OVERLEARNING REVERSAL IN RATS IN SPATIAL DISCRIMINATIONS

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ABSTRACT

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IN SPATIAL DISCRIMINATIONS

By Daniel Francis Tortora

The overlearning reversal effect is defined as the difference between two groups on the acquisition of a reversal task. One group is given overtraining after original acquisition and then is reversed, the other group is reversed immediately after original acquisition. When overtraining facilitates reversal, ORE is positive, when overtraining retards reversal, ORE is negative. Two opposing views on the nature of discrimination learning have been examined. One model, that of Mackintosh, hypothesizes that discrimination learning proceeds in two stages. First, the animal learns to pay attention to the relevant dimension(s) and ignore irrelevant dimensions. Second, the animal learns to respond appropriately to the correct cue. It is postulated that switching to relevant dimensions and switching away from irrelevant dimensions takes a consideribly long period of time. Thus, the reversal of any task (using large reward) that includes many irrelevant stimuli will be facilitated by the extra practice afforded by overtraining. The other model, the elicitation position of Denny, and the one guiding this thesis postulates a single-stage analysis of discrimination learning, in which the laws

of classical conditioning are exploited. CS-US contiguity is the necessary condition for learning. The elicitation position states that for a complete understanding of ORE one must perform a detailed analysis of the CS-US relations arranged by the experimenter. Such an analysis is presented in the body of the thesis. This study explored ORE in spatial discriminations in which the CS-US relations were controlled; five experiments were performed.

The first three experiments explored the effect of overtraining upon the subsequent reversal of a kinesthetically controlled turning response where size of incentive and length of the stem of a T-maze were manipulated. It was found that where the stem of the maze was long, as in experiments I and III, a significant negative or reverse ORE was obtained. However, when the stem was short, as in experiment II, no ORE was obtained. It was suggested that size reward was inversly related to the magnitude of the negative ORE. Experiment I, using a small reward, yielded a greater negative ORE then experiment III using a large reward.

Experiments IV and V investigated the effect of overtraining on the reversal of a place response in which all controlling stimuli were relevant and redundant; two different reward sizes and a low acquisition criterion were used. A significant negative ORE was found for the small reward groups in experiments IV and V. A significant positive ORE was found for the large reward group of experiment V.

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By

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INTRODUCTION

The Overlearning Reversal Effect (ORE) can be defined as the facilitation of reversal learning as a result of overtraining. This phenomenon is usually investigated using a two group experiment. Both groups are trained to a criterion on a discrimination task, eg. 18 correct out of 20 consecutive responses. The experimental group is then given from 100-300 percent overtraining on the original task and then reversed. The control group is reversed immediately after it has reached criterion on the original acquisition. During reversal, the cue values are reversed, i.e., the stimulus that previously led to reinforcement now leads to non-reinforcement, and the former negative stimulus is now positive.

In 1953, Reid performed the first overlearning reversal study. He found, contrary to theoretical preconceptions, that overlearning facilitated reversal. In the next 16 years over 50 studies had been performed and several theoretical analyses (Lovejoy, 1966, 1968; Mackintosh, 1965a, 1969; Paul, 1965; and Sperling, 1965a & b) have been postulated to explain this phenomenon.

Table 1 presents the results of such experiments. An undeniable conclusion can be gleaned from a perusal of these studies. Up to the present there is not one hypothesis or theory which can explain the divergent results.

TABLE 1.--Results of Reversal Experiments with Rats.

Overtraining facilitates Reversal	Overtraining has NO Effect on Reversal	Overtraining Retards Reversal
Brookshire, Warren, & Ball (1961)	Clayton (1963a,b)	Hill & Spear (1963b)
Bruner, Mandler, O'Dowd & Wallach (1958)	D'Amato & Jagoda (1962)	Hill, Spear, & Clayton (1962)
Capaldi (1963)	D'Amato & Shiff (1965)	Clayton (1963)
Capaldi & Stevenson (1957)	Erlebacher (1963)	Krechcevsky & Honzik (1932)
Hooper (1967)	Galanter & Bush (1959)	Mackintosh (1965c)
Ison & Birch (1961)	Hill et al (1962)	
Komaki (1961)	Komaki (1962)	
Mackintosh (1962, 1963b, 1965b, 1969)	Mackintosh (1965c)	
North & Clayton (1959)	Paul & Kesner (1963)	
Pubols (1956)	Theios & Blosser (1965)	
Reid (1953)		
Theios & Blosser (1965)		
Sperling (1968)		

From Table 1, it can be seen that this proceedure has yielded three kinds of experimental results. They are as follows: (a) the experimental group learns to reverse faster than the control group-ORE or positive ORE, (b) there is no significant difference between the two groups-no ORE, and (c) the control group reverses faster than the experimental group-reverse or negative ORE. Thus any satisfactory explanation of ORE must also explain its variants.

ORE is studied either in a visual discrimination task (brightness or pattern discrimination) in which values of the positive and negative cues are reversed or in a spatial discrimination task (T-maze or y-maze) in which the direction of turn is reversed. When a large incentive has been used in the experiment, ORE occurs equally often in visual and spatial discriminations.

Another important aspect of ORE is that it is a robust' phenomenon. When differences do occur they are usually very substantial, necessitating only a few animals to obtain significant results. What is in question here is not internal but external validity. When, where and how it occurs are the pressing issues. This can only be accomplished by a thorough analysis of the procedural differences among diverse experiments in order to identify the functional variables.

THEORETICAL ANALYSIS OF ORE

Of the theories that have been proposed to answer the above questions, two theories of learning, the two stage discrimination model of Mackintosh (1969) and the elicitation position of Denny (1967, 1970) will be reviewed here.

Mackintosh's Theory of ORE

Mackintosh postulates a two-stage attentional model to explain ORE (Lovejoy, 1966). The first stage is the learning of the appropriate stimulus analyzer. Here S learns which stimulus dimension to attend to and which dimensions are irrelevant. It is postulated that learning not to attend to irrelevant dimensions is a relatively slow process taking much longer than learning to attend to the correct dimension and make the correct response. The second stage is the learning of the cue value of the relevant stimulus dimension. Once this is accomplished discrimination is said to be complete.

For Mackintosh, the occurrence of ORE depends on the joint satisfaction of two conditions-a difficult discrimination and a large incentive. He assumes that ORE occurs only when the probability of attending to the relevant dimension is not very high at the outset of training. Another way of saying this is that the ORE will only occur when rats are trained in a relatively difficult discrimination.

In such a situation, overtraining increases the probability of attending to the relevant dimension and decreases the probability of attending to the irrelevant dimension(s). Thus overlearning facilitates reversal learning. The animal has only to learn the new cue values since he is already attending to the correct dimension and ignoring the irrelevant ones. The immediate reversal group has not learned to ignore irrelevant dimensions. Thus, during reversal, it shifts from dimension to dimension until the correct one is rediscovered. Only then can it proceed to learn the reversal discrimination. When the discrimination is easy the relevant dimension is strong from the outset (i.e. strong in relation to the irrelevant dimensions), and no benefit is supposed to accrue from overtraining.

Mackintosh introduces size of incentive into his theory by assigning parameter values to "reward" operators in the Bush and Mosteller stochastic model of learning. The actual psychological significance of magnitude of reward is not postulated.

<u>Elicitation Theory</u>

This theory is monistic in its approach to learning. All learning is viewed in a contiguity framework in which classical conditioning principles are exploited. The theory states that learning depends upon consistently eliciting the to-be-learned response in close temporal contiguity with a particular stimulus situation. This in turn means minimizing the elicitation of alternative responses to the same or similar stimulus situations. In this way, the response that is being learned wins out over other possible responses. The function of incentives or reinforcers is that they are important elicitors in the learning situation. These stimuli elicit a characteristic response over and over again and thereby minimize the occurrence of competing responses.

Elicitation theory states that the UR of approaching the goal object (food, water or whatever) is always present in an instrumental learning situation and that this UR mediates the learning of the entire instrumental chain. Eventually the animal learns to approach the goal object via this chain.

According to the theory the absence of the incentive in the previously reinforced goal area is itself a US which elicits antagonistic responses that take the animal directly away from the goal area. The frustration-instigated antagonistic responses consist of aggressive or tangential responses, i.e., very possibly displacement activity when S cannot actually escape from the frustrating situation. Denny postulates that during discrimination learning both the response class of approaching the goal object in the context of the positive cue and withdrawal from non-reinforcement in the context of the negative cue are learned.

Elicitation Theory Applied to ORE

According to elicitation theory, (Denny, 1970) reversal learning is accomplished by the extinction of the original response. Extinction is considered to be the result of counterconditioning. It is postulated that without the competition from an alternative response the original response will never be replaced. Secondary elicitation is the mechanism used to handle this phenomenon. By this is meant that extinction is due to the elicitation of withdrawal by the ommission of the food from the food tray. The elicitation here is called secondary elicitation since the animal must have experienced food at the food cup, in the presence of the prevailing stimuli, in order for the absence of food to be an elicitor. Thus the removal of food serves as a unconditioned stimulus, consistently eliciting a characteristic class of antagonistic responses (Rc). Rc's are conditioned to contiguous stimuli and through backchaining becomes conditioned to earlier stimuli in the chain. Eventually Rc competes effectively with all stages of the original instrumental response (Ro). In reversal learning, this means that the Rc must occur at the choice point area before it affects the choice response. This occurs via backchaining which is initiated at the empty food cup in the context of whatever stimuli are presented at the time of non-reinforcement.

