THE EFFECT OF DEPRIVATION AND OVERTRAINING ON SPATIAL REVERSAL LEARNING

by

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ABSTRACT

The purpose of the present experiment was to examine the effect of the level of training and the level of deprivation on the learning of spatial reversals by rats in a WGTA. Thirty-two male albino rats were presented with a spatial discrimination problem involving two reversal discriminations. In Phase I all Ss received equal treatment under either 6 or 48 hour deprivation. In addition, in Phase II half of the Ss received criterion training (8 out of 10 correct choices) and the other half received overtraining (23 out of 25 correct choices). In Phase III all Ss were tested to a criterion of 23 out of 25 correct choices. Consistent with other studies, no ORE was found. Possible explanations were examined and implications were discussed.

INTRODUCTION

A discrimination reversal task presents the subject with stimuli varying along two or more dimensions, for example, position and size. The subject is reinforced for attending to one of these dimensions and responding differentially to different points on it, usually by approach or non-approach responses. Such learning has been studied with animals in a number of situations. The simplest case is reversal learning wherein the animal is presented with a choice between two responses, only one of which is reinforced. After the animal is trained to a certain performance criterion, the problem is reversed such that the previously unreinforced response is then reinforced. This sequence is repeated, and it has been found that performance on both acquisition and reversal subsequently improves progressively.

The question then arises as to whether the rate of such improvement is better after criterion or overtraining procedures. The first discrimination experiment to study the effect of different numbers of trials before reversing the values of the two stimuli was reported by McCulloch and Pratt (1934). Their experiment attempted a direct test of Lashley (1929) and Krechevsky's (1932) assertion that animals, in the course of learning to discriminate between cues, attend to only one dimension at a time trying one solution to a problem and then another until they finally find the correct dimension and solve the problem. Such systematic

responses were referred to as hypotheses, and the underlying assumption became known as the non-continuity assumption. McCulloch and Pratt (1934) argued that if repetitive training produces evidence of learning irrespective of the hypothesis being tested, a summation of scores could be taken as representative of an animal's ability on a given task. The test of this proposition, they said, lay in reversing the values of the cues in a discrimination problem at different stages of training. If the effect of training on cue A was to retard the learning to select cue B regardless of whether the subject was responding systematically to A or not, then the non-continuity hypothesis was wrong. To test this experimentally, McCulloch and Pratt had rats pull strings attached to weighted trays in a weight lifting discrimination. The correct tray in all cases was the heavier of the two and weighed 75 grams; the incorrect tray weighed 25 grams. Five groups of animals with differential exposure to the correct stimulus were tested. Group I, the control group, had all training trials with the heavy stimulus correct. Group II started with the lighter stimulus correct, but after 28 trials, the heavier one became correct and remained so until the end of training. Group III was trained with the lighter stimulus correct until the subjects gave some evidence of discriminating between the two--this took a median of 84 trials--and was then trained to criterion on the heavier weight. Group IV was trained the lighter weight for 348 trials prior to reversal. Group V was given 84 trials with two equal weights midway between the positive and the negative and was then changed to the heavier weight correct. It should be noted that no group would correspond

directly to a group trained with the lighter stimulus correct to criterion and then switched; therefore it is impossible to tell whether an overtraining effect would have occurred or not. In terms of the number of trials to learn the discrimination after the shift to the heavier weight, Group I required 52.04 on the average; Group II required 64.35; Group III, 94.65; Group IV, 115.83; and Group V, 49.17. Comparison of Groups I and II indicate that the effect of first 28 trials is not negligible as a strict non-continuity position would maintain; therefore, this was construed as evidence against the non-continuity position.

Spence (1936, 1937, 1952) considered discrimination learning to be a cumulative process wherein there is a continuous increment in the strength of the "excitatory tendency" of a stimulus cue or the tendency of this stimulus cue to evoke an approach response from the subject. The excitatory tendency of the positive stimulus cue is strengthened through the successive reinforcements of appropriate approach responses to it. The subject thus learns to approach the stimulus complex containing the positive cue. That is, this continuity interpretation that Spence was proposing said that the subject associates all features of the stimulus with the approach response as a function of reinforcement--the non-continuity position held that the subject learned only about the dimension which was attended to and did not acquire available information about other features of the stimulus complex. The negative stimulus cue, according to Spence, is weakened or inhibited because responses to it result in non-reinforcement. Basically, then, Spence's paradigm

is a dual 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 non-reinforcement is likewise increased. Thus in regard to discrimination reversal learning, the subject receiving extensive overtraining on a discrimination, as opposed to a criterion trained subject, might be expected to display a relatively slow reversal of the discrimination. This result could be expected since both habit strength and the 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 suggested that in discrimination learning, a subject learns to discriminate or orient towards a specific set of stimuli within the total stimulus complex. In addition to this discrimination response, a subject also learns to respond appropriately to the set of stimuli in which the positive stimulus is embedded--this is labeled as a discrimination of choice or a choice response. In essence, discrimination learning is viewed as a dual process phenomenon wherein 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 response toward the relevant dimension.

According to Reid, evidence for this proposed dual process theory would be provided if subjects displayed faster reversal learning as a function of overtraining on the original problem. He predicted that if an animal learned a simple discrimination such as a black-white problem, overtraining would increase reversal speed rather than retard it. To test the accuracy of this prediction, he trained three groups of rats on a black-white discrimination in a Y maze. One group was trained to a criterion of 9 out of 10 consecutive correct responses; the second group was trained to the same criterion, and received 50 additional overtraining trials; the third group was trained to the same criterion, and received 150 overtraining trials. After completion of the initial training, each group learned the reversal of the original problem. The mean number of trials to learn the reversal was 138.3 for the non-overtrained group, 129 for the group receiving 50 overtraining trials, and 70 for the group receiving 50 overtraining trials. Overtraining, therefore, significantly facilitated reversal learning. Reid's results simultaneously supported his prediction and posed something of a problem for most theories of learning. However, subsequent research has demonstrated similar results and the Overlearning Reversal Effect (ORE) is an accepted, if somewhat elusive, phenomenon.

