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Overlearning and Reversal of a Successive Discrimination Task

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OVERLEARNING AND REVERSAL OF A
SUCCESSIVE DISCRIMINATION TASK

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In Partial Fulfillment
Of the Requirements for the Degree of
Master of Arts

By
Phyllis Ann Hornbuckle
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APPROVAL SHEET

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ABSTRACT

Differiential predictions for reversal learning of a successive discrimination task by criterion and overtraining groups of rats were drawn from existing explanations of the overlearning reversal effect. The purpose of the present study was to test the validity of these predictions.

Sixteen rats were trained to criterion on a light-on, light-off discrimination problem in a modified Skinner box. Half the animals were given reversal training on the day after learning was complete while the other half was given 50% as many additional trials as were needed to reach the original criterion before reinforcement contingencies were reversed.

The criterion trained animals were superior to the overtrained animals in reversal learning. Overtrained animals continued to avoid the previously negative stimulus in reversal significantly longer than criterion trained animals in the first six days of reversal. Differences in extinction rates to the previously positive stimulus were noted in the latter part of reversal learning.

The observed differences in group performance were related to the various explanations of the overlearning reversal effect. The results were interpreted as supporting of the D'Amato and Jagoda avoidance hypothesis and the Birch-Amsel extinction hypothesis. The existing mediation explanations were not supported.

OVERLEARNING AND REVERSAL OF A SUCCESSIVE DISCRIMINATION TASK

INTRODUCTION

In numerous studies dealing with habit reversal of a discrimination task it has been demonstrated that additional training beyond some criterion of learning of the original discrimination problem facilitates the learning of the reversal problem. This phenomenon, often called the overlearning reversal effect (ORE), is a particularly compelling one since it appears to contradict the traditional assumption that resistance to extinction increases monotonically with increased numbers of acquistion trials. ORE has been reported in studies by Reid (1953); Pubols (1956); Capaldi and Stevenson (1957); Bruner, Mandler, O'Dowd and Wallach (1958); North and Clayton (1959); Birch, Ison and Sperling (1960); Brookshire, Warren and Ball (1961) for two groups: D'Amato and Jagoda (1961); Capaldi (1963); Mackintosh (1962, 1963a, 1963b) and others.

The overlearning reversal effect, however, does not appear to be a consistent one, occurring each time additional training is given prior to reversal learning. Failure to observe ORE has been reported by Bruner, *et al.*, (1953) for a high deprivation group; D'Amato and Jagoda (1962) in four experiments; D'Amato and Schiff (1962) in six experiments; Hill, Spear and Clayton (1962) in three experiments; North (1962); Clayton (1963a) Experiment II; Earlebacher (1963); and D'Amato and Schiff (1965) in eight experiments. At least three studies have shown superior performance of criterion groups over overtrained groups (Clayton, 1963b, Experiment I; Hill, Spear and Clayton, 1962 in Experiment III and for some groups in Experiments I and II; Hill and Spear, 1963b).

This inconsistency in experimental results has brought about an active search for the critical variable or variables contributing to ORE and much speculation aimed at explaining the effect as well (for reviews of the literature see Paul, 1965; Sperling, 1965a, 1965b; Mackintosh, 1965; and Lovejoy, 1966).

Isolating the critical variables which control ORE has not proved to be an easy task since experiments dealing with habit reversal have varied along a multitude of conditions. The following variables do not appear to contribute to the effect since ORE has been both observed and not observed under these conditions: 1) difficulty of the discrimination problem (e.g., North, 1962; Reid, 1954); 2) massed vs. spaced trials (e.g., Capaldi and Stevenson, 1957, with an ITI of 20 seconds and North and Clayton, 1959, with an ITI of 30 minutes both showed ORE; 3) reinforcement schedule (all studies mentioned above employed 100% reinforcement in the presence of the positive stimulus during acquisition); 4) deprivation level (all studies approximately the same deprivation level was used except Bruner, et al., 1958, in which drive was manipulated); 5) irrelevant cues (e.g. Mackintosh, 1963b; Clayton, 1963b); correction vs noncorrection procedures (e.g., Theios and Blosser, 1965a; Theios and Blosser, 1965b).

One variable which does seem to influence ORE is the type of discrimination task employed. Apparently the probability of ORE occurring is greater when exteroceptive discriminative stimuli are used than when proprioceptive stimuli are used. The majority of the studies involving visual discrimination tasks have shown the overlearning reversal effect. Exceptions include studies by Erlebacher (1963) and D'Amato and Schiff (1965). Most studies in which a spatial or position discrimination was required failed to show ORE. Exceptions include studies by Pubols (1966), Capaldi (1963) and Brookshire *et al.*, (1961). Theios and Blosser (1965b) suggest that the critical factor contributing to the occurrance of ORE in spatial or position tasks is the size of the reward used as reinforcement of the correct response. They observed ORE for large reward groups and reversed or no ORE for small reward groups. This variable does not appear to be responsible for inconsistent results in visual discrimination tasks, however. North and Clayton (1959) with a five second feeding time and Mackintosh (1962) with a twenty second feeding time both report ORE for a visual discrimination task. Sperling (1965a) has rightly suggested that the variables affecting learning of visual tasks may be quite different from those affecting learning of spatial tasks.

In spite of the fact that the overlearning reversal effect is not understood at present in terms of experimental variables, several hypothetical explanations have been ventured. These explanations are generally couched in either the "mediation-cognitive" tradition of Tolman and Krechevsky or in the Hull-Spence S-R orientation. The theoretical disagreement centered around ORE is reminiscent of the continuity-noncontinuity issue of the 1930's and 1940's.

