JOURNAL OF THE EXPERIMENTAL ANALYSIS OF BEHAVIOR 1968, 11, 459-463 NUMBER 4 (JULY)

# *STIMULUS FUNCTION IN SIMULTANEOUS DISCRIMINATION*[1]

GERALD B. BIEDERMAN

UNIVERSITY OF TORONTO

In discrimination learning, the negativity of the stimulus correlated with nonreinforcement (S−) declines after 100 training trials while the stimulus correlated with reinforcement (S+) is paradoxically more positive with lesser amounts of discrimination training. Training subjects on two simultaneous discrimination tasks revealed a within-subjects overlearning reversal effect, where a more-frequently presented discrimination problem was better learned in reversal than was a discrimination problem presented less frequently during training.

In simultaneous discrimination the stimulus correlated with reinforcement (S+) and the stimulus correlated with nonreinforcement (S−) are presented on each trial. Discrimination might be attributed to subjects' learning to approach S+ or to avoid S−, or might be a weighted function of either possibility. Generalization gradients around S+ and S− have been the primary method for investigating whether a stimulus is exhibiting excitatory or inhibitory control. The logic of this method has been discussed by Jenkins (1965). A method described by Biederman (1967*a*) and by Deutsch and Biederman (1965) may allow a more direct evaluation of the relative contribution of S+ and S− to discriminative performance. In this procedure two simultaneous discriminations are trained at once, one receiving more training than the other. The probability that the more-trained discrimination problem will be presented is twice the probability, for example, that the less-trained discrimination problem will occur. After a prearranged number of trials the negative stimuli from the more-trained and less-trained discriminations are paired on a critical-choice trial. The stimulus selected is presumed to be the less aversive. In a similar manner, the positive stimuli may be paired, and the stimulus chosen is presumed the more positive. The preliminary experiments mentioned above indicated that the negative stimulus is not increasingly negative in the course of learning. Rats, in highly significant proportions and in a variety of tasks, chose more-trained S− rather than less-trained S−, contrary to models of discrimination learning which assume that S− directly increases in negativity with increases in amount of training (*cf*. Mackintosh, 1965; Sutherland, 1964).

The present experiment sought to determine the role of the positive and negative stimuli in simultaneous discrimination, using pigeons as subjects. A second purpose was to investigate the possibility of obtaining a within-subjects overlearning reversal effect by training subjects on two simultaneous discrimination problems at once. The overlearning reversal effect refers to the observation that animals receiving considerable overtraining reverse faster than subjects reversed after some learning criterion has been reached (Lovejoy, 1966). A within-subjects overlearning reversal effect may be said to be present if the more-trained discrimination is easier to retrain than the less-trained discrimination, after reversing the stimuli within each discrimination (S+ becomes S−, and S− becomes S+).

## METHOD

### *Subjects*

Thirty-six White Carneaux male pigeons (experimentally naive) were maintained at 80% of free-feeding weight.

[1]Research supported in part by Canadian National Research Council grant 185, and by Ontario Mental Health Foundation grant 106. I thank Miss M. Archer and Mr. G. Heighington for their assistance. Reprints may be obtained from the author, Scarborough College, University of Toronto, 1265 Military Trail, West Hill, Ontario, Canada.

*Apparatus and Procedure*

Training took place in commercial (Grason-Stadler) operant-conditioning chambers controlled by automated programming equipment. Stimuli were provided by standard stimulus projectors which illuminated the backs of the response keys. Pigeons were trained on Day 1 to peck, for food reinforcement, a single key illuminated with uniform white light. On Day 2 they were transferred to two-key experimental chambers where they were trained to respond to the lighted key. After a reinforced response, the illumination shifted on a random basis between the alternate keys. No reinforcement was given for a response to a darkened key; this obviated subject key-preference.

On Days 3 to 5, 150 discrimination training trials were given each day. This training consisted of 100 more-trained and 50 less-trained discrimination trials, in a randomly intermixed sequence. The pairs of discriminanda are shown in Fig. 1. Eighteen subjects were trained with color stimuli composing more- and less-trained discrimination problems, and 18 were trained with figure discrimination problems; this assignment was made on a random basis. Discrimination 1 served as the more-trained for nine subjects with Discrimination 2 as the less-trained for these subjects. Discrimination 2 was the more-trained for the remaining nine subjects in the color discrimination group, with Discrimination 1 the less-trained. A similar assignment occurred for subjects assigned a figure discrimination with the restriction that figures 4 and 5 were not presented as more-and less-trained discriminations. The assignment of a particular subject to a condition was random for any single subject. The positive stimulus within each discrimination was determined at random with the restriction that each stimulus serve an equal number of times as S+ and S− across subjects.

