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Assessment of relative importance of S+ and S- after various stages of training

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Using a discrimination box, male rats were trained to criterion or overtrained on a visual discrimination. Then a transfer test was given in which either S+ or S— was retained, and the other was replaced with a new stimulus. Next, the subjects were trained on the reversed discrimination. Tests were then given with either the reversed S+ or S— retained and the other replaced. In all tests, fewer errors were found when S— was retained than when S+ was retained. Other animals were tested after training to a precriterial level in a second experiment with similar results.

D'Amato and Jagoda (1961) have offered an explanation for the overtraining reversal effect (ORE) based on the assumption that in discrimination learning acquired tendencies to not approach S– are more important at mastery than acquired tendencies to approach S+. They suggested that as a result of the infrequency of errors during overtraining (OT), the cue function of S– decreases. When the stimuli are reversed, subjects given OT learn more rapidly than subjects trained only to mastery since the new S+ (old S–) is more likely to be approached by the former than by the latter subjects. This explanation was tested by forcing one group of rats to respond to S– on 20% of the trials during OT and similarly forcing another group to respond to S+ during OT. The results supported their hypothesis; rats forced to S– learned the reversal more slowly than those forced to S+.

While these results support D'Amato and Jagoda's hypothesis with regard to the functional relationship between frequency of errors and OT, they do not bear on the primary assumption that during acquisition S– acquires more control over choice than S+.

One way the question of the relative control by S+ and S– in discrete-trial simultaneous discrimination has been examined is the replaced-stimulus transfer test. Animals are trained on a two-choice discrimination and then tested with either S+ or S– replaced by a new stimulus. The finding of fewer errors when S+ is replaced, as compared to when S– is replaced is consistent with S– being the more important stimulus. On the other hand, the finding of fewer errors when S– is replaced as compared to when S+ is replaced suggests that S+ is the more important stimulus.

Using this method, Stevens and Fechter (1968) found results indicating S– to be the more important stimulus after mastery with positively reinforced rats. However, Mandler (1968) and Hall (1973) found no significant effects after mastery but significant results opposite from one another after OT. In view of these discrepant results, the present study was undertaken. Here, replaced-stimulus tests were given after mastery, OT, and mastery of reversal acquisition.

EXPERIMENT I

Method

Subjects. The subjects were 40 male rats of the Charles River CD strain, about 80 days old. The subjects were adapted to and maintained on a 23-h-and-50-min water deprivation schedule.

Apparatus. The apparatus was a discrimination box similar to that described by McGaugh and Thomson (1962, Figure 1). It was trapezoidal in shape, 27 in. (68.6 cm) long, 12 in. (30.5 cm) wide at one end, and 6 in. (15.2 cm) wide at the other end, with a grid floor. A Plexiglas door 7 in. (17.8 cm) from the narrow end provided a startbox. Two openings, 3 in. (7.6 cm) square and 6 in. (15.2 cm) apart, were located in the wall at the wide end. A 3-in. (7.6 cm) partition separated the openings. Swinging doors, which served as stimuli, were located behind these openings. One door opened into a goalbox, and the other was locked shut. In the goalbox was a small cylinder which, on reinforced trials, contained .2 ml water.

The stimuli used for acquisition and reversal training were cards with alternating ½-in. (1.3 cm) black and white horizontal or vertical stripes. The stimulus used in the replaced-stimulus tests was a four-cell black and white checkerboard. This pattern was used since no differential transfer is obtained with it following acquisition of a horizontal vs. vertical stripe discrimination (Stevens, 1974). To provide an objective determination of errors (responses to the incorrect door), two microammeters were used. For each meter, one pole was wired to one of the grid sections between the end of the partition and a door, and the other pole was wired in series with a 220,000 ohm resistor, a 6-V dry cell, and the remainder of the grid. When a subject touched the floor in front of either of the doors, it was indicated by deflection of the needle of the appropriate meter. The current passed (about 5 microA) was not aversive and was probably subliminal.