The former group of explanations are based on the assumption that some "cognitive" process is acquired in the learning of the initial discrimination problem which is subsequently transferred to the reversal situation, facilitating reversal learning. As early as 1932 Krechevsky (1932) wrote about the acquisition of "hypotheses" by rats in discrimination learning, while Tolman (1939) spoke of "vicarious trial and error", which suggested a cognitive process of comparing stimuli at the choice point. Lawrence (1949, 1950) concluded that animals pay "attention to stimuli", implying a mediating response learned to the cues, and made the distinction between "relevant" and "irrelevant" cues. Harlow (1959) has suggested that ORE is the result of a reduction in the probability that animals will respond to irrelevant cues after overtraining. The development of "observing responses" in discrimination learning was proposed by Wycoff (1952). This means that animals learn where and what the appropriate cues are in the situation. Reid (1953) and later Pubols (1956) extended Wycoff's interpretation, suggesting that a "response of discriminating" is acquired in the original discrimination which transfers to the reversal situation and is facilitating. Mackintosh (1966) has recently re-emphasized the importance of attention in discrimination learning and in reversal learning in particular.

A physiological-cognitive approach to ORE was taken by Sutherland (1964). He presented a model for discrimination learning in which he suggested that the "switching-in of analysers" occurs. These "analysers", according to the model, become more firmly "switch in" during overtraining and thus that particular analyser appropriate to the discriminanda is more likely to be applied early in reversal learning than one not so firmly established. As Sutherland (1964) has stated, there is little neurophysiological evidence which bears directly on how different "analysers" are brought into play in learning. Consequently, Sutherland's explanation adds little to the previously mentioned mediational interpretations.

All of these cognitive explanations suggest, in one form or another, that discrimination learning is a two stage process, the first stage being the location and identification of the relevant stimulus dimension and the second being the development of preferences within that dimension. It is the first stage which is assumed to be transferred to the reversal problem. Since stage one is virtually eliminated in spatial discriminations, nothing is transferred from the original to the reversal task and therefore ORE should not occur. In visual discriminations ORE would be predicted by the mediation-cognitive interpretations.

The second group of explanations, which basically follow a Hull-Spence theoretical framework, assume only one stage to be involved in discrimination formation. The basic assumption of these interpretations is that discriminations are learned through reinforcing responses to the positive stimulus and extinguishing responses to the negative stimulus. Reversal learning, from this point of view, is simply the establishment of a new discrimination, with certain residual positive and/or negative transfer effects. Obviously, a strict Hull-Spencian interpretation of reversal learning encounters certain difficulties in handling the overlearning reversal effect. If resistance to extinction is assumed to increase with increased amounts of training, ORE should not occur. Since ORE does occur in some studies, the conclusion must be drawn that either extinction rate is nonmonotonically related to the amount of acquisition training given or that some factor other than the approach tendencies to the original S+ controls the rate of reversal learning.

Without abandoning a one-stage interpretation of discrimination learning, modifications of the reinforcement theory of learning have been suggested to account for ORE. Brown and Farber (1951), working within the Hullian theoretical framework, have suggested that "emotions", specifically frustration, may be included as intervening variables in learning. This suggestion is basically an extention of a part of Hull's corollary 17 which states that in nonreinforced trials following regular reinforcement the evoking stimulus...sometimes will evoke the response for a long time with a rise in reaction potential (Hull, 1952). Brown and Farber propose that this rise is the result of the presence of the emotion of frustration upon the instigation of nonreward and that frustration may act as a drive source. Amsel (1958, 1962) following the same general orientation, has further elaborated on the role of frustration following nonreward. Amsel (1962) has stated that the greater the frustration associated with a nonrewarded response, the faster that response will extinguish. Presumably the greater the initial number of reinforced responses, the greater the frustration when reinforcement is discontinued. In reversal learning, suggests Amsel, overtrained animals experience greater frustration associated with nonreinforcement of the previously reinforced stimulus and, therefore, negative transfer is reduced through faster extinction of responses to the formerly positive stimulus. Amsel's interpretation not only leads to the prediction of ORE in discrimination reversal, but also predicts a nonmonotonic relationship between acquisition trials and extinction in simple response learning.

Birch, Ison and Sperling (1960), while not subscribing to Amsel's theoretical justification of his hypothesis concerning ORE, have also proposed that the overlearning reversal effect is the result of decreased resistance to extinction after increased training. Support for this notion can be found from several sources (e.g., Birch et al., 1960; D'Amato, Schiff & Jagoda, 1962). Sperling (1965a) suggests that if spatial or position problems can be considered nondiscriminative, i.e., learned on the basis of serial chaining, delay of reinforcement gradients, etc., then the data on resistance to extinction following nondiscrimination training (e.g., Williams, 1938; Perin, 1942) would apply and account for the lack of ORE in most studies where spatial discriminations are required. This interpretation cannot account for the failure to observe ORE in studies utilizing visual discriminanda (e.g., D'Amato and Schiff, 1965) unless it may be assumed that the discriminanda employed in such studies were sufficiently difficult as to be virtually nondiscriminable and that position tendencies facilitated learning. The assumption would also have to be made that ORE occurs in spatial discrimination problems, (e.g., Pubols, 1956) to the degree that visual cues can be utilized in learning. Such information is not readily discernible from the existing literature.

Both the Birch et al. (1960) and the Amsel (1962) interpretations of the overlearning reversal effect suggest a modification in existing reinforcement theory which would take into account the nonmonotonic relationship between amount of initial training and extinction after discrimination training. The major factor influencing ORE, according to these explanations, is the positive stimulus in the original problem.

Another explanation has been suggested by D'Amato and Jagoda (1960) which places emphasis on the importance of the negative stimulus in the original problem. They suggest that in learning a discrimination problem a strong avoidance response develops to the negative stimulus as well as an approach response to the positive stimulus. During overtraining, in simultaneous discrimination tasks, this avoidance response begins to extinguish since the subject makes few errors and has little contact with the negative stimulus. When reversal learning begins, overtrained subjects begin to approach the previously negative-now positive stimulus more rapidly than criterion subjects whose avoidance response is stronger. Such an explanation is primarily applicable to simultaneous discrimination situations and would predict no ORE for successive discrimination problems since the negative stimulus is continually presented and cannot be avoided. The validity of this prediction remains in doubt since ORE has been observed (Birch et al., 1960) and not observed (North, 1962) under conditions of successive presentation.