On each trial the problem (more-trained or less-trained) and the key displaying S+ were predetermined by plugboard units programmed with the aid of random number sequences. No subject was trained for more than one daily session under a particular program. Subjects were randomly assigned to one of three reinforcement duration groups (1.5, 3.0, or 6.0 sec), and to one of three time-

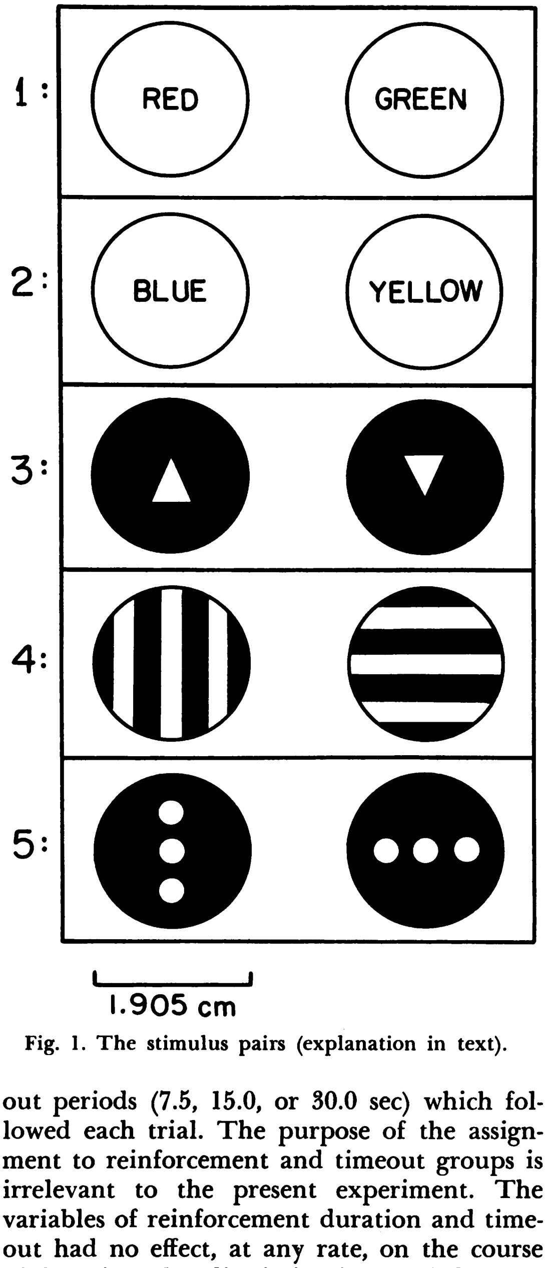


Fig. 1. The stimulus pairs (explanation in text).

out periods (7.5, 15.0, or 30.0 sec) which followed each trial. The purpose of the assignment to reinforcement and timeout groups is irrelevant to the present experiment. The variables of reinforcement duration and timeout had no effect, at any rate, on the course of learning the discriminations (Biederman, 1967*b*). A trial was started by the appearance of the discriminative stimuli which remained illuminated until the subject responded. A correct response was followed by access to the illuminated grain hopper for the length of the reinforcement duration. A timeout, in which the keys were darkened and deactivated, followed the reinforcement. An incorrect response produced only the timeout. A 20-pen event recorder and automatic counters recorded the performance on each trial and on the test pairings.

At the end of each subject's daily session an additional trial was presented consisting of discrimination components (*e.g.*, more-trained S— and less-trained S—) and a choice was permitted. The key at which the more-trained stimulus appeared was randomly preselected with reinforcement given randomly.

On Days 6 to 8, 150 reversal trials were presented daily. More-trained and less-trained discriminations retained their relative frequency of occurrence, but the stimuli originally negative were correlated with reinforcement, and the originally positive stimuli were now correlated with nonreinforcement.

## RESULTS

After 150 training trials (100 more-trained, 50 less-trained) 14 of 18 subjects chose the more-trained S— rather than the less-trained S—. The binomial expansion shows that this selection is significant ($p < 0.030$). This finding is consistent with the choices of rats in previous experiments (Biederman, 1967*a*). A result not consistent with rat data was that 15 of 18 pigeons preferred the less-trained S+ to the more-trained S+ ($p < 0.008$). Choices in later stages of training declined in significance, as might be expected, because in later trials less-trained discriminations received the same absolute amount of training as more-trained discriminations after 150 trials. The choices were in the same direction as choices after 150 trials, except for more-trained S— *vs.* less-trained S— after 450 trials, where nine subjects chose each stimulus (see Table 1).

Figure 2 (left) shows that the more-trained discriminations were better learned than the less-trained discriminations throughout training. This performance difference is shown statistically by t tests, with each subject providing a difference score between more-trained and less-trained discriminations. On the block of 50 trials preceding Test I, $t = 5.59$, $df = 35$, $p < 0.005$; on the block preceding Test II, $t = 4.84$, $df = 35$, $p < 0.005$; on the 50 trials preceding the last test trial, $t = 5.90$, $df = 35$, $p < 0.005$.