In order to explicate the elicitation position of ORE further, an analysis of current research will be undertaken. Table 2 presents a summary of research methods used and results obtained in this area. It must be pointed out here that the organization of the table is based upon the conviction that a complete understanding of ORE can only be accomplished by a detailed analysis of the procedures used by the various experimenters. Elicitation theory helped in abstracting the critical stimulus-response relationships.

TABLE 2.--Analysis of Overlearning Reversal Effect (ORE) in Rats.

Type of learning situation (large incentive except where noted)	Finding	Investigators
Visual Discrimination		
A. Black vs. white - only cues are a black or white door in an alley a foot or so in front of the goal region, in Y-maze or Grice box. End boxes following + and - cues are identical	Positive ORE (Against Mackintosh)	Reid, 1953 Pubols, 1956 Hooper, 1967- more ORE with correction procedure Mandler, 1968
B. Black vs. white or lighted vs. unlighted alleys. The cues fill the whole alley and are continuous with the goal region, or a Lashley jumping stand is used	No ORE (For Mackintosh)	Mackintosh, 1969 Lukaszewaka, 1968 Erlebacher, 1963 D'Amato & Shiff, 1965
	Slightly positive ORE when both food dishes were unpainted, Or when the aversive, brightly lit alley was positive, or when trained against preference	Mackintosh, 1969 Brookshire, Warren & Ball, 1961 Birnbaum, 1967
C. As in (B) above the discrimination is more difficult: light grey vs. dark grey or black & white stripes vs. checkerboard	Positive ORE (For Mackintosh)	Mackintosh, 1969 Sperling, 1968

TABLE 2.--(con't) An Analysis of Overlearning Reversal Effect (ORE) in Rats

Type of learning situation (large incentive except where noted)	Finding	Investigators
Spatial Discrimination		
A. Typical T-maze learning - many cues relevant & redundant, including intra-maze & extra-maze visual cues	Positive ORE (Against Mackintosh)	Capaldi, 1963 Ison & Birch, 1961
	All used low acq. criterion	Theios & Blosser, 1965 good ORE with correction procedure Kendler & Kimm, 1967 (ORE not significant but size of food was visually large rather than large amount eaten)
	No ORE (For mackintosh) Used high acquisition criterion	Clayton, 1963a
B. Intra-maze cues, extra-maze cues, or both are made irrelevant, with direction of turn being the main, but not only, relevant cue	Positive ORE (For Mackintosh)	Pubols, 1956 Brookshire, Warren & Ball, 1961
	Reverse or Negative ORE (Indeterminate)	Clayton, 1963b (2) - only 2 45mg. pellets used

I. Visual Discriminations

The first half of table 2 (pp. 8) presents the three procedural variants used with visual discriminations. These are as follows:

A. Trace conditioning paradigm in which the discriminanda are not contiguous with the goal area;

B. Simultaneous conditioning paradigm in which the discriminanda are maximally discriminable at the outset of training;

C. Simultaneous conditioning paradigm with stimuli that are minimally discriminable (most generalization) at the outset of training.

For explanatory purposes condition B will be handled first. In this procedure the relevant stimuli fill the whole alley and the goal area. Thus during reversal learning the competing response (Rc) can be directly conditioned to the cue that was originally positive (rewarded during initial acquisition). The Rc then generalizes to the same cue at the choice point, and reversal learning is accomplished. In regard to overlearning reversal experiments, the important factor is the extent to which Rc generalizes to the new positive stimuli. If generalization is minimal, that is, if the stimuli are maximally discriminable at the outset, then overtraining is of no benefit and no ORE will occur. This is the general result obtained. Since black and white stimuli are distinctive for rats the Rc to the new negative cue during reversal is no more discrete after overtraining than at the end of acquisition.

In condition C the same paradigm is used except that minimally discriminable stimuli are employed (e.g. dark vs. light grey; or checks vs. stripes). Thus when the acquisition criterion is attained the discrimination may not have been perfected. Overtraining serves to perfect the discrimination, narrowing the positive stimulus generalization gradient. Thus Rc in the overtrained group does not generalize to the new positive cue as much as in the control group. Reversal learning for the overtrained subjects is thereby facilitated resulting in an ORE.

In condition A, a black-white discrimination is used with a trace conditioning paradigm. In this case the cues are attached only to one-way valve doors that are located a foot or so from identical neutral grey goal boxes. During reversal learning, the Rc is elicited in direct contiguity with irrelevant stimulation. The one relevant cue is the trace of the previously positive cue from the doors. Since traces of stimuli undergo more generalization than prevailing stimuli, the situation is analagous to simultaneous conditioning with difficult discriminandum (c). Overtraining produces a finer discrimination between the traces, permitting the conditioning of Rc to the new negative cue. Thus ORE occurs.

II. <u>Spatial Discriminations</u>

In this group of experiments the procedural variations far exceed those used in visual discriminations with the results directly related to these variants. The second half of Table 2 (pp. 9) presents a summary of these procedures. It can be seen that the procedures fall into two categories:

A. procedures with all cues relevant and redundant

B. procedures with some cues irrelevant

In the procedures where irrelevant cues were present or introduced (Table 2, IIB), both a positive and negative ORE have been obtained. It must be pointed out here that for Mackintosh's theory of ORE, the presence of irrelevant stimuli is a sufficient condition for the manifestation of an ORE. He postulates that overtraining serves the function of "switching in" the relevant stimulus dimension and "switching out" the irrelevant ones. For Mackintosh however no further analysis can or should be made.

In order to use elicitation theory one must submit to scrutiny all the procedural details of these studies. Pubols (1956) and Brookshire, Warren and Ball (1961) both obtained a positive ORE. Pubols used the same apparatus to study spatial discriminations as he did to study visual discriminations. In his visual discrimination study, (Pubols, 1956), the discriminanda were black and white one way doors set half way down the grey arms of the y-maze. It was explained earlier that using this paradigm the rat can associate only the stimulus traces of the discriminandum to the reward contingencies. In his spatial discrimination study (Pubols, 1956), these doors were the only irrelevant stimuli. Thus the likelihood of the rat incorrectly using irrelevant trace cues instead of relevant and salient extra-maze cues which are present both at the choice point and goal area, is small. This makes Pubols' experiment most similar to spatial discrimination studies classified under (A) in which ORE occurs.

The Brookshire, Warren and Ball (1961) experiment is more complicated. They used a cross-maze in which the animal began equally often in each grey stem. The irrelevant stimuli consisted of one arm being white and the other black. The direction of the turn was supposed to be the main relevant cue. However, using this arrangement, the rat could have learned a conditional discrimination during the 120 overtraining trials. That is, it learned to approach black when leaving start box #1 and to approach white after start box #2. Thus, an overtrained S during reversal could be using a compound stimulus including the trace of the start box cues plus the black or white of the arm. This situation is most similar to visual discrimination classified under (A) where a positive ORE is expected, since the stimuli from the start box were only perservative traces when reinforcement occurred. It must be pointed out that this analysis is only speculative and is not supported by direct evidence. However, it does suggest that a recategorization is reasonable.

The only study classified under (B) of spatial discrimination which obtained a negative ORE was Clayton (1963b). In this study Clayton used horizontal vs. vertical striped panels placed on the floor of the choice point and on the one-way doors preceding the goal box as irrelevant stimuli. These were randomly changed from trial to trial. The direction of the turn was defined as the relevant cue. There was no attempt to scramble extra-maze stimuli nor to control for unspecified intra-maze cues (i.e. differential olfactory, floor texture cues etc.). Thus an exact analysis of the stimulus conditions in this study is very difficult to make.

STATEMENT OF PROBLEM FOR EXPERIMENTS I, II, III

Due to the absence of a conclusive study using irrelevant stimuli in a spatial discrimination three studies were undertaken. In the studies just reviewed stimuli were introduced and then an attempt was made to make them irrelevant. In the present experiments the extra-maze and intra-maze stimuli were already present in a spatial discrimination, and all of these stimuli were made completely irrelevant except directlion of turn, right vs. left. In this way, one can specify what stimuli the animal has to be using. This should greatly facilitate the analysis of the results when using the elicitation position. In experiments I, II, and III, both the size of the incentive and the length of the stem were manipulated in an attempt to ascertain the effect of overtraining on the subsequent reversal of a pure spatial task.

EXPERIMENT I

INTRODUCTION

This study used a small incentive and a relatively long stem.

METHOD

Subjects

Ten male albino rats from Spartan Research Animals, approximately 200 days old at the beginning of the experiment, were used as *S*'s. They had been used previously in a shock study being run for one day at an age of 90-100 days.