Several interpretations of the ORE have appeared in the literature. Reid's own interpretation involved a differential rate of development for each of the processes within his two-stage model of

discrimination learning. Initially, a more rapid buildup occurs in the choice response over the discriminating or orienting response, since the choice response is temporally closer to the reinforcing event; reinforcement being contingent on this response. With prolonged training the discriminating response is strengthened, the temporal distance between it and the presentation of reinforcement diminished. At the end of criterial training, the choice response is stronger because it has been developed to a higher level than the discriminating response. Reversal following criterial training is slower because in addition to the formation of a new and appropriate choice response, the response of discriminating must be strengthened to the point of functional utility during reversal training. On the other hand, reversal following overtraining requires only that a different choice response be established; the discriminating response being functionally effective due to post criterion training. Consequently overtraining should facilitate reversal.

Spence's (quoted by Reid 1953) explanation of the ORE is based on the idea of position habit strengths. Spence analyzed the learning of a simultaneous visual discrimination into the building up of response strength into four component stimuli: the two visual stimuli and the two positions. He was able to predict that subjects will develop position habits during original training, will eventually break their position habit when the negative stimulus is on the preferred side, and will then rapidly attain criterion. The subject will retain its position habit until the difference in response strengths between S+ and S- is greater than the difference in response strengths of the two positions. At the

point of breaking the position habit, this latter difference may be quite large and Spence's explanation of the ORE rests upon supposing that it will remain significant even when the criterion run has been completed, but will be reduced nearly to zero during overtraining, i.e., irrelevant response tendencies are weakened. This being the case, criterial subjects would start reversal with a greater difference in response strengths of the two positions than would overtrained subjects; therefore, they would be more likely to fall into position habit during reversal; and would take longer to learn, since reversal can't occur until the difference in response strengths to the new S+ and S- is greater than the difference in response strengths to the two positions.

There has been some controversy over whether or not Spence's model can provide a satisfactory analysis of the ORE. Wolford and Bower (1969) simulated Spence's model by computer and were able to obtain an ORE for some parameter settings. Turner and MacKintosh (1970) extended this work and found, as Spence had specified, that the basis for the ORE was that criterial subjects reverted to their original position habit during reversal, while overtrained subjects did not develop a position habit. They also found, however, that unless subjects entered upon original learning with a strong position habit, they would not show an ORE. Since Pubols (1956) had shown that a pretraining procedure that abolishes initial position biases does not prevent the ORE from occurring, Turner and MacKintosh questioned whether Spence's explanation was satisfactory.

Sutherland and MacKintosh (1971) provided still other objections to Spence's account of the ORE, namely that it relied on the permanence of position habits. An implication of Spence's assumption that criterial subjects enter reversal learning with their original position habits largely intact and subsequently revert to these original habits during reversal is that criterial subjects should have the same preferred side in reversal as in initial training. This congruence between initial and reversal position habits should be reduced by overtraining. Sutherland and MacKintosh (1971) analyzed the position habits, defined as 20 consecutive trials of consistent choice to the same position, of 99 rats trained and reversed on a brightness discrimination on a jumping stand. They found that overtraining facilitated reversal as well as decreased the number of position responses during reversal. However, this provided no support for Spence's account as they found that only 57 percent of criterial subjects had the same position habit in acquisition and reversal; further, 58 percent of the overtrained subjects were found to have the same position habit during acquisition and reversal.

MacKintosh (1963a) examined whether the mechanism involved in the facilitation of reversal by overtraining is the weakening of attention to irrelevant dimensions. In this brightness reversal experiment, the magnitude of ORE was found to be a direct function of the number of irrelevant cues; the addition of orientation (horizontal vs. vertical lines) as an irrelevant dimension retarded reversal for criterial but not for overtrained subjects. This indicates that overtraining weakens

the effect of irrelevant cues; but the results for a third group for whom the irrelevant horizontal and vertical stimuli were not introduced until reversal began, indicate rather that overtraining strengthens the effect of relevant cues. In this group, it was impossible for overtraining to weaken attention to the irrelevant dimension (orientation) as it was not present during original learning. Criterial subjects reversed slowly but overtrained subjects reversed at the same rate as when orientation was present in original learning. Here, overtraining benefited reversal more by strengthening attention to the relevant dimension (brightness) than by weakening attention to the irrelevant dimension (orientation), according to MacKintosh (1963a). His point is that the weakening of irrelevant cues can't be the sole cause of the ORE. The model he proposes for explaining the ORE will be examined later.

Attempts have been made to account for the ORE in terms of resistance to extinction, i.e., that overtraining facilitates reversal by decreasing resistance to extinction. Proponents of this view are Birch, Ison and Sperling (1960) whose experiment provided the most direct evidence to support it. They trained rats on a go-no go brightness discrimination in a runway and found that overtraining significantly facilitated reversal. They recorded running speed separately to S+ and S- during reversal, and found that the effects of overtraining were confined to producing more rapid extinction of running to the original S+. Though there were experiments that failed to replicate this asymmetrical effect of OT, recent studies attest to the reliability of

the effect (Sperling, 1970). To transfer this explanation from the go-no go discrimination to the simultaneous discrimination, one must assume that overtraining has a similar effect on speed and choice measures of extinction. If overtraining decreased resistance to extinction of approach responses to the rewarded stimulus and running speed similarly, it's possible to hypothesize that ORE occurs in simultaneous discriminations because overtrained animals give up consistent selection of their former S+ sooner than criterial animals. MacKintosh (1963b) tested this hypothesis by training rats on a brightness discrimination on a jumping stand such that after either 0 or 150 overtraining trials, each group was extinguished to a criterion of equal choice of S+ and S- over ten trials. Overtraining was found to increase the number of trials required to reach the extinction criterion. When subjects were subsequently trained on the reversal problem, the overtrained subjects learned more rapidly. The implication is that the reacquisition phase of reversal benefits more from overtraining than the extinction phase. On latencies recorded during extinction, however, overtraining decreased resistance to extinction, i.e., overtraining was found to decrease the speed of responding, implying that the extinction phase benefited more. The discrepancy between choice and speed measures make it impossible, at least in this instance, to conclude that the ORE occurs because the overtrained subjects give up consistent selection of their former S+ sooner than do criterial subjects.

