lock in on a dimension once it was learned to be significant and subsequently exhibited resistance to altering this focus of attention, this effect being greatly enhanced by over-training. This observation fits in with and is further explained by Lawrence's concept of the "acquired distinctiveness of cues [Riley, 1968, p. 129]." In essence, Lawrence has indicated that stimuli which S has used in the past to solve a problem will usually be employed in a new problem having similar stimuli, the use of other cues being less probable. In addition, training on a particular dimension makes S more responsive to alterations in it.

Employing Lawrence's reasoning then, postcriterion training operates to increase the probability of S's focusing on the relevant dimension and using it more effectively during reversal than would be the case with minimal criterion training.

Attitudinal Variations

During the course of the present investigation, there seemed to be some qualitative difference among Ss' performances which appeared to have some correlation with pre-experimental attitude. Some Ss who approached the experimental situation possessed the attitude that the task was going to be extremely difficult and thus openly doubted their own ability to perform adequately. Such Ss appeared

somewhat rigid in their subsequent performance in that they did not readily discard hypotheses which consistently elicited negative responses from E but rather adhered to them for seemingly long periods of time. In contrast, Ss who did not initially verbalize doubts concerning the experimental task or their own problem-solving capability generally tended to exhibit a greater flexibility in rejecting and acquiring new hypotheses when the need arose.

This attitudinal factor was not subjected to systematic analysis in the present study. However, Morin (1955) in his work with college students suggests that S's pre-experimental conceptualization of the task is probably an important variable in determining whether optimal solutions are reached.

One possible explanation of this attitudinal phenomenon is offered by Restle (1962) who has found in his investigations with animals that Ss often demonstrate strong tendencies to retain a certain strategy for a long period of time even if it is wrong or irrelevant. Restle indicates that such perseverative tendencies may be present whenever the incentive for learning is not entirely adequate and/or whenever Ss have developed the attitude that rewards cannot always be obtained.

In support of Restle's ideas concerning the adequacy of the reward and its effect in a learning situation, Mackintosh (1968) has found that overtraining

effectively facilitates reversal in a visual problem when the reward is relatively large and the discrimination is relatively difficult.

Procedural Weakness

A prominent source of confounding in the present experiment was probably the post-trial interval during which each S gave a reason for his initial response ("yes" or "no"). During this interval, the stimulus card was still visible to S thus offering him the opportunity to alter his original reason and formulate new strategies based on immediate cross-comparisons between: (1) the obtained feedback, (2) the configurations of previously presented stimuli, and (3) the still observable stimulus complex. The main effect of this procedural weakness was probably that of decreasing the difficulty of both experimental problems by making the formulation and subsequent selection of alternative strategies easier for S than would have been the case if the stimulus card was removed or concealed immediately following S's initial response. The latter alteration would introduce a greater memory factor making comparisons and resulting decisions somewhat more difficult thereby lengthening acquisition time.

This procedural change would undoubtedly produce significant effects in the proposed directions since the individual data sheets revealed that many Ss based their

initial response ("yes" or "no") on an immediate mental comparison of a stimulus configuration presented in any one trial with previously presented stimulus complexes which Ss had remembered as being either positive or negative instances as specified through the "correct" or "wrong" feedback responses previously given by E. In short, many Ss based their initial responses and subsequent reasons on a sequential comparison of stimulus complexes.

Level of Training

This variable appeared to be one of the most prominent confounding factors in the present study. The confounding effect caused by this factor was most evident in the performance of criterion trained Ss who were given the Hard Problem (Group C). Examination of the data in Tables 1 and 2 reveals that on the average Ss 3, 4, 6, 7, 9, and 10 in Group C learned the reversal of the Hard Problem in significantly fewer trials than it took them to learn the original problem in prereversal training. In effect, half the Ss in Group C obtained an ORE or trends toward one while the remaining six Ss required as many or frequently more trials to obtain reversal acquisition as expected.

On the basis of the preceding results, it seems reasonable to assume that if S takes too many trials to reach criterion, for all intents and purposes he will in

effect be overtrained by the time he reaches criterion. Once this occurs, he might as well be moved into the group receiving overtraining and be considered an overtrained S. For example, S 4 in Group C progressed through 13 trials before criterion trials could even begin to be counted. Once he reached this initial counting point, he then had to be given a block of 10 trials in order that he could meet criterion. In all, S 4 required 23 trials to meet the prereversal criterion. As the data illustrate, he learned the reversal in one trial indicating that he had in fact been overtrained.