Procedures. The subjects were randomly assigned to four experimental groups containing 10 subjects each. These groups were (a) criterial training, tested with S+ replaced; (b) criterial training, tested with S– replaced; (c) 100% overtrained, tested with S+ replaced; and (d) 100% overtrained, tested with S– replaced. Within these groups, half of the subjects were trained with horizontal stripes as S+ and half with vertical stripes as S+.

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The subjects were gentled and adapted to the water deprivation schedule. Pretraining consisted of shaping the subjects to leave the startbox, push open a homogeneous gray stimulus door, and enter the goalbox. All trials were reinforced in this and subsequent phases of the experiment. For pretraining, a gray block was placed in front of the locked door, forcing the subject to respond to the unlocked door. Ten trials a day were given throughout the experiment. The position of the unlocked door was determined by Gellerman sequences.

Training on the horizontal vs. vertical stripe discrimination began immediately following pretraining. A criterion of nine correct responses within a day was used. After the appropriate amount of training was given (criterial or OT), the subjects were tested for 10 trials with either S+ or S– replaced with the checkerboard stimulus. Then, retraining with the original training stimuli was given until the criterion was again met. Next, discrimination reversal training was given until the criterion was met. This was followed by 10 test trials in which the reversal S+ or S– was replaced by the checkerboard stimulus.

Results

Acquisition and discrimination reversal. In acquisition of the discrimination, there were no significant differences in errors to criterion between groups to be tested after criterion and OT (means were 36.2 and 37.7, respectively; F = .43), between groups to be tested with S+ and S– replaced (means were 35.1 and 38.8, respectively; F = .07), or due to an interaction (F = .67). Thus, any subsequent differences cannot be attributed to sampling error. Similar results were found for the discrimination reversal. When errors to criterion made by the different groups were analyzed by ANOVA, it showed no significant differences for criterial and OT groups (means were 109.1 and 102.8, respectively; F = .17), for S+ and S– replaced (means were 115.0 and 96.8, respectively; F = 1.42), or the interaction (F = .79). The df for all of these and subsequent F tests was 1/36.

Replaced-stimulus tests. Figure 1 shows the mean errors made on the replaced stimulus tests, plotted as a function of the kind and amount of training received prior to testing. The histograms shown for the precriterial stage refer to results obtained in Experiment II, reported later in this paper. On the first test, given following criterial training or OT, more errors were made by those subjects tested with S– replaced than with S+ replaced. An ANOVA indicated that this main effect was significant (F = 8.89, $p < .01$), but neither the main effect for amount of training nor the interaction was significant (F = .45, F = .45, respectively). On the second test, given following attainment of criterion on the discrimination reversal, the same pattern of results was found. Significantly more errors were made on tests with S– replaced than on tests with S+ replaced, and this was true regardless of the amount of previous training given to the subjects. An ANOVA showed a significant main effect for replacement of stimuli (F = 10.33, $p < .01$), but the main effect for amount of training (F = .01) and the interaction (F = 1.49) were not significant.

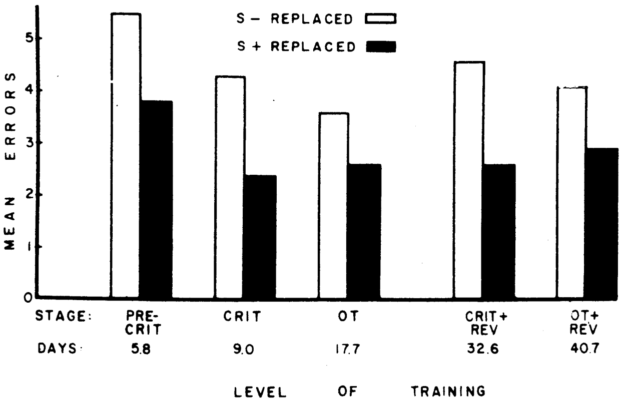

Figure 1. Mean errors made when S+ or S– was replaced after different amounts of training, identified by stage and mean days. The set of histograms shown for the precriterial stage depict results from Experiment II, the remaining histograms depict results from Experiment I.