D'Amato and Jagoda (1960) have focused primarily on the concept of avoidance of the S- in explaining the occurrence of the ORE. They

see the extinction of avoidance tendencies toward the previously negative stimulus as a critical factor in reversal learning. In overtrained subjects, experience with the negative stimulus is temporally more remote than in criterial subjects who have usually been responding to both the positive and negative stimuli until a relatively short time before reversal. The essential termination of experience with the negative stimulus for the overtrained subjects results in the reduction of avoidance toward this stimulus. Overtrained subjects, therefore, should find the previously negative stimulus less aversive than criterial subjects, and should be more likely to select it. Criterial subjects require more trials to reverse because they must perform two operations: (1) extinguish avoidance responses to the initially negative and subsequently positive stimulus, and (2) develop correct approach responses to the positive reversal stimulus. The overtrained subject, on the other hand, has essentially extinguished to this stimulus before reversal begins--he merely has to develop correct approach responses. Hence, the overtrained subject is able to learn the reversal problem more rapidly.

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) stipulates that discrimination learning involves: (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 analyze one aspect of a stimulus situation. In learning a discrimination problem, a subject

must switch in the appropriate sensory analyzer which detects the differences between relevant and irrelevant dimensions of a stimulus complex. As this is being accomplished, appropriate responses are then attached to the outputs of this analyzer. MacKintosh (1962) essentially agrees with Sutherland's "analyzer" explanation. Reversal learning is regarded as consisting of two parts: (1) the extinction of the original discrimination and (2) the acquisition of the reversal discrimination. According to the Sutherland-MacKintosh (1971) account of the ORE, overtraining serves to strengthen the referrant analyzer relative to its response attachments. During early reversal, overtraining increases the number of trials during which subjects continue to select predominately their former S+; but it decreases the probability that control of the behavior will be shifted from a relevant to an irrelevant analyzer during the course of reversal. During early reversal then, both the relevant analyzer and its response attachments are weakened; the analyzer continues to weaken until the two antagonistic choice responses are of equal strength, and from then on, the relevant analyzer will be strengthened again. When overtraining does facilitate reversal learning, it does so because in criterial subjects, the relevant analyzer is extinguished well below the point at which an irrelevant analyzer (position, for example) comes to control behavior, while in overtrained subjects, the relevant analyzer does not extinguish so far.

The ORE is an elusive phenomenon; some experimenters have found that overtraining facilitates reversal learning, while others have found that it has no effect or actually retards reversal learning. Some

investigators have attempted unsuccessfully to ascertain the conditions necessary for the appearance of the ORE. The generalization that emerges is that the ORE is most likely to appear when (1) the discrimination task involves additional irrelevant cues (for example, when subjects must discriminate between two stimuli differing in form, both forms are presented in two colors that vary randomly between trials (MacKintosh 1965b), (2) when the discrimination problem is difficult or the relevant cue is one to which the subject does not normally attend (Lovejoy 1966), and (3) when large rewards are used (Theios and Blosser 1965b). If these conditions are met, the probability of obtaining the ORE in rats is very high, if less than certain.

There are likewise conditions under which the probability of obtaining the ORE is virtually low. Spatial discrimination with rats is one example. Some 30 studies can be found in the literature dealing with overtraining and spatial reversal with rats. Of these, Brookshire, Warren and Ball (1961), Capaldi (1963), Ison and Birch (1961), Pubols (1956), and Theios and Blosser (1965b--large reward) have found that overtraining facilitates reversal. On the other hand, Clayton (1965), Eimas (1967--Experiment II), Galanter and Bush (1959), Hill and Spear (1963a), Hill, Spear and Clayton (1962--Experiment III), Krechevsky and Honzik (1932), and MacKintosh (1965c--Experiment I) have found that overtraining retards reversal. However, Clayton (1963a, 1963b), D'Amato and Jagoda (1960), D'Amato and Schiff (1964), Eimas (1967--Experiment III), Fidell and Birch (1967), Hill, Spear and Clayton (1962--Experiments I and II), Kendler and Kimm 1964, 1967), Komaki (1962),

MacKintosh (1965c--Experiment II), MacKintosh (1969--Experiment I), Mandler (1966), Paul and Kesner (1963), Theios (1965), and Theios and Blosser (1965a)--small reward) have found that overtraining has no effect on reversal. It can be seen that overtraining infrequently facilitates spatial reversal, and that it has at least as frequently retarded reversal learning. Lovejoy feels that the failure to obtain the ORE with spatial discriminations is found because of the dominance of spatial cues for the rat. That is to say that in rats, who naturally live underground, spatial orientation is important; thus their natural preference is for spatial cues. In the simple spatial problem the relevant analyzer will normally start at such a naturally high strength that it is never easy to obtain an ORE. While MacKintosh agrees with Lovejoy on this point, he feels there are additional variables to consider. The variables that he sees as important are (1) the dominance of spatial cues, (2) the weakness of irrelevant cues, and (3) the extent to which the pre-reversal habit is under external control.