The foregoing suggests that there might be a maximum level of criterion training for any one particular discrimination reversal problem passed which overtraining begins to occur. In the present study, this level seemed to settle around five to seven trials with regard to the Hard Problem. However, as mentioned previously, this level would undoubtedly vary depending on the type of experimental task employed.

Whether this maximum criterion level is an artifact and peculiar only to the present design or whether it can be generalized to other human reversal studies is not clear at this time. However, it does create an interesting area for further investigation.

Nature of the Discrimination Task

The nature of the discrimination task which is presented to S has a lot to do with whether the ORE occurs or not. Mackintosh (1965b) has stated that the ORE is found more frequently with visual than with spatial discriminations. The reason for this discrepancy being that spatial problems generally do not contain irrelevant cues which are necessary to produce the effect (ORE). Mackintosh also points out that rats have been used in the majority of ORE studies and that these animals tend to be spatially oriented. When given a position discrimination then, rats readily attend to the relevant spatial dimension with the result that no ORE is found.

Another manner in which the experimental task might vary thus affecting the appearance or nonappearance of the ORE is whether it is presented to S in a successive or simultaneous fashion.

Spence (1952) ran a black-white discrimination study with a T-maze using rats as Ss. He found that Ss took significantly more trials to learn the discrimination when it was presented in a successive as opposed to a simultaneous manner. Significantly fewer errors were made with the simultaneous arrangement.

What is the difference between a simultaneous and successive discrimination? Kimble (1961) states that in a simultaneous discrimination there is usually a choice

between two reactions (e.g., turning right or left). In contrast, a successive discrimination involves a choice between reaction or restraint.

Which discrimination is the more difficult? Kimble assumes that if discrimination learning is visualized as involving a comparison process, then learning would probably be more rapid under those conditions maximizing the execution of this process. The simultaneous discrimination arrangement appears, at face value, to fulfill this role since in this technique the positive and negative stimuli are presented together while in the successive problem they are presented separately thus eliminating any direct comparison of stimuli. However, Kimble further indicates that in terms of relational theory an indirect comparison actually occurs in the successive situation where the stimulus perceived by S at any one time is compared to the memory trace of the alternative stimulus. Since this indirect comparison is mentally more difficult to carry out than when the stimuli are presented simultaneously thus allowing an immediate direct comparison, a successive discrimination generally requires more trials to acquire.

In a study (Tempone, Capehart, Atwood, and Golding, 1966) conducted to investigate the differential effects on the ORE produced as a function of whether the discrimination task (size of squares) was presented successively or

simultaneously, a significant ORE was found with the successive condition which appeared to be the more difficult discrimination. No significant ORE was observed with the simultaneous task although trends in this direction were indicated.

The preceding results tend to fit Lovejoy's (1966) ORE model. According to the latter, the greater the difficulty of the discrimination the greater the probability of obtaining an ORE. Since the successive type of discrimination appears to be more difficult to acquire, the probability of an ORE occurring would be increased with that type of task than with the somewhat simpler and more obvious simultaneous discrimination.

Two-choice successive discrimination problems were used in the present study. The Easy Problem could be classified as a visual discrimination while the Hard Problem possessed both spatial (position plus distance dimensions) and visual aspects (color plus shape). The performance effects of a combined visual-spatial discrimination are not clearly apparent. However, within the confines of this investigation, one effect might have been to increase the difficulty of the Hard Problem thereby overcoming, to some extent, the weakness of having an inadequate number of irrelevant dimensions as well as there being three possible ways to solve this problem.

As evident from previously-mentioned material (Spence, 1952; Kimble, 1961; Tempone et al., 1966), the successive arrangement of both the Easy and Hard Problem probably added a certain degree of difficulty to each. This effect combined with the greater cue population present in the Hard Problem resulted in a more difficult discrimination and a higher probability of observing an ORE (only trends were obtained) in the latter problem as opposed to the Easy Problem.

General Conclusions

To review, some of the findings of this study were: (1) no ORE was found with the Easy Problem but trends toward one were obtained with the Hard Problem, (2) the nature of cue and dimension variables within the discrimination problem affect acquisition, (3) S's pre-experimental conceptualization of or attitude toward the experimental task affects his subsequent performance, (4) as in any study procedural weaknesses can be detrimental to predicted results, (5) the suggestion of a maximum level of criterion training in prereversal trials, and (6) the nature of the discrimination task itself (spatial vs. visual, successive vs. simultaneous) influences the probability of an ORE appearing or not.