Before the existing hypothetical explanations can be adequately evaluated, further experimental evidence is needed concerning the relative importance of acquisition and extinction rates to the discriminanda during reversal learning. While most studies have employed simultaneous presentation methods in T, Y, or X mazes, successive stimulus presentation is better suited for this type of analysis since both approach and avoidance tendencies can be measured independently.

The present study utilized successive presentation in a modified Skinner apparatus with rate of bar pressing as a measure of relative response strength. A similar approach to the problem was taken by Birch et.al., (1960). Running speed was measured in a straight runway and ORE was observed to occur. North (1962) did not find ORE under similar experimental conditions. Procedural differences may be responsible for the conflicting results. The number of trials to criterion in the Birch et al., (1960) study was approximately 45, while North (1962) used 96 set trials before reversal with no measure of degree of learning. It is possible that all of the 96-trial group in the former experiment were well into overtraining before reversal. Another difference which may be of importance is the length of the runway used. Birch et al., (1960) used a runway of approximately 2 feet, while North (1962) used a runway of about 4 feet. It would be difficult to specify whether this increased runway length might have had the effect of increasing avoidance tendencies to the negative stimulus through longer exposure periods or of decreasing avoidance tendencies through some "attention" factor related to the initial remoteness of the stimuli. At any rate, further investigation of the relative acquisition and extinction rates during reversal is needed.

The various advantages of successive stimulus presentation in the study of ORE have been discussed by Birch et al., (1960) and North (1962). The Skinner apparatus employed in the present study with bar pressing as a measure of relative response strength possesses certain additional advantages: (a) Avoidance tendencies to the negative stimulus can be maximized since the subject cannot avoid contacting that stimulus through fewer errors, as is possible in simultaneous methods, or through abortive trials which may occur in runway situations, in which case the subject may not be exposed to the negative stimulus. Such abortive trials (refusal to leave the start box) are generally not included in subsequent data computations and thus, their effect remains unknown. Contact with the negative stimulus is particularly important if we are to consider the D'Amato and Jagoda (1960) explanation of ORE. (b) Relative rates of responding can probably be more easily interpreted than relative running speeds. (c) To a greater extent than in the runway situation, the Skinner apparatus allows the maintainence of the "Choice" characteristics of simultaneous presentation methods. That is, the subject has the choice of response or restraint, whereas in the runway, if the subject does not run to the negative stimulus, the trial is usually not counted and the subject is returned to the start box repeatedly until he does respond. The maintanence of this characteristic seem important if we are to extend conclusions to studies utilizing simultaneous methods.

Differential predictions for the results of the present study may be drawn from various existing interpretations of ORE. Both the mediation-cognitive explanations and the Birch-Amsel one stage explanations would predict the occurance of ORE in visual discrimination tasks. The difference between the two lies in the stimulus, positive or negative, which is considered to be of greater importance in reversal. The mediation hypotheses would predict that since stage one (responding to the relevant stimulus dimension) is well established in overtrained animals, preference for the new S+ in reversal should occur sooner and differentiate between the two groups. The Birch-Amsel extinction hypothesis would predict that overtrained and criterion groups would respond differentially to the new S- since extinction is the important factor and the new S+ would be relatively unimportant.

Only the explanation offered by D'Amato and Jagoda (1960) would predict reversed or no ORE under successive presentation conditions since the avoidance response to the negative stimulus in the original problem is maintained or even increased during overtraining and thus interferes with approach responses to that stimulus when it is made positive in reversal training. Reversal should be retarded rather than facilitated.

The following study was designed to provide further analysis of the relative importance of acquisition and extinction in reversal learning and to investigate the validity of the predictions made by the various interpretations of ORE discussed above.

METHOD

Subects

The Ss were 16 male hooded rats of the Long-Evans strain and were approximate 60 days old at the beginning of the experiment.

Apparatus

A modified Skinner box was used, the dimensions of which were 11 in. long, by 8 in. wide, by 9½ in. high. A 2 in. wide manipulandum protruded ½ in. into the cage, 3½ in. above the wire floor. The weight necessary to depress the bar was approximately 12 gms. The end wall from which the bar protruded was constructed of masonite board, as was the opposite wall and the hinged top. The other walls were made of wire mesh; 2 in. above the bar was a small pilot light. To the right of the bar was a food cup into which a Gerbrands food dispenser delivered .045-gm. pellets (J. P. Noyes and Co.).

The entire Skinner box was placed in an insulated chamber, the inside of which was illuminated by a small pilot light with a plastic cover. The inside dimensions of the chamber were 19 in., by 25 in., by 15 in. It was equipped with an exhaust fan and all external noise was deadened by 2 in. thick insulation and masked by the fan noise. On the outside door of the chamber was a plastic window, 7 in. square, which permitted observation of the subjects' behavior.

The apparatus was wired (using Grayson-Stradler E783D power supply and E783 relay panel) so that a response of pressing the bar could be rewarded with food on a 100% schedule during the presentation of the positive stimulus and not rewarded during the negative stimulus. Stimulus presentation length and sequence were programmed by means of an automatic timing cam which operated an automatic stepper.

Procedure

Ss were placed on 23-hour food deprivation for five days prior to experimentation. Each S was given standard bar press training and on the day following successful bar training was given 20 reinforcements in the presence of the positive stimulus. S's were randomly divided into two groups, the S+ for one group being light-on and for the other light-off. The stimuli during discrimination training were presented for 20-second periods in a Gellerman random series. 40 such periods constituted one day's training. 100% reinforcement was available during S+ periods and water was available at all times.