One implication of the Lovejoy-MacKintosh position is that the ORE should occur when relatively difficult discriminations are utilized. Spatial discriminations being simple for the rat, according to this reasoning, the ORE is not expected. As noted before, there are studies demonstrating the ORE with the rat on a simple spatial discrimination. Capaldi (1963) is representative of such results. He trained two groups of rats to make a position response in a T maze. The criterion group was given 16 acquisition trials, while the overlearning group was given 120 acquisition trials. Following acquisition, all Ss were reversed

until eight consecutive correct responses occurred. The reversal performance in terms of errors and trials were significantly different such that the ORE was obtained for the overtrained group.

Adding another independent measure, namely magnitude of reward, Theios and Blosser (1965a) also obtained the ORE on a spatial task. They reasoned that the conflicting results on effects of overtraining on reversal learning may result from incentive differences. Consequently their model postulated the ORE to be a joint function of reward magnitude and number of original training trials. In Experiment I, rats were given either small or large rewards for either 30 or 90 training trials in a T maze before reversal learning. They found that large reward Ss reversed faster than small reward Ss; further with large reward, the overtrained Ss reversed significantly faster than the criterion trained Ss. With small reward, however, there was no significant difference between the groups. Thus the ORE was exhibited with the large reward groups and not with the small reward groups. Experiment II investigated the effect of a small number of original training trials and the effect of rewarded goal box placement. Rats were given a small or large reward with 15 training trials following 0 trials, 50 trials, or 50 rewarded goal box placements. Ss receiving rewarded goal box placement reversed faster than non-placed Ss, but not significantly so. There was no differences among the large reward groups, but overtraining retarded reversal with the small reward group. This suggests that the interaction of overtraining and reward magnitude are variables to consider when explaining the ORE as its occurrence seems facilitated by large rewards.

Kendler and Kimm (1967) cast further light on the role that reward magnitude has on the ORE. Their experiment was designed to investigate whether spatial reversal learning was facilitated by a large reward during the initial discrimination, during reversal learning or during both stages. In addition they sought to find out whether a differentiated maze providing numerous exteroceptive cues for spatial discrimination would facilitate reversal learning. This was aimed at assessing the importance of irrelevant cues. Their design involved rats learning to a criterion or overlearning, in a differentiated maze (different portions were painted black, others white, and others left unpainted) or an undifferentiated maze (painted gray and covered with translucent plastic), with small or large food reward during initial learning, and with small or large food reward during reversal learning. They found no significant main or interaction effects relating to the number of trials to reach the criterion of initial learning. During reversal learning, however, small rewards were found to retard reversal learning. Further, small rewards retards reversal learning when it is present either during initial or reversal learning. The retarding influence tended to be greater following overlearning. Though no ORE was found, they did note that a large reward, as compared to a small reward, facilitated reversal learning. In addition, they found that the discriminability of the maze had no effect. It seems here that, contrary to MacKintosh's contention, the presence of a salient irrelevant cue did not foster the ORE; though the confounding nature of this design does not lend itself to easy interpretation.

In a series of three experiments, Eimas (1967) studied the effects of overtraining on reversal in rats. Experiment I investigated the effect of type of task (spatial or non-spatial), number of irrelevant dimensions, and amount of overtraining (0 vs. 100 trials). There was no ORE found for spatial or non-spatial discriminations. Experiment II included the same manipulations as the former and the effect of reward magnitude was examined as well. Again no ORE was found. Overtraining was found to interfere with reversal. In both of these experiments, increasing the number of irrelevant dimensions retarded reversal as did small rewards and more difficult original discriminations. Experiment III varied the number of original training trials (40, a criterion of 9/10, and a criterion of 9/10 plus 200 overtraining trials) as well. Here large rewards facilitated reversal, as one would expect after Theios and Blosser, and 200 overtraining trials also facilitated reversal, though the magnitude fell just short of significance. The factors that emerge from these experiments as contributing to the ORE are reward magnitude, and number of original training trials--providing support for MacKintosh's assertion that pre-reversal habit is important; the presence of irrelevant cues did not have any effect.

D'Amato and Schiff (1964) had earlier investigated the effect of extensive overtraining and the presence of irrelevant cues on position reversal. In Experiment I, a visual cue (brightness) was correlated with the correct position. In Experiment II the stimulus consequences of an incorrect response were made highly discriminable by associating an abrupt illumination change with an incorrect choice. Despite these modifications, the ORE failed to occur in both experiments.

Clayton et al. have consistently failed to note the occurrence of the ORE. Hill, Spear and Clayton (1962) analyzed the importance of the various mechanisms called upon in explaining the ORE, namely, additional practice in making choices, the long series of rewarded trials, and the greater number of rewards. They compared four groups on a spatial reversal task. One group was reversed as soon as the discrimination was learned; one group was given regular overtraining before reversal; one group was given overtraining but was forced to the correct side on all overtraining trials, thus being deprived of making choices; and the last group was given twice as many overtraining trials with half forced to the correct side and half to the incorrect side, thus having more experience with the incorrect side than the others. No ORE was found. Since a fixed number of trials was used rather than a criterion for acquisition and reversal, Hill and Spear (1963b) repeated the study with changes to make it more comparable to previous experiments. Again no ORE was found. Clayton (1963b) examined the role of irrelevant cues (present v. absent) on reversal learning following overtraining. No ORE was found, rather he suggested that reversal following overtraining was made even more difficult by the presence of irrelevant stimuli. Clayton (1963a) examined the effect of a different method of giving both daily food rations and reinforcement (access to wet mash) compared to his previous (1963b) study and still found no ORE.