What synthesizing induction can be formulated from the aforementioned findings? It is that just one or two

factors are not sufficient to account for the ORE, and this may be the main source of its relative elusiveness. It is an understatement to say that many factors must be considered when attempting to account for the presence or absence of the ORE, but it is a necessary one to make and stress. Some of these more prominent variables as have been suggested in the preceding discussions surrounding the current investigation are: problem dimensions and cues, species of Ss, general procedure, training levels, and structure of discrimination tasks. There are doubtlessly countless other factors which affect the final results, as there are in any experiment, but the preceding appear to be the most dominant and relevant for ORE investigations.

Can ORE findings derived from infrahuman studies be generalized to the human situation and still provide an adequate explanation of the latter's reversal behavior? This question, which is still open to inquiry, arose constantly throughout the progression of the present study from the gathering of background material to the tabulation of results. Kendler and Kendler (1964) appear to ask this question and even narrow it down further to include the question of within-species generalization. A more formal statement as to inter-species differences with specific emphasis on reversal learning has been made by Mackintosh (1965a, 1965b, 1968). These sources tend to indicate that the specifics of infrahuman reversal learning cannot

adequately explain the intricacies of such learning in the human; however, there is the possibility that some generalities may carry over. Overall, this question is still unsettled and continues to be open to inquiry and controversy.

So in addition to the limited number of factors affecting the ORE which have already been detected during the course of this study and previously listed, the species variable, including both the intra- and inter-species aspects, seemingly needs to be added to this list in order that a somewhat more complete explanation may be offered for the occurrence of the ORE as well as for its rarity or absence. With regard to the rarity of the ORE, Mackintosh (1968) emphasizes that an adequate explanation of the ORE must be able to account for this factor as well.

Finally, the distinction between a stimulus dimension and a stimulus cue appears essential for a clear understanding of reversal learning in connection with the ORE. Within the context of the present investigation, a stimulus dimension was considered to be a more inclusive factor while a stimulus cue was considered to be of a more limited nature, in essence a subelement of a stimulus dimension. For example, the stimulus dimensions used in the present study were those of color, shape, position, and distance while the corresponding cues within these larger dimensions were respectively: red or black,

triangle or square, left or right, and close together or far apart. As can be seen from this example, stimulus dimensions tend, conceptually speaking, to be more abstract types of entities while stimulus cues are of a more concrete directly observable nature.

As illustrated in this investigation and as more formally presented in an earlier writing (Kendler and Kendler, 1964), the essential aspect of discrimination reversal problems is that the relevant stimulus dimension in such a problem remains essentially intact and unaltered from pre- through postcriterion trials even though the stimulus cue(s) associated with this dimension is (are) varied. If S is able then to select out and respond appropriately to the relevant dimension in a problem before reversal, then the probability of his continuing to focus on the same dimension during reversal learning would, a priori, appear to be greater than chance thus leading to rapid reversal acquisition. One function, if not the primary one, of overtraining appears to be that of increasing the probability that S will continue to focus on the relevant dimension during reversal trials thereby speeding up reversal learning. Overtraining does this by offering S a greater opportunity to pick this dimension out of the stimulus population and once focused on this dimension, affording S extensive experience with it.

Since in a discrimination reversal situation the same stimulus dimension is relevant in both reversal and prereversal trials, S is not in actuality being presented with a completely different problem in the reversal trials. As an illustration, the relevant dimension (e.g., color) in a discrimination reversal situation may be viewed in terms of a continuum with one cue (e.g., red) being positive during criterion trials and another (e.g., black) being positive in reversal trials. Although these stimulus cues change, the variations occur within the same, stable, unaltered, relevant dimension, in this case color. This is in direct contrast to the nonreversal shift wherein both the stimulus dimension and its member cues vary from pre- to postcriterion trials.

From the foregoing discussion, the two most evident factors, although as seen from this study not the only ones, which could operate either to facilitate or impede reversal acquisition appear to be the amount of prereversal training and the variation or modification of intra-dimensional cues, not to mention the confusional effect on S of inter-dimensional cue manipulation. The latter point as well as all of the preceding discussion on stimulus dimensions versus stimulus cues tends to support a "stimulus analyzing mechanism" approach (Sutherland, 1959; Sutherland and Holgate, 1966) in explaining the intricacies of reversal learning and the ORE.

As has been the case with many previous studies, the present inquiry has not given rise to a well-defined formula for the ORE but rather has, hopefully, delineated and clarified to a small extent what seem to be some of the prominent factors operating to effect either the occurrence or absence of the ORE with regard to human Ss. The actual operational nature of these factors remains an open issue in many cases and a pertinent area for experimental investigation.

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