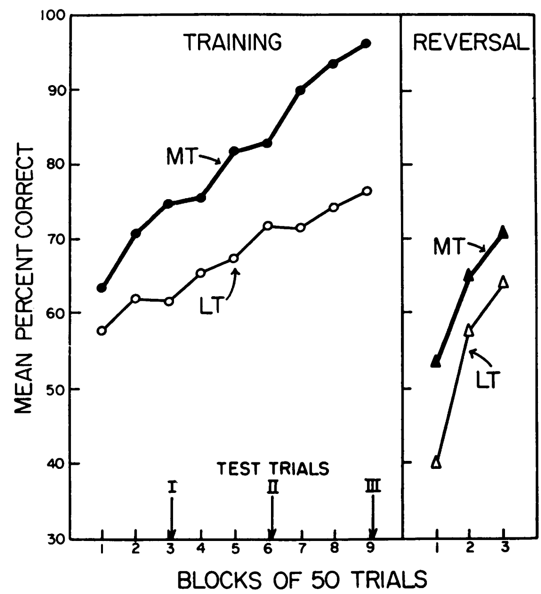


Fig. 2. (Left) Performance during training and reversal. Training blocks represent 50 trials each containing more-trained (MT) and less-trained (LT) discriminations in a ratio of 2:1. (Right) Reversal data from the first 150 more-trained and total 150 less-trained discriminations on reversal days.

Table 1

Number of subjects choosing more-trained or less-trained stimulus component on the critical test trials.

| Trials Preceding Choice | *Test Choice (N = 18) More-Trained S+ vs. Less-Trained S+* | | *Test Choice (N = 18) More-Trained S— vs. Less-Trained S—* | |
|---|---|---|---|---|
| | *More-Trained* | *Less-Trained* | *More-Trained* | *Less-Trained* |
| 150 (100 more-trained 50 less-trained) | 3 | 15 ($p < 0.008$) | 14 | 4 ($p < 0.030$) |
| 300 (200 more-trained 100 less-trained) | 7 | 11 | 10 | 8 |
| 450 (300 more-trained 150 less-trained) | 7 | 11 | 9 | 9 |

The technique of training each subject on two simultaneous discriminations (more-trained and less-trained) revealed a within-subject overlearning reversal effect, as shown in Fig. 2 (right). The discriminations better learned during training are better learned during reversal. When the reversal performance on the first 150 more-trained trials was compared with the reversal learning on 150 less-trained reversal trials, the more-trained were significantly better. During the first block of 50 reversal trials, $t = 4.35$, $df = 35$, $p < 0.005$; during the second block of 50 trials, $t = 3.96$, $df = 35$, $p < 0.005$; during the third block of 50 trials, $t = 3.54$, $df = 35$, $p < 0.005$.

## DISCUSSION

The choices of more-trained S− and less-trained S+ on the critical test trials cannot both be explained by any present theory of discrimination learning. Theories which have as an explicit assumption that the inhibitory properties of S− increase monotonically over the course of learning would predict that the less-trained S− would be less inhibitory than the more-trained S− (Sutherland, 1964).

Frustration theory (Amsel, 1962) might predict the choice of the more-trained rather than the less-trained S−, since it might be assumed that subjects have less experience with more-trained S−, than with the less-trained S−. D'Amato and Jagoda (1961) assumed that less-frequent exposure to S− attenuates its inhibitory properties. In fact, subjects responded more frequently to more-trained S− than to less-trained S− in absolute terms, although the performance was better in more-trained discriminations. The mean accuracy of pigeons on the more-trained discriminations over 100 trials was 69.5% (30.50 errors) while on 50 less-trained discriminations trials the mean accuracy was 60.5% (19.75 errors). The choice of more-trained S− might occur through stimulus generalization, but the preference for the less-trained S+ cannot be similarly explained. In any event, if generalization of S+ to S− were occurring, the discriminative performance might be retarded. Stimulus novelty might explain the preference for less-trained S+, but the choice of more-trained S− could not be so explained.

In summary, the results of this experiment suggest that the excitatory and inhibitory properties of S+ and S−, respectively, do not increase monotonically throughout the course of discrimination learning. It would seem that the control provided by S+ and S− proceeds through a stage in which the controlling properties of the positive and negative stimuli are temporarily strengthened. Terrace (1966) provided data which may be relevant to the results of the present experiment. He has found that behavioral contrast and the peak shift tend to disappear as discrimination training continues. Responding to S+ and the shift from S− are presumed to be the result of emotional responses elicited by S− which may diminish as training becomes more extensive (as in the more-trained case).

Future investigations using the present method might study choices in probe trials consisting of the stimulus components of the discrimination and neutral (novel) stimuli, and a wider range of training might be considered. It would also be interesting to consider the results of choices not attempted in the present experiment, such as more-trained S− *vs.* less-trained S+, or more-trained S+ *vs.* less-trained S−. It might be profitable to attempt to train these stimulus combinations as a new discrimination problem. Thus, the problem would be to determine which stimulus components from the original discriminations are most effective in facilitating subsequent discrimination.

The method of comparing more-trained and less-trained discriminations in reversal may provide a method for studying the overlearning reversal effect within each subject rather than the statistical comparison of overtrained and criterion groups. The present results indicate that an overlearning reversal effect may have been present within subjects.

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*Received 1 September 1967.*