In most of the studies just cited, overtraining had either no effect or a negative effect on learning the reversal of a spatial discrimination task with the rat. Since a rather large number of

studies have failed to obtain the ORE it seems that the "critical" experimental variables are not yet adequately known--hence the explanations are inadequate or of limited generality. The few studies that obtained positive results from overtraining on a spatial task, did so by utilizing large rewards, a large number of original training trials, or a salient irrelevant cue. There is a paucity of prior deprivation studies. In most cases a simple T or Y maze was used; there are virtually no prior studies with rats in the WGTA. Perhaps the position cue in the WTGA is not as salient as the position cue in a locomotion task such as a Y maze or jumping stand. The purpose of the present investigation was to examine the effect of the level of training and the level of deprivation on learning of spatial reversals by rats in a WGTA.

METHOD

The basic task was a spatial discrimination wherein the animal was rewarded for response to one position and not to the other. A trial began with the opaque screen in front of the test cage lowered. After the objects were baited, the food tray was pushed forward and the opaque screen raised. The stimulus objects were presented simultaneously with a food pellet concealed under each one. To obtain the reward, the Ss had to displace the baited object on the correct side. If S touched the negative object the tray was withdrawn before the object could be moved and the pellet underneath retrieved. The non-correction method was used. After the S's response, the tray was withdrawn, the opaque screen lowered, and the objects baited for the next trial.

Subjects

Ss were 34 male albino rats, two of which died during the experiment. All Ss were approximately three months old at the start of the study and had no previous experience on a spatial reversal discrimination.

Apparatus

The apparatus was a Wisconsin General Test Apparatus (WGTA), components and dimensions of which follow. The test cage was 12 x 10 x 11-1/2 inches and was partially covered by a 11 x 7 inch wooden board

at the front. This board, raised three inches above the floor of the cage, served to confine the animal to the cage during inter-trial intervals. A 12 x 5-1/2 inch movable food tray was placed on a track 24 inches long. The tray contained two 1-1/2 inch diameter food wells, 1/4 inch deep, situated flush with the bottom of the wooden board. An unpainted wooden block 2-1/2 x 2-1/2 inches covered each food well. An 11 x 7 inch opaque screen, which could be raised or lowered by E was between E and S. The E was seated behind a one-way screen located at the end of the track. The food tray was illuminated by a 75-watt incandescent light. The entire apparatus was painted flat gray.

Rewards were 45 milligram Noyes pellets. The stimulus objects were two 2-1/2 inch square unpainted wooden blocks which covered either one or both foodwells, dependent on the stage of experimentation. During adaptation, only one food well was covered while both were covered during subsequent training and testing. During adaptation, the stimulus was randomly presented according to a Gellermann sequence.

Adaptation

All Ss were given 20 trials per day with 45 mg pellets as rewards. Adaptation to the WGTA was according to the following schedule:

Day 1: Ss were placed in the test cage and allowed to eat 20 pellets which were placed in a row along the edge of the tray.

Day 2: Ss were allowed to eat one pellet at a time placed in front of one of the food wells. The position of the reward was taken from a Gellermann sequence.

Day 3: One pellet at a time was placed in the foodwell according to a Gellermann sequence. A neutral (wood block) object was placed behind the rewarded foodwell.

Day 4: The object was gradually placed over the foodwells. The non-rewarded foodwell was left uncovered and a Gellermann sequence again determined the rewarded side.

Day 5: The stimulus tray was moved back between trials. The neutral object was placed further and further over the foodwell until it was completely covered.

Day 6: The opaque screen was lowered between trials.

Day 7: The procedure was the same as for Day 6--adaptation was continued until Ss responded within 15 seconds on 18 out of 20 trials.

Procedure

There were two main treatment groups of 16 Ss each. One group was tested after six hours of deprivation and the other group was tested after 48 hours of deprivation. In Phase I, all Ss were trained to a criterion of 23 consecutive correct choices out of 25 trials. During Phase II, the contingencies were reversed such that choice of the previously negative position, was reinforced. In addition, each group was further subdivided and 1/2 Ss were trained to a criterion of eight consecutive correct choices out of ten while the other 1/2 Ss received overtraining by having to make 23 consecutive correct choices. In Phase III, the contingencies were again reversed such that reinforcement was reintroduced to the position rewarded in Phase I--all Ss were tested

to a criterion of 23 correct choices out of 25. Half of the Ss in each subgroup were trained to respond initially to the object on the left; and half to the object on the right. In all, eight treatment groups with four Ss in each were formed. Groups I (R+) and II (L+) were given overtraining under 48 hour deprivation; Group III (R+) and IV (L+) were given overtraining under six hour deprivation. Groups V (R+) and VI (L+) received criterion training under 48 hour deprivation; and Groups VII (R+) and VIII (L+) received criterion training under six hour deprivation. Note that L+ and R+ refer to the initially positive position.

RESULTS

Phase I (Pretraining)

The number of errors, and latencies each group took to reach the Phase I (pre-training) criterion of 23 consecutive correct choices is shown in Table 1. Groups are not separated according to order of presentation, i.e., R+--Phase I, L+--Phase II, R+--Phase III, or, L+--Phase I, R+--Phase II, L+--Phase III. The average number of errors for six hour Ss was 11.8 while 48 hour Ss averaged 12.5 errors. The average latency for six hour Ss was 7.5 seconds while the average for 48 hour Ss was five seconds. Application of analysis of variance to each of the above measures revealed no significant main or interaction effects.

Phase II (Training)

Table 2 reports the mean number of errors, and latencies to reach the training criterion. Note that in this phase criterion and overtraining procedures were instituted. These data are reported for each of the major variables. An individual analysis of variance for errors again produced no significant main or interaction effects. Ss under 48 hour deprivation responded faster in this phase, ($F = 7.31$, $df = 1/24$, $p < .05$) than those under six hour deprivation; there was no significant difference in the number of errors made as a function of training level or deprivation level.

