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Assessment of the relative importance of S+ and S− in rats, using intercurrent simultaneous and successive discriminations

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Replaced-stimulus transfer tests were used to assess the relative importance of S+ and S− without the confoundings typically associated with that procedure. Albino rats were given intercurrent training on a successive discrimination and a simultaneous discrimination. Then, two replaced-stimulus transfer tests were given. For one test, the S+ from the simultaneous discrimination was replaced by a stimulus from the successive discrimination. For the other test, the S− from the simultaneous discrimination was replaced by the other stimulus from the successive discrimination. More errors occurred when S− was replaced than when S+ was replaced. This finding showed that S− was the relatively more important stimulus.

Investigations of the relative importance of S+ and S− in discrimination learning have used several procedures: replaced-stimulus transfer tests (e.g., Hall, 1973; Mandler, 1968; Stevens & Fechter, 1968), single-stimulus training (e.g., Harlow & Hicks, 1957; Vaughter, Tyer, & Halcomb, 1966), and multiple-stimulus discriminations (e.g., Mandler, 1970, 1971; Mullins & Winefield, 1979). The interpretation of results obtained using these procedures is beset by problems in experimental design and errors in fundamental assumptions.

Stevens and Wixon (1976) assessed whether novel or complex stimuli confound replaced-stimulus transfer tests, single-stimulus training, and multiple-stimulus discrimination. They found that the relative complexity of replacement stimuli significantly biased the results of replaced-stimulus transfer tests in favor of an interpretation stressing the relative importance of S−. The relative novelty of the replacement stimulus produced a similar bias. Finally, manipulating the relative attractiveness of stimuli produced results consistent with an interpretation stressing the importance of S+. While these findings suggest that previous assessments of relative stimulus control have produced results influenced by nonassociative factors, they did not indicate which stimulus was relatively more important.

Recently, using a new method, Mason, Stevens, Wixon, and Owens (1980) reported two studies that assessed the degree of control exerted by S+ and S− without confoundings by nonassociative factors. For the first experiment, training was given on two discrimination problems with more training on one problem than on the other. During transfer tests that followed training, the more-trained stimuli from the one problem were paired with the less-trained stimuli from the other. The transfer test results were consistent with an interpretation stressing the relative importance of S−; that is, fewer errors were made when a more-trained S− was paired with a less-trained S+ than when a more-trained S+ was paired with a less-trained S−. The results from a control group given uncorrelated reinforcement during training showed that differences in stimulus exposure could not account for the differences in stimulus importance. The second experiment by Mason et al. demonstrated that S− was the relatively more important stimulus over various levels of training.

Because these results have theoretical importance, their confirmation using another technique is required. Replaced-stimulus transfer tests could be used if the novelty of the replacement stimulus (and thus its nonassociative attractiveness) could be eliminated in a way that precludes confounding by differential associative transfer. Lawrence (1949) provided a means of eliminating the novelty of the replacement stimulus in replaced-stimulus transfer tests while precluding differential associative transfer. Specifically, simultaneous and successive discriminations can be presented intercurrently, so that there is no differential associative transfer. These intercurrent presentations preclude confounding by position bias interacting with stimulus configuration and reinforcement contingencies when successive discrimination is followed by a simultaneous discrimination (Siegel, 1967). In the present study, rats were trained intercurrently on simultaneous and successive discriminations and then given replaced-stimulus transfer tests using stimuli for the successive discrimination for replacement.

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METHOD

Subjects

The subjects were 48 male albino rats of the Charles River CD strain, bred in our laboratory. All animals were 60 days old at the start of the experiment.

Apparatus

A medium-gray trapezoidal discrimination box similar to that described by McGaugh and Thomson (1962, Figure 1) was used. The box was 68.5 cm long x 30.5 cm wide at one end and 15.2 cm wide at the other end x 12.7 cm high. A guillotine door 18 cm from the narrow end of the apparatus defined the startbox. Two openings, each 7.6 cm square and 15.2 cm apart, were located in the wall at the wide end. Swinging doors faced with stimulus cards were located behind these openings. When pushed, one door (S+) exposed a dish containing .2 ml of water. The other door (S−) was locked shut. Both stimulus doors were illuminated by a 15-W bulb 76 cm away. Approaches to within 7.6 cm of S− were detected by an electrical circuit that objectively defined errors (Stevens & Wixon, 1976).

The stimuli were a card with a black-and-white four-cell checkerboard pattern (3.8-cm squares) and cards with black-and-white alternating 1.3-cm horizontal, vertical, or diagonal stripes.