The criterion for learning was five consecutive S- periods in which no responses were made, provided there was an average of four responses to the S+ during the corresponding five S+ periods (this criterion was selected on the basis of a pilot study which indicated that immediately prior to this level of learning, Ss were making about 80% of their total responses to the S+). Animals reaching criterion from either light-on and light-off positive stimulus groups were alternately assigned to the Criterion Group (Group C) and the Overlearning Group (Group OL). The two groups did not differ significantly in the trials required to reach criterion on the original problem ($U = 31.5$, p $.48$). This was taken to mean that the groups were essentially equal in rate of learning. When the learning criterion was met, Group C received no further training on the original problem and reversal training was begun on the following day. Group OL was given 50% as many additional training trials on the original problem as were needed to reach criterion. If an S in Group OL met the learning criterion in the middle or at the beginning of a daily session, that session was continued through 40 trials and these trials counted as part of the overtraining. After overtraining, the reinforcement contingencies were reversed as for Group C. The criterion for learning the reversal problem was the same as for the original problem.

RESULTS

The mean and median numbers of trials to acquisition of the original and reversal discrimination tasks for Groups C and OL are contained in Table 1. The Mann-Whitney U-Test was employed for all data analysis in arriving at probabilities of significance.

All Ss took longer to learn the reversal problem than the original task, but Group C was superior to Group OL, requiring fewer trials to reach criterion (U = 16, p = .052). A subsequent comparison of percentage of individual loss, calculated as are savings scores (original trials minus reversal trials/original trials) further substantiated the superior performance of Group C (U = 11, p = .014). The median percentages were 84.70% for Group C and 125.45% for Group OL.

Figure 1 represents the median number of responses given by each group to the S+ and S- during the last 40 trials of the original task, the last 40 trials of overlearning for Group OL, the reversal days in which all Ss could be included, and the final 40 trials of the reversal training.

No statistically significant difference was found between groups in response rate to either the S+ or to the S- in the last trials of original learning (U = 30, p = 439; U = 26, p = .28). In overlearning the rate of responding to S+ did not increase significantly from

TABLE 1

Number of Trials to Criterion on The Original and Reversal Problems for The Criterion and Overlearning Groups

Group	N	Original			Reversal		
		Median	Mean	SD	Median	Mean	SD
Criterion	8	192.00	198.62	48.00	329.50	369.37	113.85
Overlearning	8	189.00	200.70	40.50	452.50	478.12	153.60

Figure 1. Median Number of Responses made by Groups C and OL during the last 40 trials of Original Learning, by Group OL during the last 40 Overtraining trials, by both Groups on Days 1-6 of Reversal and the last 40 trials of Reversal Learning.