Table 1. Mean Number of Errors and Latency Required to Reach the Phase I (Pretraining) Criterion.

Group	Errors	Latency (sec.)
1 & 2 (48 hr dep)	14	5
3 & 4 (6 hr dep)	13	8
5 & 6 (48 hr dep)	11	5
7 & 8 (6 hr dep)	10	7

Table 2. Mean Number of Errors and Latency Required to Reach the Phase II (Training) Criterion.

Group	Errors	Latency (sec.)
1 & 2 (Overtrained--48)	22	9
3 & 4 (Overtrained--6)	18	12
5 & 6 (Criterion--48)	13	7
7 & 8 (Criterion--6)	13	15

Phase III (Reversal)

Table 3 reports the mean number of errors, and latencies to reach the reversal criterion. In an analysis of variance for errors, a significant interaction was obtained between position and level of training such that the effect of position was negligible within the criterion group, but considerable within the overtrained group. ($F = 5.4$,

Table 3. Mean Number of Errors, and Latency Required to Reach the Phase III (Reversal) Criterion

Group	Errors	Latency (sec.)
1 & 2 (Overtrained--48)	13	6
3 & 4 (Overtrained--6)	10	11
5 & 6 (Criterion--48	6	5
7 & 8 (Criterion--6)	8	7

df = 1/24, $p < .05$). No significant main effects were obtained. An individual analysis of variance of latency also produced no significant main effects or interactions. Overall analyses of variance on errors and latency for Phases II and III are generally supportive of the results obtained in the individual analyses. Thus, the ORE was not obtained.

A graphical representation of errors, and latency to criterion is given in Figures 1 and 2.

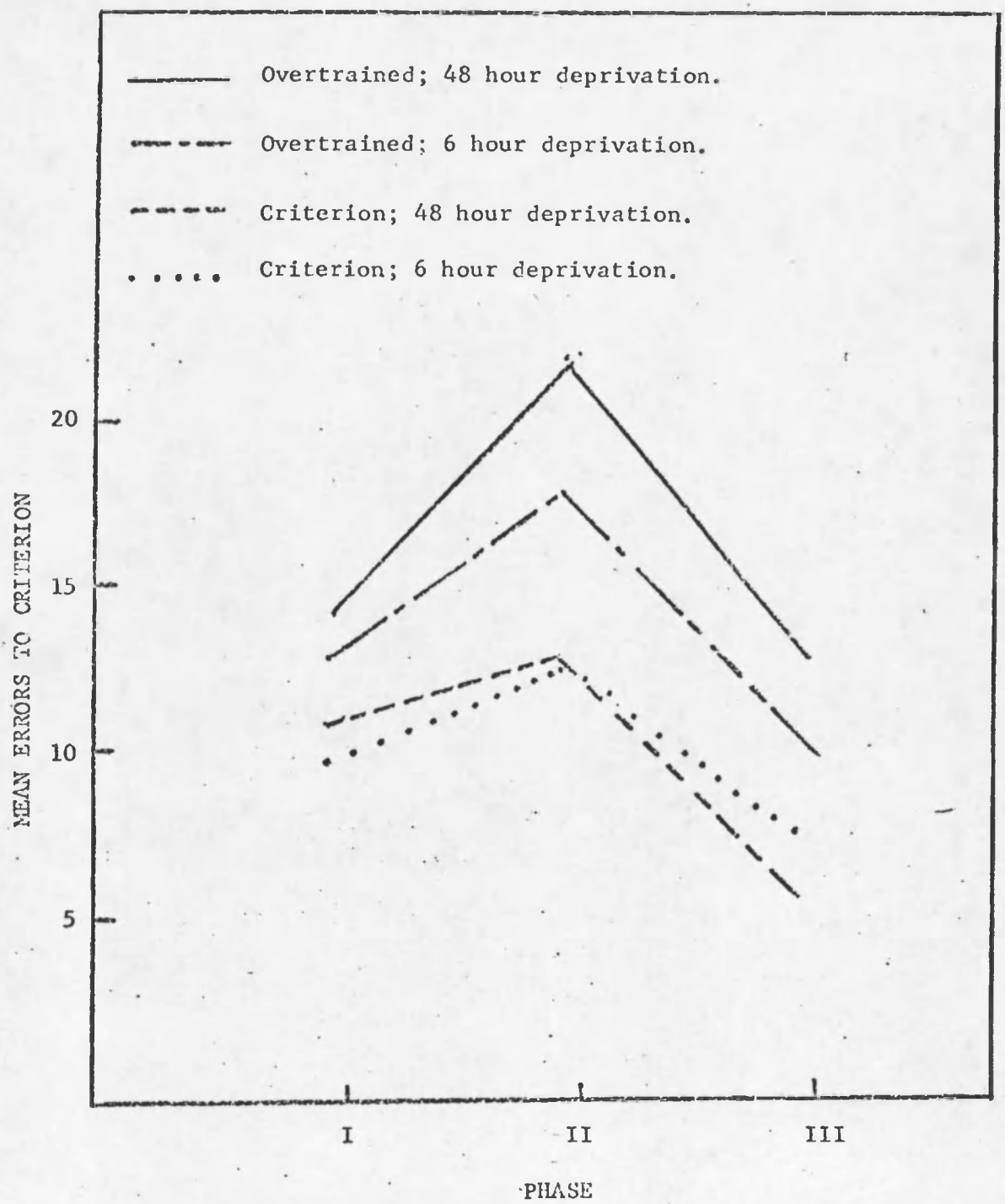

Figure 1. Mean Number of Errors to Criterion in All Treatment Groups, for All Phases, and with Order of Presentation Irrelevant.