Procedure

Animals were gentled and adapted to 23 h 50 min of water deprivation. Then 10 reinforced pretraining trials were given on each of 4 consecutive days. Medium-gray stimulus doors were used. The rats were shaped to run from the startbox to the other end of the apparatus and to push against the unlocked door. Approaches to the locked door were prevented by a gray wooden block placed in front of it. Throughout the experiment, a correction procedure was used, and the intertrial interval was approximately 60 sec.

After pretraining, the animals were given reinforced intercurrent training on a simultaneous discrimination problem and a successive discrimination problem. The design is shown in Figure 1. The animals were given 10 trials/day on each problem until a criterion of 9 correct out of 10 responses was reached on the simultaneous discrimination. Next, two intercurrent replaced-stimulus transfer tests were given to each subject. For one test, the S+ from the simultaneous discrimination was replaced by a stimulus from the successive discrimination. For the other test, the S− from the simultaneous discrimination was replaced by the other stimulus from the successive discrimination. Transfer testing continued until the animals responded correctly on 11 out of 12 trials. To counterbalance potential stimulus effects on transfer tests, each of the 24 pairs of rats was assigned 1 of the 24 mutually exclusive two-pair stimulus sets that could be formed from the four stimuli. Spatial placement of stimuli from trial to trial was determined by Gellerman sequences during training, in which 20 trials/day were given, and by Fellows sequences during transfer tests, in which 12 trials/day were given.

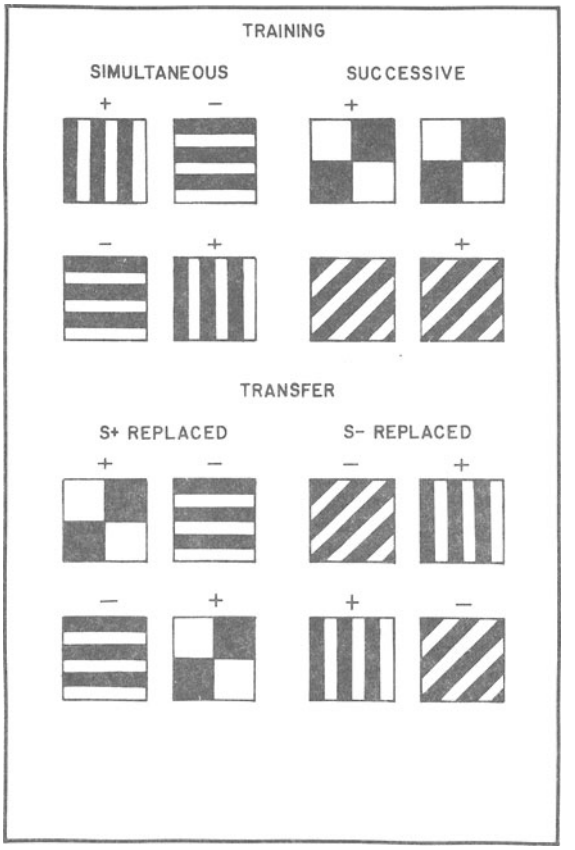

Figure 1. Experimental design: Animals were trained on intercurrent simultaneous and successive discriminations, and then they were given the simultaneous discrimination with one successive stimulus or the other replacing either S+ or S−. All possible combinations of stimuli were used; the combination shown is only an example.

RESULTS AND DISCUSSION

Errors from the training and transfer phases were analyzed using one-way analyses of variance for repeated measures. During training, significantly more errors were made on the successive discrimination problem (mean = 33.10) than on the simultaneous discrimination problem (mean = 22.10) [$F(1,47) = 75.20$, $p < .05$]. This result is consistent with those of a variety of studies that have shown that acquisition of a simultaneous discrimination problem is more rapid and occurs with fewer errors than does acquisition of a successive discrimination problem (e.g., Bitterman & McConnell, 1954; Spence, 1952). Mackintosh (1974, pp. 546-553) concluded that the relative ease of simultaneous discrimination learning stems from the subjects' predisposition to learn by approaching S+ and/or avoiding S−. The transfer tests in the present study assess which of these predispositions is the relatively more important.

On the transfer tests, significantly more errors were made with S− replaced (mean = 10.52) than with S+ replaced (mean = 9.48) [$F(1,47) = 4.31$, $p < .05$]. This result indicates that S− is the relatively more important stimulus. The results of the present investigation are consistent with those of other recent investigations carried out in our laboratory. In every case, greater transfer followed more frequent experience with S− than with S+. Studies carried out in other laboratories have shown that S− has inhibitory effects; they demonstrated that a previously given S− functions as a conditioned negative reinforcer (Terrace, 1972) and that a previously given S− is resistant to subsequent conditioning as an S+ (Hearst, Besley, & Farthing, 1970).