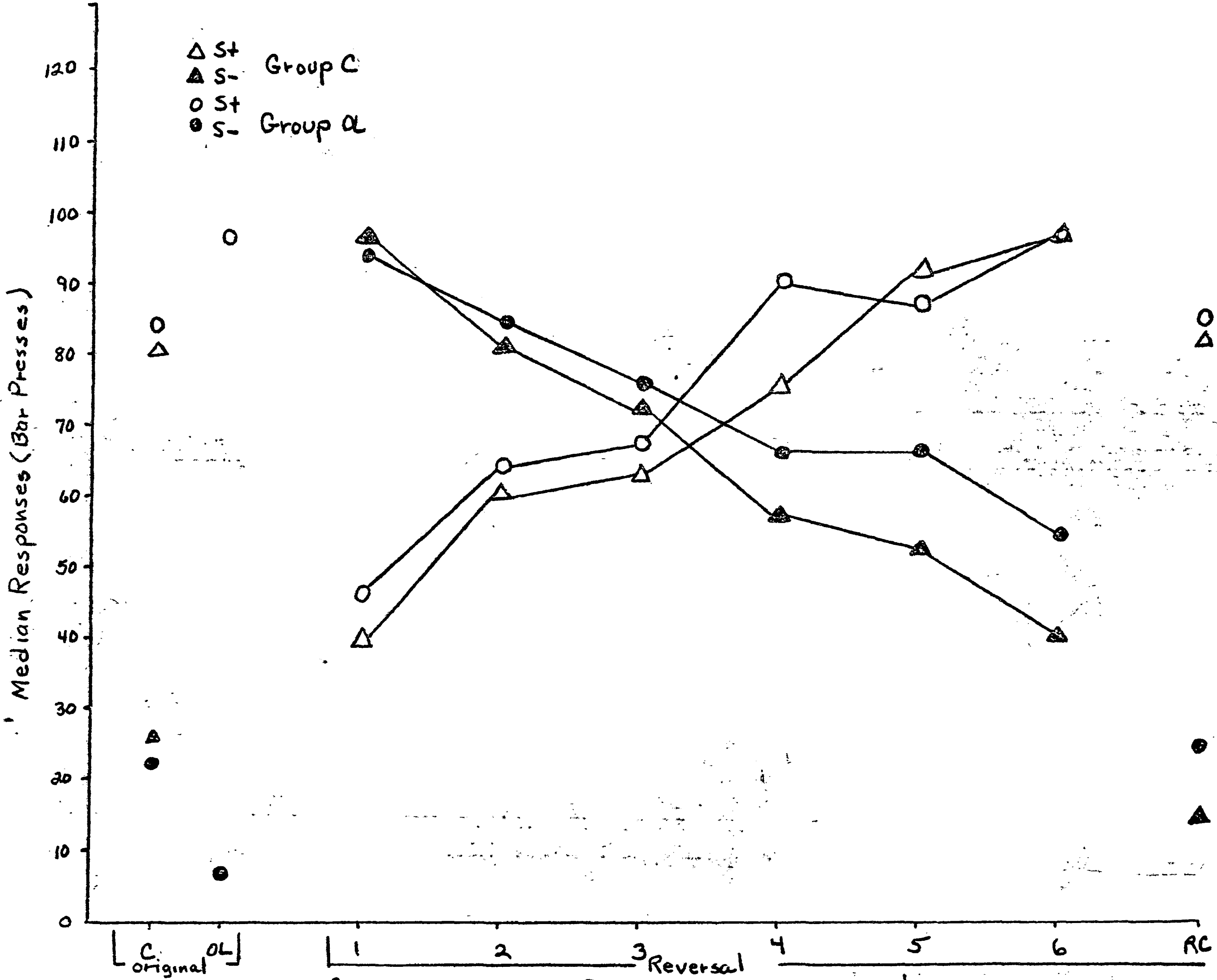

Fig. 1. Median number of responses made by Groups C and OL during the last 40 trials of original learning (C), Group OL during the last 40 overtraining trials (OL), and by both groups on days 1-6 of reversal and the last 40 trials of reversal learning (RC).

the original rate when criterion was reached ($U = 20$, $p = .117$), but the rate of responding to S- did decrease significantly ($U = 10$, $p = .01$). Comparisons of daily response rates and of total responses made during the first six reversal days revealed no significant differences between groups in number of responses to either S+ or S-. Hence, the source of difference in learning the reversal problem is not reflected in differences in response rates during the first six days of reversal learning.

Figure 2 shows the median numbers of trials in which no responses were made during a given stimulus presentation and constitutes a measure of avoidance. The two groups showed no difference in the number of avoidance responses made to the S+ or S- in the last trials of original learning. The number of avoidance responses made to the S-, in overlearning was found to increase significantly for group OL ($U = 2$, $p < .001$) while the number of avoidances of the S+ did not change significantly.

In reversal, the two groups did not differ in the number of avoidances of the negative stimulus on any single day or summed across days. The total number of avoidances of the positive stimulus was significantly different ($U = 14.5$, $p < .041 > .032$) with Group OL making more avoidances. Daily comparisons during reversal revealed significant differences on day two ($U = 14$, $p = .032$) and marginal significance on days 5 and 6 ($U = 16$, $p = .052$; $U = 16$, $p = .065$). Avoidances apparently occurred randomly throughout daily sessions. An analysis of quartiles of responding each day revealed no consistent individual or group patterns of avoidance (See Appendix D).

Figure 2. Median Number of Trials in which no Responses were made (Avoidance Responses) to S+ or S- by Group C and Group OL during the last 40 Trials of Original Learning, by Group OL during the last 40 Overtraining Trials, by both Groups on Days 1-6 of Reversal and the last 40 Trials of Reversal Learning.