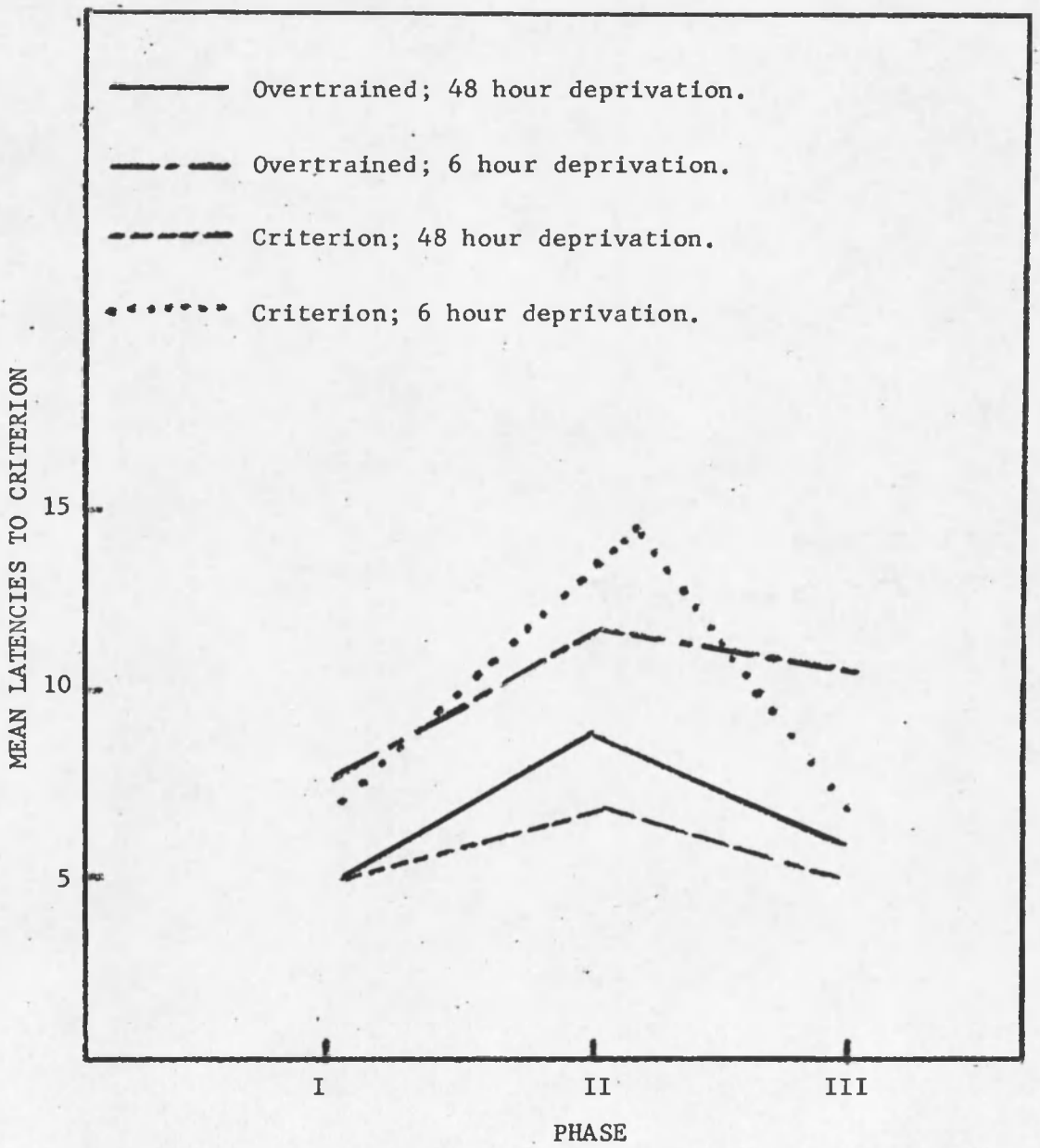

Figure 2. Mean Latencies to Criterion in All Treatment Groups, for All Phases, and with Order of Presentation Irrelevant.

DISCUSSION

Whether performance on spatial reversal discriminations in a WGTA varied as a function of deprivation level was one of the questions this study attempted to answer. Another question was whether over-training, as a function of deprivation, would yield the ORE which has been so elusive in the past with rats on spatial reversal tasks. Statistical treatment by overall analyses of variance indicate that these variables had no significant effect and the ORE was not found. The failure to find the ORE on this spatial task was consistent with other studies involving a different apparatus and manipulating sundry variables. Various explanations appear in the literature in regard to the failure to obtain the ORE.

Paul (1965) in commenting on the problem of getting the ORE reviewed variables potentially important. According to him, the effect of irrelevant cues is undecided; intertrial intervals are not crucial; age, sex, and strain are not of essential importance; amount of handling does not seem paramount; and food and water are not critical. He sees experimental sequence following an incorrect response as having to do with the presence or absence of the ORE. He points out that in every cited study which failed to obtain the ORE, a non-correction procedure was used, i.e., following an incorrect response the animal ended up in an unbaited goal box. On the other hand, the majority of the studies

which obtained the ORE used a different non-correction method--after an incorrect response was made the animal was removed from the apparatus. Thus, an incorrect response was never followed by entry into an unbaited goal box. He notes that a few experiments reported the ORE even when an incorrect response led to an unbaited goal box. To him, importance of the events following non-reward was speculative and worthy of investigation.

MacKintosh's explanation for the failure to find the ORE in spatial studies is in terms of the dominance of spatial cues and the weakness of irrelevant cues. According to his theory, speed of reversal partly depends upon the relative strength of analyzers and responses at the outset of reversal, and an ORE is predicted by the assumption that overtraining may strengthen the relevant analyzer more than its response attachments. For him the necessary conditions for the ORE are a difficult problem and a large reward. Salient irrelevant cues (MacKintosh 1963a) enhance the probability of the ORE. He feels that in a spatial task, since the rat shows a natural preference for spatial cues, the relevant analyzer starts at such a high strength that the problem is easy and the probability of attaining the ORE is low. In addition, in straightforward studies of spatial learning in a maze, irrelevant cues are not usually intended. Thus, if present, they are weak and the probability of the occurrence of the ORE is low.