Apparatus

The apparatus as shown in figure 1 was a T-maze with movable stem and start box, constructed of plywood floor and 1.9cm. pine sides, and was covered with hinged hardware cloth. It consisted of the following parts: starting box, runway, two arms and a choice point. The start box was 34.4cm. long. The runway was 18.8cm. long and the arms 35.6cm. long. All parts were 7.6cm. wide and 7.6cm. high. The choice point was 7.6cm. square and 30.0cm. high.

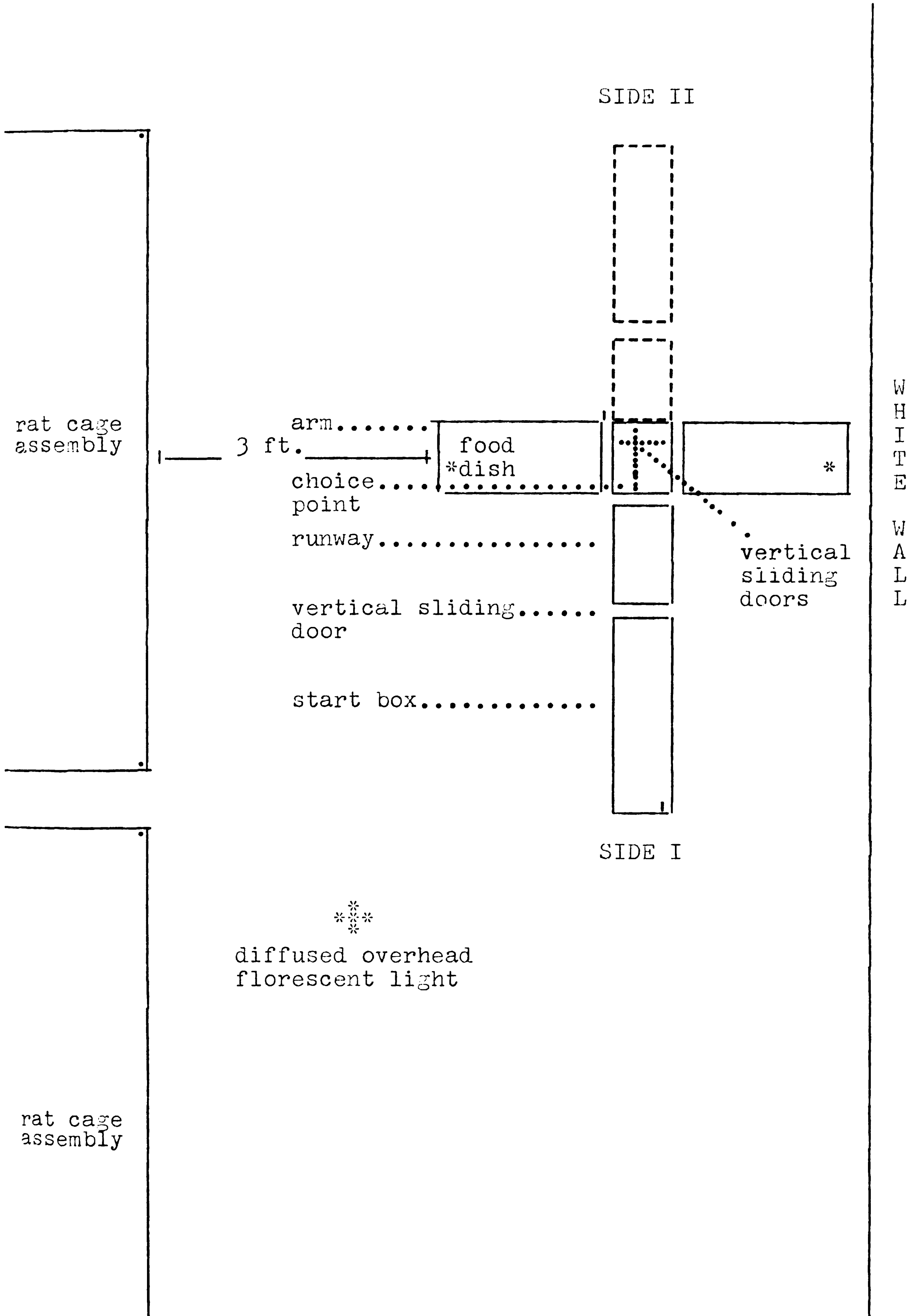

Fig. 1 A diagramatic representation of the running room and T-maze used in the experiments.

Five vertical sliding doors, manually operated, were employed in the maze. One separated the start box from the runway and four were on the four sides of the choice point. The doors on the choice point were necessary since a non-correction procedure was used and the procedure called for alternating the start box and runway to opposing sides.

The entire maze was painted flat black and the top 22.9cm. of the choice point was covered with flat black cardboard. Thus, the only illumination in the choice point came from the open sliding doors facing the arms. These doors were open to 5.9cm. from the maze floor.

The extra-maze stimuli in the running room consisted of a white wall to the right of the maze perpendicular to and butting the right arm and a rat cage assembly perpendicular to and .9144 meters from the left arm. The overhead illumination was diffused forescent light to the left of and behind the choice point. Figure 1 diagrams the floor plan and apparatus.

Procedure

Preliminary training

The S's were handled for 10 days prior to any experience with the maze. The first 10 days of handling were in the following order. The rats were placed on 24 hour food deprivation (1 day) prior to the first day of handling. The first five days of handling consisted of holding rats, transferring them from hand to hand and placing them back in their individual living cages with three large food pellets (190mg.) on the floor of the cage. The next five days consisted of continued removing and replacing the rats in individual feeding cages baited with two 190mg. Noyes pellets. This was continued until the rat reached the double criterion of being placid when held (i.e. no struggle against E's hand) and eating the pellets within two seconds after replacement in the feeding cage. The next four days the rats were allowed free access to the entire T-maze for five minutes per day. Both arms of the maze were baited with adlibitum food (45mg. Noyes pellets). By the fourth day all rats were eating the pellets in both arms for an equal amount of time. On the fifteenth day discrimination training was started.

Discrimination training

The reward size was two 45mg. Noyes pellets placed in the food cup at the end of the arm. All rats were trained to discriminate the kinesthetic stimuli of turning, half trained to make a right turn and half a left turn. This was accomplished by alternating the start box 180 degrees to opposing sides in a quasi-random schedule. The response designation dictated the placement of the reward. Thus a rat trained to make a right turn would have to enter the right arm and approach a white wall when started on side I, (see figure 1). However, he would have to go to the left arm and approach the rat cage assembly when started on side II. The arms were kept in a constant position throughout the experiment. By this method the only relevant cues associated with reward were the proprioceptive stimuli generated by turning.

All rats were given twelve trials per day, with an inter-trial interval of fifteen seconds. The criterion for acquisition was 83 percent correct or more in one day (10 correct responses in 12 trials). Upon completion of the discrimination task, the animals were assigned to groups so that the mean trials to criterion of the groups were as equal as possible. That is, if S's score was higher than the cumulative means of the two groups then it was placed in the group with the lower mean. Conversely, if an S's score was lower than the cumulative means then it was placed in the group with the higher mean. When S reached criterion it was assigned to a group and the appropriate stage of training (i.e. overtraining or reversal) was begun the following day. The experimental group received 96 trials more training on the original discrimination and then given reversal training.

The fixed number of trials of overtraining was obtained by taking 200% of the median trials to criterion (Md.=48 trials). The control group was reversed immediately.

Reversal training

During this training the original negative cues were now associated with reward. The reward again was two 45mg. Noyes pellets. All rats were given fifteen trials per day on the reversal task and were run to a criterion of 80 percent or more correct in one day (12 or more correct in 15 trials).

RESULTS

Table 3 presents the results for original learning and reversal learning. The measure of performance used for all stages of this experiment was the mean number of trials to a criterion including criterion trials.

TABLE 3.--Mean trials to criterion for original acquisition and reversal of the experimental and control groups.

STAGE OF EXPERIMENT / Group	N	MEAN	STANDARD DEVIATION
ORIGINAL ACQUISITION			
Experimental (overtrained)	5	62.6	13.9
Control (no overtraining)	5	76.8	19.6
	t=1.73; d.f.=8; n.s.		
REVERSAL ACQUISITION			
Experimental	5	81.0	7.38
Control	5	51.0	15.29
	t=3.54; d.f.=8; p.<.005		

Original Acquisition

The mean trials to criterion on the original learning for the experimental (overtrained) group was 62.2 and for the control group it was 76.6 trials. There is no significant difference between the groups (*t*=1.73; *d.f.*=8; p<.1).

However, the groups were not closely matched with regard to learning rate.

Position preference was assessed from the first 2 trials of original acquisition. If an *S* produced two incorrect responses in the first two trials it was classified as having a strong negative preference, i.e., a strong preference opposite to the designated correct response. If an *S* produced two correct responses it was considered to have a strong positive preference. An *S* with a weak negative preference would first produce an incorrect response and then a correct response. A weak positive preference was a correct-then-incorrect response order.

Table 4 presents the number of *S*s in the experimental and control groups exhibiting a specific position preference. From this table it can be seen that the groups were

TABLE 4.--Number of *S*s in each group exhibiting a specific position preference.