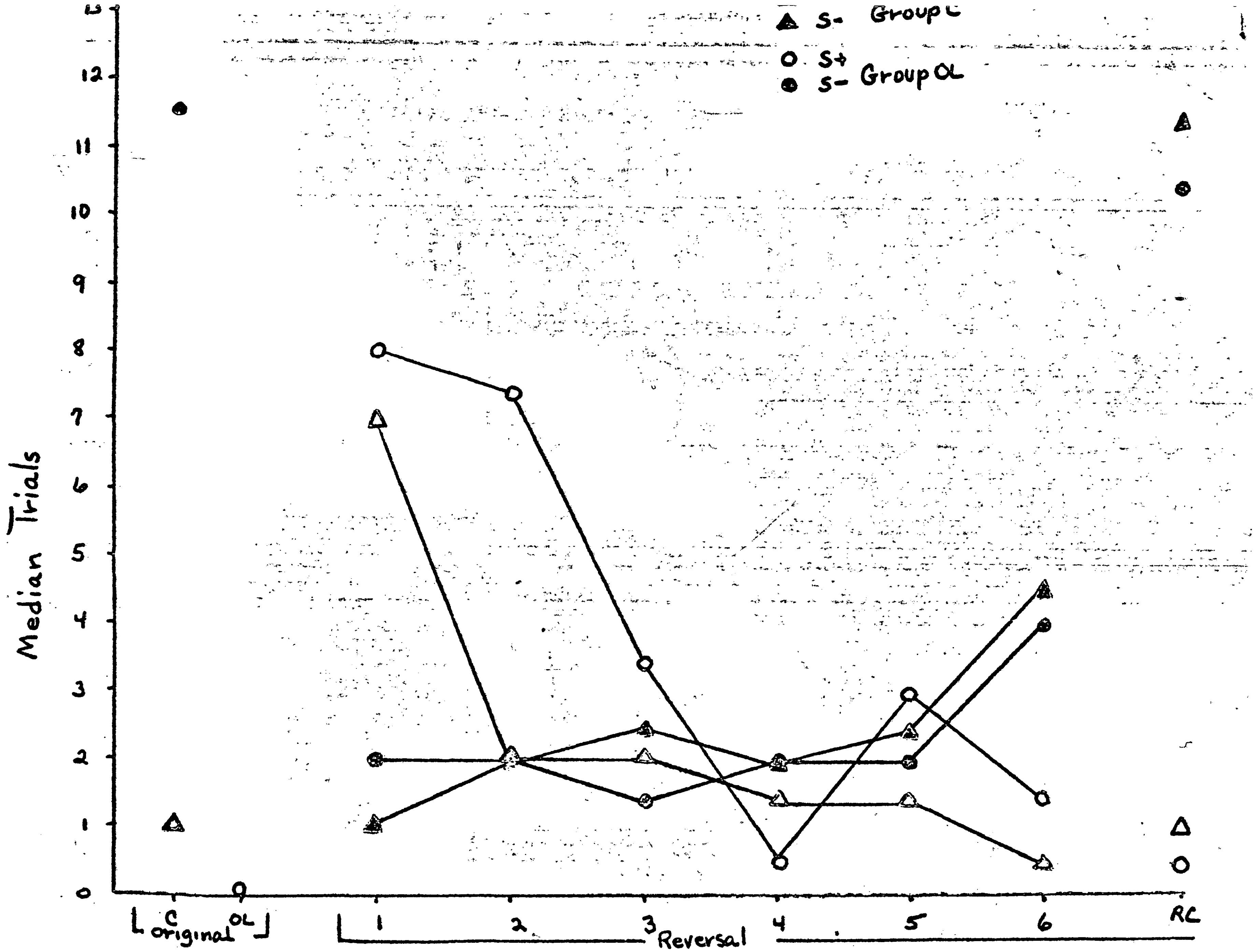

Fig.2. Median number of trials in which no responses were made (avoidance responses) to S+ or S- by Group C and Group OL during the last 40 trials of original learning (C), by Group OL during the last 40 overtraining trials (OL), and by both groups on days 1-6 of reversal and the last 40 trials of reversal learning (RC).

Although the number of avoidance responses made would be expected to be reflected in differences in rate of bar pressing, this clearly is not the case in the present study. Computation of the mean number of bar pressing responses made on trials in which any responses were made (*i.e.*, total bar pressing responses divided by the number of trials in which responses occurred) showed that Group OL averaged 4.6 bar pressing responses per trial while Croup C averaged 4.1 responses during the six reversal days. Means calculated on the basis of the number of trials in which bar pressing responses could have occurred showed that Group OL averaged 3.6 responses per trial and Group C averaged 3.5. This suggests that while daily rates appear to be equal, Group OL was in fact making more bar pressing responses on those trials in which such responses occurred but at the same time responding on fewer trials.

DISCUSSION

The results show that reversal learning is retarded by overtraining under conditions of successive stimulus presentation in the Skinner apparatus. The difference in the performance of the two groups appears to be the result of an increased tendency of the overtrained subjects to continue to avoid the previously negative stimulus after reinforcement contingencies are changed in reversal learning. This result is consistent with the explanation of ORE offered by D'Amato and Jagoda (1960) and supports their prediction that overlearning would impede rather than facilitate reversal learning in a successive discrimination situation since avoidance of the negative stimulus is maintained by the nature of the situation. Under conditions of successive stimulus presentation increased avoidance tendencies resulting from overtraining interfere with the acquisition of approach tendencies to the new positive stimulus since the avoidance response itself prevents the subjects from obtaining the reward which would reduce the avoidance response. Any agent which would serve to reduce such avoidance tendencies would facilitate the learning of a reversal problem. D'Amato and Jagoda (1960) have proposed that in simultaneous discriminations, training beyond criterion effectively terminates experience with the negative stimulus and thus facilitates reversal.

Behavior in the first six days of reversal training gives no support for the Birch-Amsel hypothesis that group differences in reversal learning can be accounted for in terms of differential rates of extinction to the former S+. However, it appears that extinction rates were a factor in the latter part of reversal learning. Since the rate of responding to S+ on the sixth day of reversal was in fact higher than that of the last or criterion day of original learning, it seems logical to conclude that subsequent differences between groups were in rate of response to the S-. This would mean that although continued avoidance of the previously negative stimulus is the critical factor in reversal learning, these avoidance responses do not of themselves interfer with the reaching of criterion. A _post hoc_ inspection of the reversal data revealed that only one animal in the overtrained group failed to reach criterion sooner because of insufficient responding to the S+. Smith and Hoy (1954) have shown that throughout discrimination learning in the Skinner apparatus the total number of responses made each day remains roughly the same, although the distribution of response to the appropriate stimuli may change over the course of learning. Possibly, in the present study, avoidance tendencies of subjects in Group OL had the effect of prolonging responding to the negative stimulus, thus interferring with their meeting the criterion. All this may be taken to mean that the D'Amato and Jagoda and the Birch-Amsel hypotheses are not necessarily incompatible, if they can be shown to affect different portions of discrimination learning.

If extinction is a factor in the present study, then the Birch-

Amsel explanation must be extended to include the assumption that the occurance of ORE, no difference, or reversed ORE will depend on the amount of training given the two groups and its effect on extinction. There is some evidence that resistance to extinction after discrimination training results in first a rise, then a decrease in resistance to extinction (e.g., D'Amato, Schiff and Jagoda, 1962). The training given the two groups in the present study probably fell within this initial rise in extinction rate. If so, then a further experimental test of the extinction hypothesis could be made by giving another group of subjects extended training, sufficient to carry them into the decreasing portion of the extinction curve. ORE would be predicted for this group on the basis of the extinction hypothesis. However, if such extended training merely serves to strengthen avoidance tendencies, then reverse ORE would still be expected to occur and the conclusion drawn that avoidance tendencies are more important in reversal learning than any differences in extinction rates which may exist.

The reverse ORE observed in the present study, does not support existing explanations based on transferred mediations or cognitive processes. Criterion trained animals would have performed less effectively in the reversal situation than overtrained animals if, as these explanations imply, "observing responses", "responses of discrimination", "analysers", and so on, were strengthened by increased training. This result does not rule out the possibility that such responses do occur in visual discrimination learning, but rather suggests that the transfer of mediating responses is not critical in reversal learning.

Consideration must be given to the fact that rate of response did not differentiate between the two groups and did not provide an adequate measure of approach-avoidance tendencies. While subjects in Group OL approached the bar during fewer S+ periods in reversal training, when an approach was made, responses followed at a higher rate. It might be argued that the drive level of Group OL was heightened during the course of a daily session due to long periods of nonreward in which these animals were avoiding the positive stimulus, particularly during the initial part of each session. Avoidances did not, however, occur more frequently at the beginning of daily sessions but were dispersed throughout each session, so that both groups were receiving relatively equal amounts of reward at any given time.