EXPERIMENT II

Experiment I assessed the relative importance of S+ and S– over levels of training from criterial performance through reversal following OT. The negative stimulus was consistently more important throughout all tests. Vaughter, Tyer, and Halcomb (1966) found greater transfer from training with S+ than from training with S– in an experiment which involved only 54 trials. This finding suggested that a reversal in the relative importance of S+ and S– might be found if replaced-stimulus tests were given relatively early in acquisition. Accordingly, Experiment II was done to assess transfer from S+ and S– before mastery was attained.

Method

Subjects. The subjects were 24 male rats, about 80 days old, of the Charles River CD strain.

Apparatus and procedure. The apparatus and general procedure were the same as used in Experiment I. Following pretraining, during which three subjects were dropped from the experiment because of excessive balking, the subjects were randomly assigned to groups to be tested with S+ replaced (N = 10) and S– replaced (N = 11). Ten test trials were given on the day following the attainment of a criterion of seven correct choices within a daily block of 10 trials. The data from Experiment I indicated that this encompassed 79% of the training required to attain 9 out of 10 correct choices. Discrimination reversal training was not given in this experiment.

Results

Subjects for which S+ and S– were replaced did not differ in errors during the acquisition training. Mean errors were 25.8 and 30.7, respectively (t = .74, df = 20). The results of the replaced-stimulus tests are shown on the left of Figure 1. Again, subjects tested with S–

replaced made significantly more errors than those tested with S+ replaced ($t = 2.18$, $df = 20$, $p < .05$).

DISCUSSION

The results of the two experiments clearly show the maintenance of a significantly higher frequency of errors in S− replaced conditions over a wide range of training. From precriterial training through OT to attainment of reversal discrimination replacement of S+ and retention of S− consistently produced significantly fewer errors than the opposite condition. Since the same findings were obtained before and after mastery of reversal discrimination, the transfer effects were not influenced by prior experience with the stimuli in opposite roles; after reversal, the replacement of S+ produced fewer errors than replacement of S−, despite the fact that before reversal replacement of that same stimulus as S− produced more errors.

Since replacement of S− produced more errors than did replacement of S+, the results can be interpreted as supporting the general assumption of D'Amato and Jagoda regarding the relative greater importance of S− in discrimination. Unfortunately, they neither confirm nor disconfirm the proposed relationship between changes in the importance of S− as a function of training and efficiency of discrimination reversal.

The results of the replaced-stimulus tests given after mastery were consistent with those obtained by Stevens and Fechter (1968) with positive reinforcement. However, the results differ from those of Mandler (1968) and Hall (1973), both of whom failed to find significant differences in errors between S− and S+ replaced conditions after mastery.

The results of tests after OT are consistent with those of Hall but opposite those of Mandler. Both Hall and the present study found significantly more errors when S− was replaced, while Mandler found significantly more errors when S+ was replaced after OT. These differences may be due to differences in apparatus, but how the apparatus differences would produce such a pattern of results is unclear. Mandler has offered an explanation of differential transfer-test results as a function of apparatus and level of training. Specifically, this position argues that early in discrimination training, the animal develops a "detour strategy" of running past the choice point, then looking up and turning around in the presence of S−. Then the animal runs back to the choice point and chooses the correct arm of the Y maze. This "detour strategy" makes S− the more important stimulus because "it is only in the presence of S− that the animal must execute the fairly complex response of slowing down and turning around" (Mandler & Hooper, 1967, p. 148). As acquisition continues into OT, the animal's response of observing the discriminanda occurs closer and closer to the choice point, until the animal tends to stop at the choice point and observe both discriminanda (cf. Pubols, 1956). The development of this "choice point strategy" tends to decrease the relative importance of S− leading to either a greater relative importance of S+ or an equality in importance of S+ and S−. Either of these results should also be found when extensive correction behavior is not employed, as in discrimination boxes where a choice point strategy is employed throughout training (Mandler, 1968). Thus Mandler's position predicts that the frequency of errors when S− is replaced should not significantly exceed the frequency of errors when S+ is replaced with overtraining where elaborate retracing of responses has been eliminated or in a discrimination box where elaborate retracing of errors is not required. In the present experiment, both of these conditions were met yet significantly more errors were made in an S− replaced transfer test as opposed to an S+ replaced transfer test.

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