Strength of Preference	Direction of Preference Group: Positive		Group: Negative		Total
	Exp.	Control	Exp.	Control	
Strong	0	1	2	0	3
Weak	1	1	2	4	8
Total	1	2	4	4	11

approximately counterbalanced for direction of preference with the majority of *S*s having weak preference. There were two *S*s in the experimental group with a strong negative preference and one S in the control group with a strong positive preference. One would predict that a strong negative preference would lead to slow acquisition of the original response and faster reversal. A strong positive preference would produce the opposite effect. The individual data for the acquisition and reversal of the three Ss with strong preferences are opposite to the predicted result. Thus, position preference can not have systematically confounded the obtained result.

Reversal Acquisition

For reversal, the overtrained group reversed significantly more slowly then the control group ($t=3.535$; $d.f.=8$; $p<.005$). The mean trials to the reversal criterion for the overtrained group was 81 and for the control group it was 51. Due to the fact that the experimental and control groups were not well matched on trials to criterion, an analysis of covariance was also performed. Table 5 presents the summary of the analysis using trials to criterion for acquisition and reversal.

TABLE 5.--Summary of the analysis of covariance with trials to criterion as the measure.

Source of Variance	Sum of Squares	Degrees of Freedom	Mean Squares	F	p
Amt. of training	2008.419	1	2008.419	10.260	p<.025
Error	1370.220	7	195.743		
Total	3378.439	8			

From Table 5 it can be seen that the effect of overtraining was still significant (F.=10.260; df.=1/7; $p<.025$). Thus a significant negative or reverse ORE was obtained.

DISCUSSION

Experiment I showed that overtraining retards subsequent reversal learning of a pure spatial (i.e., kinesthetically controlled) response. The results plus observations of the actual behaviors of the rats while they were running in the maze led to the following explanations and predictions.

For the overtraining group it is postulated that the stimuli controlling the proprioceptively controlled turning response had backchained down the stem away from the choice point and goal box. This is partially supported by the observation that, late in training, all overtrained rats would typically start turning when the start box door was raised. They would also orient in the start box so as to facilitate the early turning. Thus, if an animal was to make a right turn, its nose would be pointed to the left side of the start box door with its hind quarters pointed to the right rear of the start box. This facilitates making a centrifugal swing to the right. Thus it may be said that the initiating stimuli of the chain could have backchained to the start box. Since these stimuli were not temporally and spatially proximal to the site of non-reinforcement during reversal they could not readily be associated with the frustration and withdrawal response necessary for the learning of reversal. The stimuli for the immediate reversal group, due to the lack of overtraining, had not back-chained very far from the potential site of frustration.

Thus, these stimuli could be more easilty associated with the frustration-elicited withdrawal response. This presumably, resulted in faster learning for the control group.

The next two studies were designed to investigate the effect of the length of the runway and reward size upon the reversal of a kinesthetically controlled turning response.

EXPERIMENT II

INTRODUCTION

In Experiment I it was postulated that overtraining retarded reversal because it lengthened the S-R chain associated with reinforcement making the initiating stimuli distal from frustration during reversal. In this experiment the runway was completely removed. The start box was shortened and attached directly to the choice point. It was reasoned that this would effectively limit the length of any chain formed during overtraining, decreasing the effect of overtraining seen in Experiment I. Large reward was used in this and the next experiment.

METHOD

Subjects

Twelve male albino rats from Spartan Research Animals, approximately 200 days old, were used as S's. All rats had prior experience in a shock study at the age of 90-100 days.

Apparatus

The apparatus was the T-maze described in Experiment I. The following alterations were made on the maze for this study. The runway was removed, and the length of the start box was shortened to 18.8cm. The start box was placed at the bifurcation and the door of the choice point was used as the start door.

Procedure

Preliminary training

This was identical to that used in Experiment I.

Discrimination training

The training procedure was identical to that used in Experiment I.

Reversal training

The reversal training was continued until all rats attained a criterion of at least 80% correct in a block of 15 trials given in one day.

RESULTS

Table 6 presents the mean trials to reach learning criterion for original learning and reversal.

TABLE 6.--Mean trials to Criterion for acquisition and reversal of experimental and control groups.

STAGE OF EXPERIMENT Group	N	MEAN	STANDARD DEVIATION
ORIGINAL ACQUISITION			
Experimental (overtrained)	6	58.5	19.576
Control (no overtraining)	6	50.0	17.549
	t=.723; d.f.=10; n.s.		
REVERSAL ACQUISITION			
Experimental	6	60.0	8.660
Control	6	45.0	12.247
	t=2.236; d.f.=10; p<.05		

<u>Original Learning</u>

A t-test performed on the mean trials to criterion of original learning yielded a of .733 (df=10) which was not significant. Although not significant, the Spearman rank order correlation between original acquisition and reversal scores was .73 for the experimental group and .33 for the control group, necessitating a need for an Analysis of Co-variance.

Position preference was assessed as in Experiment I by the score on the first two trials of original learning. Table 7 presents the number of S exhibiting each type of preference.

TABLE 7.--Number of S's in each group exhibiting a specific position preference.

Strength of Preference	Direction of Preference				Total
	Group		Group		
	Positive		Negative		
	Exp.	Control	Exp.	Control	
Strong	2	2	0	0	4
Weak	1	0	3	4	8
Total	3	2	3	4	

It is evident that the groups are clearly equated as to position preferences.

Reversal learning

The overtrained group reversed in a mean of 60 trials. The control group took 45 trials. This difference is significant at the .05 level (t=2.236) (df=10). However, the Analysis of Covariance (see table 8) on the trials to reversal criterion suggests that overtraining did not significantly retard reversal.

TABLE 8.--Summary of the Analysis of Covariance

Source of Variance	Sum of Squares	Degrees of Freedom	Mean Squares	F	p
Amount of Training	459.433	1	459.433	3.957	n.s.
Error	1044.847	9	116.094		
Total	1504.280	10			

DISCUSSION

The fact that no ORE was found in Experiment II suggests that either a relatively long stem in the T-maze or a small reward, or both, accounts for the negative ORE in Experiment I. Experiment III was done in an attempt to identify the relative role of these two variables.

EXPERIMENT III

INTRODUCTION

This experiment differed in one way from Experiment I and in one way from Experiment II. Experiment III differed from Experiment I in that a large reward was used. This should serve mainly to increase the elicitation value of non-reinforcement (i.e. frustration-withdrawal response); this in turn should facilitate the acquisition of the original response, especially for Ss trained against preference (Denny and Dunham, 1951). More importantly the increased size of reward should facilitate the acquisition of the reversal response, attenuating a negative ORE. Thus a lesser tendency toward a negative ORE should be found in Experiment III than in Experiment I.

Experiment III differed from Experiment II in that a long start box plus stem were used. This should increase the effect of backchaining by increasing the potential length of the chain. Thus a greater tendency toward a negative ORE should be found in Experiment III than in Experiment II.

METHOD

Subjects

Twelve male albino rats from Spartan Research Animals, approximately 200 days old were the subjects. No subjects had received prior shock exposure.

Apparatus

The apparatus was the T-maze used in Experiment I. It had a 34.4cm. start box and a 18.8cm. runway.

Procedure

Preliminary training

The handling and feeding procedures were identical to those used in all previous experiments.

Discrimination training

This procedure was identical to the one used in Experiment I and II. All rats were trained on a turning discrimination, reward size being two 190mg. Noyes pellets. After an acquisition criterion of at least 83 percent correct in twelve trials is attained, the S's were assigned so as to equate the means of the experimental and control groups on trials to criterion. The experimental group received 200 percent overtraining trials and then were reversed. The control group was reversed immediately after reaching criterion.

Reversal training

All S's were run to a reversal criterion of at least

80 percent correct in fifteen trials presented in one day. This is identical to Experiments I and II.

RESULTS

Original acquisition

Table 9 presents the mean trials to criterion for the original learning. The experimental group acquired the original response in a mean of 40 trials.

TABLE 9.--The mean trials to a criterion of 80 percent correct in any one day of original learning for experimental and control groups.

GROUP	N	MEAN	STANDARD DEVIATION
EXPERIMENTAL	6	40	23.66
CONTROL	6	38	23.41
	t=0.6518; d.f.=10; n.s.		

The control group obtained a mean of 38 trials. This difference is not significant yielding a _t_ of .6518. It must be pointed out that the variance for both groups was higher then that obtained for Experiments I and II. The trials to criterion ranges for both groups from 12 (i.e. the first day of acquisition) to 84 trials. This large a range was never obtained before.

Table 10 presents the number of subjects per group demonstrating a positive or negative preference. It can be seen that the experimental and control group were approximately equated in the direction of preferences with the majority of subjects demonstrating weak preference.

TABLE 10.--Number of subjects demonstrating preference.

Degree of Preference	Direction of Preference Group Positive		Group Negative		
	Exp.	Control	Exp.	Control	Total
Strong	2	1	1	0	4
Weak	1	3	2	2	8
Total	3	4	3	2	12

The three S's in the experimental group and the one S in the control group did not demonstrate the appropriate change in learning rate from original acquisition to reversal as would be predicted if position preference mediated the experimental effect. Thus preference could not account for the difference between the groups found in reversal.