Perhaps a more plausible explanation lies in the frustration hypotheses of Brown and Farber (1951) and of Amsel (1958, 1962). Amsel states that "cues paired with frustrative nonreward acquire motivational properties". Behavior associated with frustration is enhanced. If then, in the present study, approaching the bar during the presentation of the previously nonrewarded stimulus is indeed frustrating, and more so for Group OL, then the observed increased response rate by that group is the manifestation of frustration.

It seems clear that at least two different responses are involved in discrimination learning in the Skinner apparatus, i.e., approaching the bar and pressing the bar. It may be hypothesised that the approach response is most strongly affected or strengthed by the first food rewards, while subsequent rewards in any given stimulus period undergo a decrease in reinforcement value for the approach response.

All rewards presumably reinforce the final response of bar pressing, which no doubt has reached asymptotic level for both groups before reversal. The actual number of reinforcements received in a positive period appear to have little effect on the approach response; therefore approach tendencies are initially weaker for Group OL and continue to be so in spite of the fact that groups are receiving essentially the same number of rewards during comparable periods.

The question arises as to the generality of such a dichotomy of responses in operant discrimination learning. If it can be supposed that the approach-avoid response in the Skinner box is equivalent to leaving the start box in a runway experiment and that pressing the bar is similar to traversing the runway, then the prediction may be ventured that reverse ORE would occur if relative starting latencies were employed as a criterion, while running speeds, as Birch _et al._, have demonstrated, would be faster for overtrained animals, resulting in an overlearning reversal effect. Empirical verification of such a proposal is lacking in the existing literature.

SUMMARY

The experiment investigated the overlearning reversal discrimination problem in rats under successive-stimulus conditions in the Skinner apparatus. Sixteen male hooded rats under 23-hour food deprivation were used as Subjects. The positive stimulus for half the Ss was light-on and light-off for the other half. Stimuli were presented in a Gellerman random series for 20-second periods. Forty such periods constituted one day's training. 100% reinforcement was available during S+ periods. The learning criterion was five consecutive S- periods in which no responses were made, provided there was an average of four responses to the S+ in the corresponding five S+ periods. The Criterion Group (N = 8) was given reversal training on the day after learning was complete. The Overlearning Group (N = 8) was given 50% as many additional training trials on the original problem as were needed to reach criterion before reversal training began.

The groups showed no difference in trials to learn on the original problem but differed significantly in trials to learn on the reversal problem. The Criterion Group was superior to the Overlearning Group.

The difference between the groups during the first six days of reversal learning appeared to lie in an increased tendency of overtrained Subjects to avoid the previously negative stimulus. Differ-

ences in the latter part of reversal learning may have been the result of differential extinction rates which were related to avoidance responses. Equivalent response rates in spite of differential avoidance rates were discussed in terms of the frustration hypotheses of Brown and Farber (1951) and Amsel (1958, 1962) with the suggestion that frustration associated with the previously negative- now positive stimulus in reversal was greater for overtrained subjects and resulted in increased response rate during trials in which they responded.

A distinction was drawn between responses of approaching or avoiding the bar and responses of pressing the bar. There are some implications of such a dichotomy for measures of starting latency and running speed in runway experiments which have not yet been experimentally tested.

In general, the data seems to support the D'Amato and Jagoda hypothesis that overtraining would increase the subject's tendency to avoid the negative stimulus in the initial problem and thus impede learning when reinforcement contingencies were reversed.

APPENDIX A

TRIALS TO CRITERION FOR EACH SUBJECT ON THE ORIGINAL AND REVERSAL PROBLEMS

Trials to Criterion for each Subject on the Original
and Reversal Problems

Group OL

Subject #	Original	Reversal	Percent loss
2	190	640	236.8
5	300	672	124.0
8	152	345	126.9
6	185	440	137.8
10	185	322	74.5
14	209	465	120.3
15	188	545	189.8
17	195	396	103.0

Group C

Subject #			
1	195	240	23.0
3	270	509	88.5
4	152	300	97.3
7	149	317	112.7
9	189	342	80.9
11	276	475	72.1
12	216	540	150.0
16	142	232	63.3

APPENDIX B

RESPONSE RATE RAW DATA TABLES

Response Rate of Each Subject to the stimulus which was positive in reversal

Group OL

Ss	Last 40 trials of original learning	Last 40 over-training trials	Reversal Day 1	Reversal Day 2	Reversal Day 3	Reversal Day 4	Reversal Day 5	Reversal Day 6	Reversal Criterion Day
2	13	5	23	54	53	63	75	77	56
5	21	5	67	50	62	71	72	78	75
6	24	8	2	3	37	68	73	71	88
8	34	1	56	82	96	101	103	100	116
10	23	22	50	52	73	89	57	80	89
14	20	21	53	75	80	94	79	95	79
15	10	11	17	93	101	121	216	119	124
17	29	4	45	74	65	98	88	93	97

Group C

Ss									
11	7	-	24	54	58	63	82	86	86
3	33	-	17	62	60	78	83	79	82
4	8	-	38	61	93	76	102	93	116
7	43	-	65	85	92	94	96	120	97
9	30	-	54	58	61	88	84	90	79
11	15	-	43	64	68	87	81	78	80
12	34	-	29	51	53	53	56	65	62
16	25	-	61	87	88	39	97	90	106