Theios and Blosser (1965b) have suggested yet another explanation for the failure to obtain the ORE--the size of incentive. They assume the growth of two habits in discrimination learning: running to the goal

box and the expectation of reward. The habit associated with instrumental approach grows more rapidly than incentive motivation but both reach a similar asymptote, especially if incentive is substantial. In accounting for the ORE then, resistance to extinction is greater at some intermediate number of trials than at a larger number of trials because the discrepancy between habit and incentive motivation will be greater. Generally, substantial incentives enhance the probability of obtaining the ORE. They found that when the ORE has not been found, the reward value is small, whereas, rewards have tended to be large when the ORE has been found. They propose that the asymptote of incentive motivation varies as a function of incentive size. Thus, studies using small reward values do not show the ORE because incentive motivation does not reach a high level and the disruptive effects of error are small. They conducted a series of experiments on position reversals that have shown, consistent with their theory, that animals receiving large rewards on each trial show the ORE, but those receiving small rewards do not.

These are but three of the explanations that appear in the literature. According to Marx (1970), the ORE is not replicable in the general sense. Attempts by several investigators to ascertain the necessary conditions have met with less than signal success. No proposal has been offered for which there is not at least one instance of contradictory evidence. Paul correctly concluded that since a large number of studies have failed to obtain the ORE, it seems that the critical experimental variables are not yet known, hence all explanations are inadequate.

Deprivation Level

Though the overall analysis of variance indicated no overall main effect for deprivation in the present inquiry, there was a main effect for deprivation level with regard to latency in Phase II such that Ss under 48 hour deprivation had significantly faster response times than Ss under six hour deprivation. These results are consistent with some other studies, though it is not clear why they were restricted to Phase II. The effect of deprivation level on a simple spatial discrimination is ambiguous. Gossette and Hood (1968) found that high deprivation level retarded spatial reversal in pigeons during the first reversal of 23 subsequent reversals. Gossette and Feldman (1968) found that increased deprivation level retarded overall spatial reversal performance in squirrel monkeys under conditions of relatively small magnitude of reward. In investigations manipulating deprivation level alone results have been variable; increased deprivation sometimes facilitates and sometimes retards discrimination and/or reversal acquisition (Armus 1958; Wike, Blocher and Knowles 1963).

Level of Training

Though there was no main effect for the level of training, this variable appeared to be one of the most prominent confounding factors in the present study. Perhaps the criterion was too stringent. Examination of individual data sheets indicated that some Ss made a series of correct responses, almost reaching the required criterion, and then made an incorrect response, thereby making it necessary to

start again by counting the next positive response as #I and progress toward the criterion. Such behavior would be more marked with criterion than with overtrained Ss. 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. This suggests that there might be a maximum level of criterion training for any one particular discrimination problem pass which overtraining begins to occur. This level would undoubtedly vary depending on the type of experimental task employed.

Richman and Coussens (1970), in an interesting experiment, investigated the effects of several levels of initial training on a simple spatial reversal problem. They had four discrimination training groups: (1) undertrained rats who were trained to an original criterion of four out of eight correct responses during a day's run, (2) criterion Ss were trained to a criterion of six out of eight correct responses, (3) overtrained Ss were run to a criterion of eight out of eight correct and (4) strictly overtrained Ss were given an additional 96 training trials following overtraining. In terms of days to criterion, both lesser trained groups took significantly more days to reach the reversal learning criterion than either of the two overtrained groups. Reversal learning differences were not found between the two lesser trained groups or between the two overtrained groups. Richman and Coussens suggest that if the initial criterion is set high enough so discriminative

responding is asymptotic (the overtrained group) further training (the strictly overtrained group) does not lead to faster reversal learning. They further suggest that the ORE may be determined E's choice of the nonovertrained groups initial criterion. When this criterion is set below discriminative responding asymptote, overtraining facilitates reversal learning. Thus they suggest that instead of focusing on the extended training effects in reversal learning, it's best to shift attendance to preasymptotic performance and consider the slower reversal learning of the latter as an instance of the undertraining reversal effect.

Position and training interacted in Phase III such that overtrained Ss were more affected by sequence of presentation than were criterion trained Ss. This occurred even though a matching design was employed in the present investigation in an attempt to accommodate for existing position habits.

It is interesting to speculate why the ORE did not occur in the present investigation. If Paul is to be believed, use of the noncorrection procedure is a contributory factor. Following an incorrect response, the animal was not allowed reinforcement, the opaque screen was lowered, and the animal was left in the test cage until the next trial. An animal following an incorrect response encounters a lowered screen; thus, the consequences of being correct and being incorrect are quite distinctive. This is a procedural weakness of the present study and a potential source of confounding which is a factor to consider in future experiments. If MacKintosh is to be believed, the easy nature

of the task and the absence of irrelevant cues or, at best, the presence of weak irrelevant cues are contributory factors. Remember that Pubols (1956) found the ORE on a simple spatial task; and Eimas (1967--Experiments I and II) did not find the ORE as a function of increasing the irrelevant dimensions. If Theios and Blosser (1965a,1965b) are to be believed the incentive size was too small--only 45 mg pellets were used as rewards. Whether these variables would have yielded the ORE awaits further investigation. As has been the case with many previous studies the present inquiry has neither obtained the ORE nor given rise to a well-defined formula for it. The nature of the operational mechanisms involved in the ORE remain an open issue.

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