Reversal learning

Due to the large variance found with the trials to criterion measure in both original learning and reversal, other measures of performance were tried. The measure that was used for comparisons was trials to a sliding criterion of five correct out of ten trials. The criterion for using this measure was that it had the lowest variance of all measures tried. In order to decrease further the amount of error variance a two by two Anovar was performed. The subjects were placed into one of two categories, fast or slow learners, based upon their original acquisition scores. This was done by dividing the range (72 trials) in half obtaining a demarcation line of 36 trials. Those S's that learned the original discrimination in less than 36 trials were considered fast learners. Those that took more than 36 trials were slow learners. This method discriminated well since no S learned in 36 trials; the fast learners ranged from 12 to 24 trials and the slow learners from 48 to 120 trials to criterion.

Thus the Anovar compared the effect of two variables upon the reversal scores: original learning rate (fast vs. slow) and the amount of training (overtraining vs. no overtraining). It should be pointed out that all reversal measures tried showed a trend toward a negative ORE.

Table 11 presents the summary of the Analysis of Variance.

TABLE 11.--Summary of the Analysis of Variance using trials to a reversal criterion: 5 correct out of 10 trials.

Source of Variance	Sum of Squares	Degrees of Freedom	Mean Squares	F	p.
Learning Rate	1,386.750	1	1,386.750	42.669	$p < .001$
Amt of Training	234.083	1	234.083	7.202	$p < .05$
Interaction	154.084	1	154.084	4.741	$p < .1$
Error	260.000	8	32.500		
Total	2,034.917	11			

It can be seen that both learning rate and amount of training are significant with F-ratios respectively 42.669 ($p < .001$) and 7.202 ($p < .05$). The interaction was not significant at the .05 level but was significant at the ten percent level. The overall mean trials to criterion (five correct out of ten trials) for the overtrained group was 32.22 and for the control group it was 23.3 trials. Thus the results of this analysis demonstrate an overall negative ORE.

Table 12 presents the means and variance. It can be seen from this table that the most pronounced effect of overtraining is with slow learners. For the fast learners the 200% group is only 1.74 trials slower than the 0% group. For the slow learners this difference is 16.01 trials. In the former case this is a 9% retardation in the latter a 28% retardation.

TABLE 12.--Mean and variance for the four groups used in the Anovar summarized in Table 11.

ACQUISITION RATE	AMOUNT OF OVERTRAINING					
	200% exp. group			0% control group		
	N	Mean	Standard Deviation	N	Mean	Standard Deviation
FAST	3	18.00	2.828	3	16.33	2.896
Slow	3	46.67	4.120	3	30.66	7.320

DISCUSSION

The interaction between learning rate and amount of overtraining makes sense with the analysis of the negative ORE obtained in Experiments I and II. It will be recalled that overtraining was postulated to elongate the behavioral chain that results from a kinesthetically controlled response. This occurs through the addition of the individual links of the chain which follows the laws of classical conditioning. It is generally accepted that there is a point where a further increase in the number of trials has little discernible effect on learning. I am saying that with fast learners the aysmptote of learning is reached earlier for each link of the chain, allowing a rapid elongation of the entire chain. Thus it is possible that the fast learners in the immediate reversal and overtraining reversal groups had lengthened the chain as far as possible at the end of original learning. Thus, overtraining would not separate the fast learners as much as the slow learners since the former would have less room for elongating the chain than the latter.

EXPERIMENTS I, II, & III

CONCLUSION

From the point of view of Mackintosh, the presence of many salient irrelevant cues and a concomitant difficult discrimination should result in the occurrence of an ORE. However, as it has just been shown, the opposite effect can occur.

The procedure used in Experiments I, II, and III was designed in order to specify exactly what stimuli and responses were being used by the subject. This makes the results amiable to analysis using Elicitation Theory. This procedure places all of the stimulus control on the cues which result in making the appropriate turn. These cues were present at the choice point or even before (kinesthesis attendent upon the centrifugal swing in the stem of the T-maze). Thus, during reversal training the competing responses elicited by non-reinforcement (frustration-withdrawal) did not occur in close temporal contiguity to the new negative cue. Only a perservative trace of kinesthesis was present when the competing responses are elicited. Thus the effect of overtraining was as follows:

a) through backchaining the critical kinesthetic cue was pushed back down the stem further away in time and space from the locus of the frustration elicitation of Rc during reversal training, resulting in a reverse ORE.

b) with more trials the perservative traces of the left-right turn may have become more discriminable, as described earlier, decreasing but not overpowering the first effect. . This might yield a less substantial negative ORE when large reward was used.

The above analysis receives support from results obtained by Mackintosh (1965) which show that when all cues are relevant, kinesthesis (direction of turn) acquires an increasing proportion of stimulus control as the number of trials is increased.

EXPERIMENTS IV & V

INTRODUCTION

In order to round out the picture of ORE in spatial discriminations Experiments IV and V were performed. These experiments are complementary to, but quite different from, the first three experiments. In Experiments IV and V all cues were relevant and redundant and the T-maze used had a shortened stem to minimize backchaining. Together, these two studies investigate the effect of the stringency of the acquisition criterion, the amount of training, and the size of reward upon reversal learning.

EXPERIMENT IV

METHOD

Subjects

Twelve male albino rats from Spartan Research Animals, approximately 200 days old at the beginning of the experiment, were used as S's. They had been used previously in a shock study being run for one day at an age of 90-100 days.

Apparatus

The apparatus was the T-maze described in Experiment I. The following alterations were made in the maze for this study. The runway was removed, and the length of the start box was shortened to 18.8cm. The start box was placed at the bifurcation and the door at the choice point was used as the start door.

Procedure

Preliminary training

This procedure was precisely the same as in Experiment I.

Discrimination training

The start box remained for the entire experiment on Side I. Half of the S's were training to go to the left arm and half to the right arm of the maze. They were given 2-45mg. Noyes pellets as reinforcement. When the rats reached a criterion of 83% or more correct in 12 trials given each day, they were matched on trials to criterion and randomly assigned to two groups. The experimental group received 51 overtraining trials on the original response and then reversed. The amount of overtraining was determined in the same way as Experiments II and III. The control group was reversed immediately.

Reversal training

Reversal training was the same as Experiment I. All S's were given 15 trials per day until they reached a reversal criterion of 80% or better in one day of training.

RESULTS

In this study two measures were used to assess performance. These were trials to a performance criterion of 80% correct on any one day, including criterion trials and trials to the last error, excluding criterion trials. Table 13 and 14 present a summary of the results for acquisition and reversal respectively in both groups.

TABLE 13.--Summary of the acquisition data for two measures and both groups.

Group	N	Mean	Standard Deviation
Experimental			
Trials to Criterion	6	24.7	1.501
Trials to Last Error	6	15.0	5.773
Control			
Trials to Criterion	6	26.7	4.426
Trials to Last Error	6	13.3	9.621

Original Acquisition

Table 13 presents the summary of results for the experimental and control groups. The groups did not differ significantly on both measures at the outset of the experiment. Trials to criterion and trials to the last error produced t-test results equal to 0.951 and 0.332 respectively. (d.f.=10; n.s.)

Reversal Acquisition

Table 14 presents the summary of results of the reversal stage of this experiment. There was no difference between the experimental and control groups when trials to

TABLE 14.--Summary of the reversal data for three measures and for both groups.

Group	N	Mean	Standard Deviation
Experimental			
Trials to Criterion	6	30.0	0
Trials to Last Error	6	19.5	5.530
Control			
Trials to Criterion	6	30.0	0
Trials to Last Error	6	8.7	4.385

criterion was compared. Since all reached criterion in 30 trials there was no variance. It was concluded that trials to criterion was too gross a measure to detect differences when learning was so rapid. Thus, trials to the last error was used. Mean trials to the last error was significant ($t=3.435$; $df=10$; $p < .005$) with the experimental group averaging 19.5 and the control group averaging 8.7. It must be pointed out that the Spearman Rank order correlation between acquisition and reversal scores on trials to the last error was -.04 for the experimental group and -.1 for the control group. This makes it highly unlikely that the obtained difference was due to differential learning rate or position preference of two groups. Thus the overtrained group made on the average more errors over more trials than the control group. Consequently a reverse CRE was obtained.

EXPERIMENT V

To clarify the results obtained in Experiment IV, Experiment V was performed. Here reward size and level of acquisition were manipulated to determine their effect upon the reversal of a place response.

METHOD

Subjects

The S's were 24 male albino rats obtained from Spartan Research Animals. All were 200 days old at the beginning of the experiment and were used previously in a shock study at 90-100 days old.

Apparatus

The apparatus was the T-maze used in Experiment IV.

Procedure

Preliminary training

The handling and habituation procedure was the same as Experiment I.