Response Rate of each Subject to the stimulus which was negative in reversal

Ss	Last 40 trials of original learning	Last 40 over-training trials	Reversal Day 1	Reversal Day 2	Reversal Day 3	Reversal Day 4	Reversal Day 5	Reversal Day 6	Reversal Criterion Day
Group OL									
2	80	87	84	77	50	50	56	42	18
5	85	87	96	95	70	52	48	33	17
6	63	77	47	38	84	66	73	37	23
8	86	107	95	70	51	48	46	52	26
10	90	123	134	112	122	94	87	67	36
14	69	82	107	50	63	66	77	56	48
15	100	118	91	105	83	71	64	64	24
17	112	107	191	110	165	123	98	87	38
Group C									
1	89	—	109	127	117	55	62	34	34
3	81	—	64	92	88	71	78	60	37
4	99	—	105	51	29	30	32	25	11
7	73	—	92	69	45	32	41	28	17
9	80	—	104	102	87	62	61	47	8
11	127	—	72	72	59	65	47	51	18
12	82	—	101	140	111	136	84	67	6
16	61	—	90	67	38	38	32	15	15

APPENDIX C

RAW DATA TABLES OF AVOIDANCE RESPONSES

Number of Avoidances made by each Subject to the positive stimulus in Reversal

Group OL

Ss	Last 40 trials of original learning	Last 40 trials of over-learning	Reversal Day 1	Reversal Day 2	Reversal Day 3	Reversal Day 4	Reversal Day 5	Reversal Day 6	Last 40 trials of reversal learning
2	11	17	11	5	5	5	3	0	1
5	15	16	3	6	6	4	3	4	1
6	12	16	18	19	9	2	4	2	0
8	6	19	5	2	2	0	0	1	1
10	14	16	8	8	5	0	5	4	1
14	13	13	7	2	0	0	3	1	2
15	10	16	16	3	2	0	1	0	0
17	9	18	8	9	3	1	3	3	3

Group C

Ss									
1	17	-	7	2	3	5	2	0	0
3	7	-	15	2	2	0	0	1	0
4	16	-	8	4	2	3	2	1	0
7	7	-	4	2	1	0	0	0	1
9	13	-	7	2	2	1	1	2	2
11	14	-	7	6	4	0	1	0	0
12	14	-	11	3	3	2	3	0	3
16	12	-	4	0	2	4	3	1	2

Number of Avoidances made by each Subject to the Negative Stimulus in Reversal

Group OL

Ss	Last 40 trials of original learning	Last 40 trials of over-learning	Reversal Day 1	Reversal Day 2	Reversal Day 3	Reversal Day 4	Reversal Day 5	Reversal Day 6	Last 40 trials of Reversal learning
2	1	0	0	1	4	2	4	4	12
5	1	1	2	2	1	2	2	3	11
6	1	0	10	8	3	1	2	4	14
8	0	0	2	2	4	2	0	1	10
10	1	1	3	2	2	3	1	5	10
14	2	1	0	3	1	2	1	4	9
15	0	0	3	1	1	0	1	0	7
17	0	0	1	0	1	4	5	7	9

Group C

Ss	Last 40 trials of original learning	Last 40 trials of over-learning	Reversal Day 1	Reversal Day 2	Reversal Day 3	Reversal Day 4	Reversal Day 5	Reversal Day 6	Last 40 trials of Reversal learning
1	2	-	0	1	1	1	5	9	9
3	0	-	8	0	2	0	2	2	7
4	0	-	1	2	4	4	2	6	13
7	1	-	0	1	0	4	4	8	9
9	1	-	1	3	3	2	1	4	14
11	1	-	1	2	0	0	0	1	10
12	3	0	5	2	3	2	3	4	17
16	0	-	1	4	7	4	8	9	12

APPENDIX D

Explanatory note: The following table contains a breakdown of subject's daily avoidance responses to the reversal positive stimulus into quartiles. Each quartile represents five trials and contains the number of positive periods in which no responses occurred.

Analysis of quartiles of avoidances of the positive stimulus in the first six days of reversal learning

Group OL	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6
Ss 2	1 5 5 0	0 1 3 1	0 2 2 1	1 1 1 2	1 1 1 0	0 0 0 0
5	0 1 1 1	0 0 2 5	1 1 1 3	0 0 2 2	0 2 0 1	1 1 0 2
6	3 5 5 5	4 5 5 5	1 2 5 1	0 1 1 0	2 0 2 0	0 0 0 2
8	0 0 1 4	0 0 2 0	0 0 1 1	0 0 0 0	0 0 0 0	0 0 1 0
10	0 2 5 1	2 1 5 0	0 1 2 2	0 0 0 0	1 1 1 2	0 0 3 1
14	1 1 4 1	1 0 0 1	0 0 0 0	0 0 0 0	0 1 2 0	0 0 0 1
15	1 5 5 5	2 1 0 0	1 0 1 0	0 0 0 0	1 0 0 0	0 0 0 0
17	4 2 0 2	2 1 3 3	1 0 2 0	0 1 0 0	1 0 1 1	0 1 0 2
Totals	10 21 26 19	11 9 20 15	4 6 14 8	1 3 4 4	6 5 7 4	1 2 3 8
Group O						
1	1 3 1 2	1 0 0 1	1 1 0 1	0 1 3 1	0 0 1 1	0 0 0 0
3	0 5 5 5	0 0 1 1	0 0 1 1	0 0 0 0	0 0 0 0	0 0 1 0
4	1 1 4 2	0 2 1 1	0 1 1 0	0 2 1 0	0 0 2 0	0 0 0 1
7	0 0 1 3	0 0 1 1	0 0 1 0	0 0 0 0	0 0 0 0	0 0 0 0
9	1 1 2 3	0 0 1 1	0 0 2 0	0 0 1 0	0 0 1 0	0 1 1 0
11	0 4 2 1	1 2 1 2	0 3 0 1	0 0 0 0	0 0 0 1	0 0 0 0
12	1 4 1 5	0 1 1 1	0 1 1 1	0 0 2 0	0 1 2 0	0 0 0 0
16	0 0 1 3	0 0 0 0	0 1 0 1	2 0 1 1	0 1 1 1	0 0 1 0
Totals	4 18 17 24	2 5 6 8	1 7 6 5	2 3 6 2	0 2 7 3	0 1 3 1

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