In addition to the instrumental procedures used here, a number of studies using classical paradigms have also obtained results that stress the importance of S–. For example, Rescorla (1969) and Wasserman, Franklin, and Hearst (1974) found that animals consistently moved away from a stimulus that was correlated with nonreinforcement and approached a stimulus that was correlated with reinforcement, even though no response was required to obtain reinforcement. This result supports Jenkins' (1965) statement that inhibition may be identified with the development of a response to S– that is incompatible with the reinforced response.

The results obtained here imply that rats learn a stimulus-nonreinforcement correlation more rapidly and with fewer errors than they learn a stimulus-reinforcement correlation. Similar implications follow from the results obtained using both free-operant and classical techniques (cf. Hearst et al., 1970). Consequently, we suggest that traditional views of animal learning that place either relatively greater emphasis on reinforcement or equal emphasis on reinforcement and nonreinforcement in discrimination learning require reevaluation.

REFERENCES

BITTERMAN, M. E., & MCCONNELL, J. V. The role of set in successive discrimination. *American Journal of Psychology,* 1954, **67**, 129-132.

HALL, G. Response strategies after overtraining in the jumping stand. *Animal Learning & Behavior,* 1973, **1**, 157-160.

HARLOW, H. F., & HICKS, L. H. Discrimination learning theory: Uniprocess vs. duoprocess. *Psychological Review,* 1957, **64**, 104-109.

HEARST, E., BESLEY, S., & FARTHING, G. W. Inhibition and the stimulus control of operant behavior. *Journal of the Experimental Analysis of Behavior,* 1970, **14**, 373-409.

JENKINS, H. M. Generalization gradients and the concept of inhibition. In D. Mostofsky (Ed.), *Stimulus generalization.* Palo Alto, Calif: Stanford University Press, 1965.

LAWRENCE, D. H. Acquired distinctiveness of cues: I. Transfer between discriminations on the basis of familiarity with the stimulus. *Journal of Experimental Psychology,* 1949, **39**, 770-784.

MACKINTOSH, N. J. *The psychology of animal learning.* New York: Academic Press, 1974.

MANDLER, J. M. Overtraining and the use of positive and negative stimuli in reversal and transfer. *Journal of Comparative and Physiological Psychology,* 1968, **66**, 110-115.

MANDLER, J. M. Two-choice discrimination learning using multiple stimuli. *Learning and Motivation,* 1970, **1**, 261-266.

MANDLER, J. M. Multiple stimulus discrimination learning, II. Effects of prior training. *Psychonomic Science,* 1971, **23**, 195-196.

MASON, J. R., STEVENS, D. A., WIXON, D. R., & OWENS, M. P. Assessment of the relative importance of S+ and S– in rats using differential training on intercurrent discriminations. *Learning and Motivation,* 1980, **11**, 49-60.

MCGAUGH, J. L., & THOMSON, C. W. Facilitation of simultaneous discrimination with strychnine sulphate. *Psychopharmacologica,* 1962, **3**, 166-172.

MULLINS, G. P., & WINEFIELD, A. H. The relative importance of responses to S+ and S– in simultaneous discrimination learning. *Quarterly Journal of Experimental Psychology,* 1979, **31**, 329-338.

RESCORLA, R. A. Conditioned inhibition of fear. In N. J. Mackintosh & W. K. Honig (Eds.), *Fundamental issues in associative learning.* Halifax, Nova Scotia: Dalhousie University Press, 1969.

SIEGEL, S. Overtraining and transfer processes. *Journal of Comparative and Physiological Psychology,* 1967, **64**, 471-477.

SPENCE, K. W. The nature of the response in discrimination learning. *Psychological Review,* 1952, **59**, 89-93.

STEVENS, D. A., & FECHTER, L. D. Relative strengths of approach and avoidance tendencies in discrimination learning of rats trained under two types of reinforcement. *Journal of Experimental Psychology,* 1968, **76**, 489-491.

STEVENS, D. A., & WIXON, D. R. Stimulus quality and assessment of the relative importance of S+ and S–. *Journal of Experimental Psychology: Animal Behavior Processes,* 1976, **2**, 214-220.

TERRACE, H. S. By-products of discrimination learning. In G. H. Bower (Ed.), *The psychology of learning and motivation* (Vol. 5). New York: Academic Press, 1972.

VAUGHTER, R. M., TYER, Z. E., & HALCOMB, C. G. Discrimination performance in deprived and non-deprived rats as a function of pre-discrimination information. *Psychonomic Science,* 1966, **5**, 199-200.

WASSERMAN, E. A., FRANKLIN, S., & HEARST, E. Pavlovian appetitive contingencies and approach vs. withdrawal to conditioned stimuli in pigeons. *Journal of Comparative and Physiological Psychology,* 1974, **86**, 616-627.

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