Discrimination training

Before training the S's were assigned randomly into 4 groups in a 2x2 Factorial design. The four were as follows:

Overlearning-small reward, Overlearning-large reward, Immediate reversal-small reward, and Immediate reversal-large reward. All rats were trained on a place discrimination as in Experiment IV with all extra and intra maze and kinesthetic cues relevant. The animals in each group were haphazardly assigned to the response designation of right or left arm correct with the provision that half of each group was assigned to each side.

The overlearning groups were run to a criterion of at least 80% correct during a daily block of 12 trials. They were then given 100% (i.e. 24 trials) overtraining. Reversal groups were trained to an acquisition criterion of at least 5 correct out of a sliding block of 6 trials. Here acquisition was continued until the S's reached criterion. The next day they were reversed. This manipulation was used to sample the effect of very low levels of acquisition and overtraining upon reversal. The small reward group received 2-45mg. Noyes pellets throughout all stages of the experiment. The large reward was 2-190mg. pellets throughout. The total intake for each animal was balanced by manipulating the quantity of home cage food, so all animals received an equal amount of food.

Reversal training

During reversal all S's were run to a criterion of at least 80% correct in a block of 15 trials per day. The S's received the same quantity of reinforcement as they did in earlier stages.

RESULTS

In this study the main measure of performance used was trials to the last error, excluding criterion trials. The subjects learned the original task and the reversal of the task so fast as to render trials to criterion a gross, nondifferentiating measure (see Table 15a). Acquisition data for the immediate reversal and overtraining groups were not compared due to the difference in acquisition criterion for the two groups. Table 15 a & b presents reversal data for all four groups.

TABLE 15a.--Trials to Criterion during reversal for all four groups.

GROUPS	TRIALS TO CRITERION			
	N	Mean	Standard Deviation	t
LARGE REWARD				
Experimental	5	18	6	1.109ns
Control	6	17.5	5.590	
SMALL REWARD				
Experimental	5	33.0	6	1.260ns
Control	6	30.0	0	

TABLE 15b.--Trials to the Last Error during reversal for all four groups.

GROUPS	TRIALS TO LAST ERROR			
	N	Mean	Standard Deviation	t
LARGE REWARD				
Experimental	5	2.8	.748	2.96 p .02 d.f.=9
Control	6	9.0	4.163	
SMALL REWARD				
Experimental	5	27.4	3.878	3.046 p .001 d.f.=9
Control	6	20.0	3.415	

It can be seen from the comparison of group means in Table 15b that a significant positive ORE was obtained with large reward whereas a significant negative ORE was obtained using a small reward. In order to test the significance of the interaction between reward size and amount of training a 2x2 Anovar was performed. Since this analysis assumes equal cell sizes one S was randomly deleted from each of the large and small reward immediate reversal groups. Table 16 presents a summary of the Analysis of Variance.

TABLE 16.--Summary table for the Analysis of Variance with trials to the Last Error as a measure.

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F	p
Amount of Training	.800	1	.800	.065	ns
Magnitude of Reward	1411.200	1	1411.2	115.435	p<.001
Interaction	304.200	1	302.2	24.883	p<.001
Error	195.600	16	12.225		
Total	1911.800	19			

From the Table (16) it is apparent that magnitude of reward and the reward by training interaction was significant. Figure 2 graphically presents the interaction effect with size of reward as the parameter. Large reward yields an CRE whereas small reward results in the expected negative CRE.

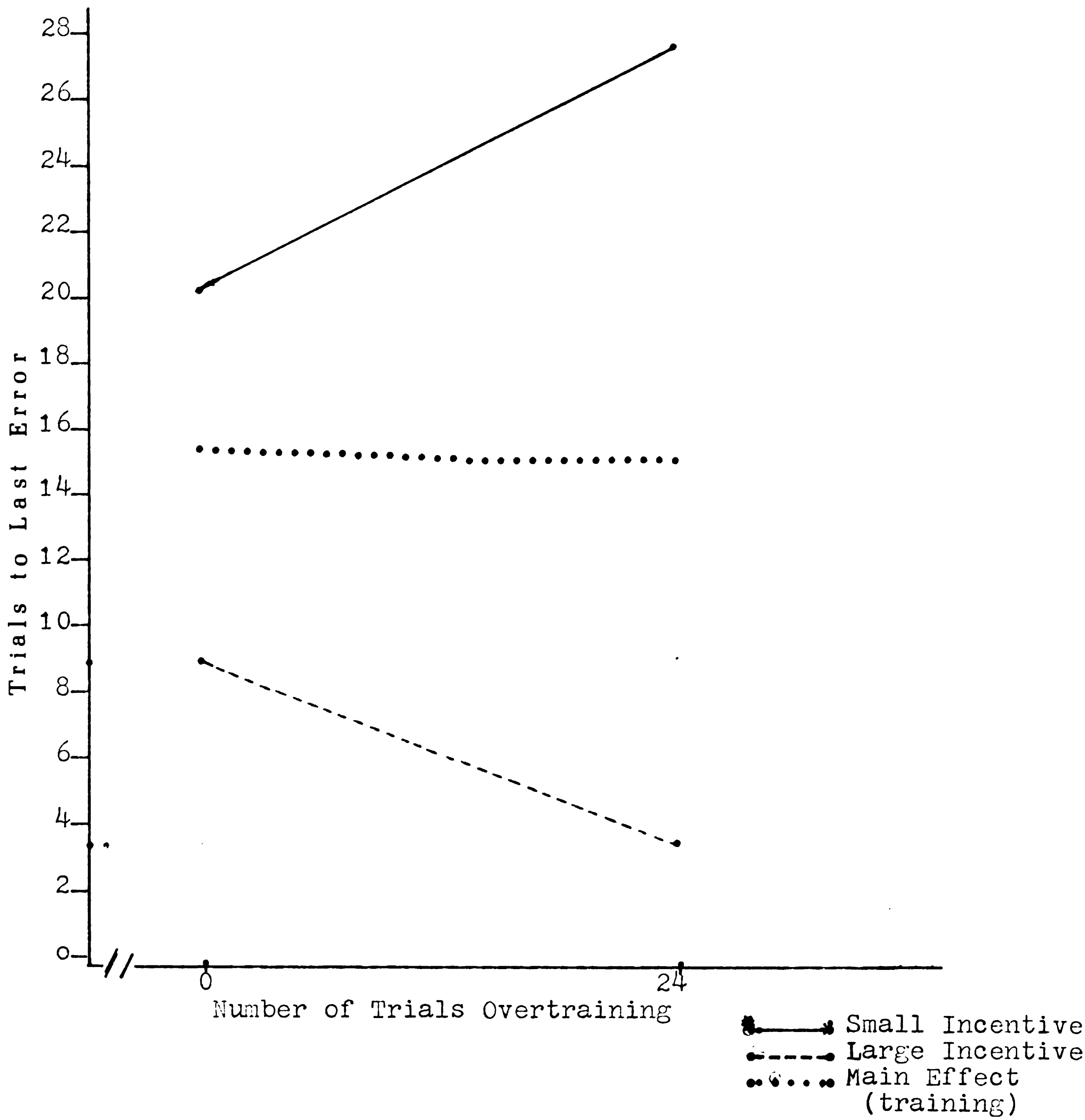

Figure 2.--Graphic presentation of the interaction of incentive size and amount of training with trials to the last error as the measure.

EXPERIMENTS IV & V

DISCUSSION

An explanation of the results of experiments IV & V stems from the assumption that the effect of overtraining was twofold:

a) whether small or large reward was being used, the approach response to the positive stimuli was being strengthened by increased number of trials, this alone would yield the expected negative ORE.

b) since the acquisition criterion for all studies was low the total number of trials in original learning did not exceed 33 trials with one S obtaining this and the rest of the S's learning in 12 to 18 trials. Since the non-correction procedure was used, even fewer trials were reinforced. Thus, overtraining would enhance the frustration effect by strengthening the expectation of the reward (Amsel, 1962). In theory, this means a more consistent elicitation of a more vigorous withdrawal response to the new negative cue during reversal. Several studies indicate that the frustration effect increases with the number of original reinforcements (Marzocco, 1951; Yelen, 1969) and requires at least 35 to 40 reinforcements to reach aysmptote (Amsel, 1967). Thus when learning is as fast as in these studies, the criterion can be reached before the expectation has been maximized. Many cues are also contiguous with the frustration event that occurs on incorrect reversal trials. Thus the withdrawal response is directly conditioned to them and can readily yield an ORE following overtraining.

Since the vigor of the frustration effect is directly related to the size of reward (Amsel, 1962; 1967; Bower, 1962) then in the small reward groups the aysmptote of the frustration effect is lower than with large reward. Thus, with small reward the facilatory effects of overlearning due to increased frustration did not exceed the retarding effect of strengthening the original response. The opposite is true for large reward. In this case, the frustration effect was maximized by both size of reward and number of trials, so that it became the potent effect of overtraining.

TABLE 17.--Summary of all results of Reversal Learning from all experiments.

		GROUP							
		Experimental			Control				
TYPE OF EXPERIMENT	MEASURE	N	MEAN	S.D.	N	MEAN	S.D.	TEST OF SIGNIFICANCE	
PURE SPATIAL *									
Experiment I Long stem small reward	trials to criterion, 10-12 correct in one day.	5	81	7.4	5	51	15.3	t=3.535 $p < .005$ d.f.=8	Negative CRE
Experiment II Short stem large reward	trials to criterion, 10/12 correct in one day.	6	60	8.7	6	45	12.2	Analysis of Covariance F=3.957, d.f.=1/9	No CRE n.s.
Experiment III Long stem large reward	trials to criterion, 5/10 correct sliding.	fast learners: 3	18	2.8	3	16	2.8	2x2 Anovar F train.=7.2 $p < .05$ d.f.=1/8	Negative CRE
		slow learners: 3	46.7	4.1	3	30.6	7.3		

* All cues irrelevant except direction of turn (kinesthetic)

TABLE 17.--(con't) Summary of all results of Reversal Learning from all experiments.

		GROUP							
		Experimental			Control				
TYPE OF EXPERIMENT	MEASURE	N	MEAN	S.D.	N	MEAN	S.D.	TEST OF SIGNIFICANCE	
TYPICAL T-MAZE **									
Experiment IV Short stem small reward	trials to Last Error	6	19.5	5.5	6	8.7	4.4	t=3.435 $p < .005$	Negative CRE d.f.=10
Experiment V Short stem large & small reward	trials to Last Error	large reward: 5	2.3	.8	6	9	4.2	t=2.976 $p < .02$	Positive CRE
		small reward 5	27.4	3.9	6	20	3.4	t=3.878 $p < .001$	Negative CRE

** All cues relevant

GENERAL SUMMARY OF RESULTS & CONCLUSIONS

Table 17 presents a summary of the results obtained for all five experiments. Experiments I, II, and III investigated the effect of overtraining on the subsequent reversal of a kinesthetic discrimination in which most cues were irrelevant. In Experiment I a long stem and small reward was employed. An Analysis of Covariance indicated that overtraining significantly retarded reversal. It was hypothesized that the length of the stem may be the relevant variable.

In Experiment II the length of the stem was shortened and large reward was used. The effect of overtraining was not significant when the results were submitted to an Analysis of Covariance. Thus no ORE was found. In order to isolate the respective contributions of reward size and length of stem, Experiment III was performed.

In Experiment III the stem of the T-maze was the same as in Experiment I and large reward was used. A significant negative ORE was obtained when a 2x2 Analysis of variance was performed, with one variable as the speed of original learning and the other variable as the amount of training. It was noted that the greatest retardation due to overtraining was for slow learners.

Thus, it was concluded that the length of the stem was the controlling variable since a negative ORE was obtained either with a small or large reward when the stem was long. It was hypothesized that a negative ORE resulted because the initiating stimulus for the original response (Ro) that led to the goal was placed temporally and spatially distant from the site of reinforcement. This occurred because overtraining served to elongate the S-R chain. Thus, when the animal reversed, the initiating stimulus for Ro was not in close temporal contiguity with the site of non-reinforcement, i.e., the site of reinforcement during acquisition. This separation of Rc and cue for Ro would slow down the conditioning of Rc to this cue and thus impede the acquisition of reversal. Due to the lack of overtraining, the S-R chain for the control group had not back-chained far from the site of reinforcement. Thus, during reversal, the initiating stimulus for Ro could be readily conditioned to Rc resulting in faster reversal learning.

Presumably, shortening the stem physically limited the length of any S-R chain thus overtraining had little if any effect on reversal.training.

Experiments IV and V investigated the effect of overtraining on the reversal of a place response in which all cues were relevant and redundant. In Experiment IV a shortened stem was used and all S's were given small reward. It was found that overtraining significantly retarded reversal. In Experiment V both size of reward and amount of training were manipulated in a 2x2 factorial design. It was found that for the small reward group overtraining significantly retarded reversal as in Experiment IV. However, overtraining facilitated reversal for the large reward group. It was postulated that with large reward, the frustration elicited Rc would be enhanced by extra reinforcements (Marzocco, 1951; Yelen, 1969) during overtraining. Thus the experimental group would reverse faster than the control. For small reward this does not occur. Thus only the strength of the original positive response is increased during overtraining, resulting in a negative ORE.

There were two main explanatory principles employed in the analysis of these results. Each principle when exploited alone will yield opposing predictions. Therefore it is incumbent upon any analysis to specify the principles and state when and where and why they are most potent. As was pointed out in the introduction, this is the basic orientation of the elicitation position.

Elicitation Theory postulates that overtraining had the following effects:

a) increasing the number of trials, increases the strength of the conditioning of approach to the original positive stimuli. This is accomplished in the following ways:

1. The conditioning of the approach response to the original positive cues is increased.

2. The approach response backchains as far as possible by strengthening distal (from reinforcement) CS-CS pairings, allowing the most distal CS to serve as functional

US's for a more distal pairing. This would remove the imitating stimuli for Ro far from the site of frustration during reversal, retarding the conditioning of the withdrawal response (Rc) to the new negative stimulus.

b) When a low criterion is used, increasing the number of trials (reinforcements) would increase the eliciting value of non-reward during reversal. This would allow the withdrawal response to be more consistently elicited by non-reward resulting in better conditioning and faster reversal.

In Experiments I, II, and III the first explanation is applicable whereas the second is not. In these experiments, the only way a subject could possibly learn the response was through backchaining. Since the stimuli were purely kinesthetic, they could occur only at the choice point and before it (those kinesthetic stimuli resulting from making a centrifugal swing). This leads to a condition where the discriminative stimuli are not contiguous with the site of frustration during reversal. Overtraining serves to heighten this effect by strengthening and elongating the chain. The second explanation is not applicable since the discrimination was difficult. Thus, the S's took a relatively large number of learning trials and since the aysmptote of the frustration effect is reached in about 35-40 trials (Amsel, 1962) overtraining would not have this effect. At least, this is true for Experiments I and II. However, in Experiment III at least 6 subjects (3 in each group) presumably reached criterion sufficiently fast to obtain some benefit from overtraining, increasing the frustration effect. When a 2x2 Anovar was performed the negative CRE for the fast learners was not as pronounced as for the slow learners.

In Experiments IV & V both the above explanations are applicable. Increasing the number of trials would increase the approach response and possibly cause the formation of a kinesthetic chain. This would result in the negative CRE. In Experiment IV using small reward the S's acquired the original discrimination in approximately 25 trials. In the small reward group of Experiment V original acquisition occurred in approximately 32 trials. Both these figures are close to the aysmptote of the frustration effect. Thus there is little benefit from overlearning. The large reward group of Experiment V acquired in approximately 18 trials. This would leave considerable room for beneficial increase in the eliciting value of non-reward. In addition large reward yields a still greater increase in non-reward elicited frustration-withdrawal then small reward. When both considerations are combined, this would outweigh the retarding effects of overlearning and result in positive CRE.

From the above analysis one can specify all the variables operative in the learning situation to yield any specific result. This is unlike the stand of other theoretical positions in which one or two factors are sufficient to yield CRE. An example of such a theorizing is that of Mackintosh (1969). His analysis leads to the predictions of a positive CIE when there are many salient and irrelevant stimuli present in the discrimination as in Experiments I, II, and III. He would predict no effect when all cues are relevant as in Experiments IV and V.

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APPENDICES

TOTAL CORRECT FOR EACH DAY OF TESTING
FOR EXPERIMENTAL GROUP OF EXPERIMENT I

Acquisition* Stage				Days					
S's	1	2	3	4	5	6	7	8	Total
1	7	4	8	6	9	8	10		52
2	5	9	9	12					35
3	6	7	7	6	7	11			44
4	8	7	6	7	10				38
5	7	9	5	11					32
Overtraining Stage									
1	14/15	15/15	13/15	13/15	11/12	11/12	12/12		89/96
2	12/12	12/12	12/15	8/15	15/15	14/15	11/12		84/96
3	14/15	15/15	15/15	13/15	10/12	11/12	12/12		90/96
4	10/12	10/15	15/15	15/15	15/15	12/12	12/12		89/96
5	10/12	12/12	12/12	11/12	9/12	11/12	12/12	11/12	88/96
Reversal Stage**									
1	2	4	3	7	7	13			37
2	3	6	8	9	14				40
3	1	3	1	5	10	14			34
4	2	3	8	10	14				37
5	4	6	5	10	11	15			51

* 12 trials per day

** 15 trials per day

TOTAL CORRECT FOR EACH DAY OF TESTING
FOR CONTROL GROUP OF EXPERIMENT I

Acquisition Stage*					Days				
S's	1	2	3	4	5	6	7	8	Total
1	8	7	7	9	9	10			50
2	6	8	8	7	9	9	9	12	68
3	6	8	8	8	9	11			50
4	6	8	11	5	6	11			47
5	5	7	8	5	9	11			45
Reversal Stage**									
1	4	11	14						29
2	8	11	15						34
3	6	7	10	11	15				49
4	5	12	15						32
5	7	6	9	12					34

* 12 trials per day

** 15 trials per day

TOTAL CORRECT FOR EACH DAY OF TESTING
FOR EXPERIMENTAL GROUP OF EXPERIMENT II

S's	Days 1	2	3	4	5	6	7	Total
Acquisition Stage*								
1	9	11						20
2	6	6	9	12				33
3	9	4	7	8	12			40
4	6	8	8	8	11			49
5	5	12	9	8	11			45
6	8	6	7	12	11/15	12		56
Overtraining Stage*								
1	13/15	15/15	15/15	3/3				46/48
2	15/15	15/15	15/15	15/15	15/15	12/12	12/12	99/99
3	14/15	15/15	15/15	14/15	12/12	12/12	11/12	93/96
4	15/15	15/15	15/15	14/15	11/12	11/12	12/12	93/96
5	15/15	15/15	14/15	15/15	12/12	12/12	12/12	95/96
6	15/15	15/15	14/15	15/15	12/12	12/12	12/12	95/96
Reversal**								
1	3	6	9	13				31
2	4	8	14					22
3	3	4	7	12				26
4	1	4	9	15				29
5	0	4	10	14				28
6	0	3	7	8	14			32

* 12 trials per day

** 15 trials per day

TOTAL CORRECT FOR EACH DAY OF TESTING
FOR CONTROL GROUP OF EXPERIMENT II

				Days				
S's	1	2	3	4	5	6	7	Total
Acquisition Stage *								
1	7	7	7	9	10			40
2	7	5	12					24
3	6	5	4	11				26
4	7	7	11					25
5	6	8	11					25
6	5	5	6	8	7	9	12	62
Reversal Stage**								
1	11	9	13					33
2	4	7	7	13				38
3	5	13						18
4	4	13						17
5	5	10	14					29
6	3	8	11	13				35

* 12 trials per day

** 15 trials per day

TOTAL CORRECT FOR EACH DAY OF TESTING
FOR EXPERIMENTAL GROUP OF EXPERIMENT III

	Days									
S's	1	2	3	4	5	6	7	8	9	Total
Acquisition Stage*										
1	10	10								20
2	5	5	8	11						29
3	8	12								20
4	7	5	7	7	9	9	11			55
5	6	10								16
6	9	12								21
Overtraining Stage*										
1	11	12	10	12						45
2	10	12	11	12	12	12	12	12		93
3	12	11	12	12	11	12	12	12		94
4	11	11	12	11	12	12	11	12		92
5	10	12	12	11						45
6	12	11	12	12						47
Reversal Stage*										
1	3	10								13
2	1	2	4	4	4	6	7	7	10	46
3	0	1	2	7	8	9	10			37
4	1	4	5	6	8	9	8	11		52
5	3	6	7	11						27
6	3	6	8	11						28

*12 trials per day

TOTAL CORRECT FOR EACH DAY OF TESTING
FOR CONTROL GROUP OF EXPERIMENT III

	Days									
S's	1	2	3	4	5	6	7	8	9	Total
Acquisition Stage*										
1	11	12								23
2	7	8	12							27
3	7	11								18
4	7	6	6	6	7	7	10			49
5	9	12								21
6	8	9	8	12						37
Reversal*										
1	4	7	12							23
2	1	3	6	10						20
3	3	7	10							20
4	3	5	7	9	12					36
5	2	12								14
6	3	1	2	4	4	3	5	8	11	41

*12 trials per day

TOTAL CORRECT FOR EACH DAY OF TESTING
FOR EXPERIMENTAL GROUP OF EXPERIMENT IV

			Trials				
S's	1-6	7-12	13-18	19-24	25		Total
Acquisition Stage*							
1	3	6	6	6			21
2	4	5	5	5			19
3	3	4	5	6			18
4	3	4	4	5	4/4		20
5	4	4	6	5			19
6	2	4	5	5			16
Overtraining Stage**							
			Days				
S's	1	2	3	4			
1	14/15	11/12	11/12	11/12			47/51
2	14/15	12/12	11/12	12/12			49/51
3	14/15	11/12	11/12	12/12			48/51
4	14/15	11/12	11/12	12/12			48/51
5	13/15	10/12	11/12	12/12			46/51
6	15/15	11/12	12/12	11/12			49/51
Reversal***							
			Trials				
S's	1-5	6-10	11-15	16-20	21-25	26-30	
1	0	4	4	4	5	4	21
2	1	2	4	5	4	5	21
3	1	4	4	4	4	4	21
4	0	3	3	5	3	5	19
5	1	3	4	4	5	5	22
6	0	1	3	4	5	5	18

*12 trials per day
**n/m, i.e., n correct Rs in m trials
***15 trials per day

TOTAL CORRECT FOR EACH DAY OF TESTING
FOR CONTROL GROUP OF EXPERIMENT IV

			Trials				
S's	1-6	7-12	13-18	19-24	25-30	31-36	Total
Acquisition Stage*							
1	5	6	6	6			23
2	5	4	4	5	6	5	29
3	3	6	5	6			20
4	5	5	6	6			22
5	4	4	5	6			19
6	4	4	3	6	4/4		22
Reversal Stage**							
			Trials				
	1-5	6-10	11-15	16-20	21-25	26-30	
1	5	3	5	5	5	5	23
2	1	5	5	4	4	5	24
3	1	4	5	5	5	5	25
4	3	4	5	5	5	5	27
5	2	5	3	4	5	5	21
6	0	2	5	5	4	5	21

* 12 trials per day

** 15 trials per day

TOTAL CORRECT FOR EACH DAY OF TESTING
FOR SMALL REWARD EXPERIMENTAL GROUP OF EXPERIMENT V

	Trials									
S's	1-4	5-8	9-12	13-16	17-20	21-24	25-28	29-32	33-	Total
Acquisition Stage*										
1	3	4	3	3	2	3	4	3	1/1	27
2	2	2	3	4	2	4				17
3	3	2	3	3	3	4				18
4	2	2	3	3	3	3	4			20
5	4	2	3	3	3	4				19
Overtraining Stage *										
1	4	3	3	3	4	4				21
2	3	3	3	3	4	3				19
3	4	3	3	3	3	4				20
4	4	3	4	4	4	3				22
5	3	3	4	3	4	4				21
Reversal Stage**										
	Trials									
S's	1-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	
1	3	3	5	4	4	4				23
2	2	3	3	3	4	5				21
3	1	4	4	5	3	4				21
4	2	2	3	4	4	4				19
5	2	3	4	4	4	3	4	5	5	34

* 12 trials per day
** 15 trials per day

TOTAL CORRECT FOR EACH DAY OF TESTING
FOR LARGE REWARD EXPERIMENTAL GROUP OF EXPERIMENT V

S's	Trials 1-4	5-8	9-12	13-16	17-20	21-24	Total
Acquisition Stage*							
1	3	4	4	3	4	3	22
2	2	3	4	4	4	3	20
3	4	4	3	3	4	3	20
4	3	4	4	4	4	4	23
5	3	2	3	4	4	3	19
Overtraining Stage *							
1	4	3	4	4	4	4	23
2	3	3	3	4	3	4	20
3	4	4	4	4	4	4	24
4	3	4	4	4	4	4	23
5	4	4	3	4	4	3	22
Reversal Stage**							
S's	Trials 1-5	6-10	11-15	16-20	21-25	26-30	
1	3	5	5				13
2	3	5	5				13
3	1	5	5	5	5	4	25
4	3	5	5				13
5	3	5	4				12

*12 trials per day

** 15 trials per day

TOTAL CORRECT FOR EACH DAY OF TESTING
FOR SMALL REWARD CONTROL GROUP OF EXPERIMENT V

S's	Trials 1-4	5-8	9-12	13-16	17-20	21	Total	Trials to Crit.**	Total Trials
Acquisition Stage*									
1	2	3	4				9	4	12
2	3	2	4				9	5	12
3	2	2	3	3	1		10	11	17
4	2	2	2	2	3		11	13	19
5	2	3	2	3	1		11	11	17
6	2	3	2	3	2	4	16	19	25
Reversal Stage***									
S's	Trials 1-5	6-10	11-15	16-20	21-25	26-30			
1	3	3	4	4	4	5			23
2	2	4	4	4	4	4			22
3	2	3	3	4	4	5			21
4	2	4	4	4	5	5			24
5	2	3	3	5	4	5			22
6	1	4	3	5	5	4			21

* all S's run in one day until criterion reached

** not including criterion trials

*** 15 trials per day

TOTAL CORRECT FOR EACH DAY OF TESTING
FOR THE LARGE REWARD CONTROL GROUP OF EXPERIMENT V

S's	Trials 1-4	5-8	9-12	13-16	Total	Trials to Crit.**	Total Trials
Acquisition Stage*							
1	2	3	2	4	11	9	16
2	2	3	4		9	4	12
3	2	3	4		9	3	12
4	3	4	3		10	0	12
5	2	3	3	2	10	7	14
6	2	3	3	2	10	7	14

Reversal Stage***

S's	1-5	6-10	11-15	Trials 16-20	21-25	26-30	31-35	Total Trials
1	3	4	4	5	4	5		29
2	3	4	5					12
3	2	5	5					12
4	2	5	5					12
5	3	5	4					12
6	5	5	4					14

* all S's run in one day until criterion reached

** not including criterion trials

*** 15 trials per day