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TESTING FOR INHIBITORY STIMULUS CONTROL WITH S– SUPERIMPOSED ON S+[1]

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Pigeons learned a successive discrimination between a positive stimulus (red) correlated with a variable-interval 1-min reinforcement schedule and a negative stimulus (vertical line) correlated with either a variable-interval 5-min schedule or extinction. Transfer tests measured the rate of responding to the positive stimulus alone, to various orientations of the negative stimulus, and to the same line orientations superimposed on the positive stimulus. Although there were no gradients with minima at the training value for the negative stimulus dimension, the addition of the negative stimulus dimension to the positive stimulus always resulted in a lower response rate than that for the positive stimulus alone. The results demonstrate that an operational definition of inhibitory stimulus control that requires increased responding to stimuli more distant from a negative stimulus (along some dimension) is not always consistent with a definition that requires the suppression of responding in the presence of one stimulus, the positive stimulus, by the simultaneous presentation of another, the negative stimulus.

There are at present two basic methods used for demonstrating inhibitory stimulus control (Staddon, 1969). Both involve training in which responding is reinforced in the presence of a positive stimulus (S+) and reinforced less, or not at all, in the presence of a negative stimulus (S–). They differ, however, in their procedures for assessing the properties of S–.

The first technique, illustrated by Honig, Boneau, Burstein, and Pennypacker's (1963) study, explores the properties of S– by measuring the changes in response rate that result from changes in the value of S– along its defining physical dimension (*e.g.*, wavelength or line orientation). The lowest rate of responding typically occurs in the vicinity of the training value of S–, with increasing rates in the presence of stimuli more remote from S–. Although this function is traditionally called an inhibitory stimulus generalization gradient, the descriptive term *incremental gradient* is used here to denote a response curve that ascends as stimuli vary from the training value. (Conversely, a *decremental gradient* refers to a curve that descends as stimuli vary from the training value.)

The second technique is exemplified by Brown and Jenkins' (1967) study. They identified the inhibitory property of a stimulus by its ability to lower the rate of responding maintained by another stimulus when both stimuli were presented simultaneously. This direct demonstration of the suppressing effect S– has on responding obviously does not involve variations in the value of S–, as in the case of the generalization test.

These two procedures may be viewed as different operational definitions of inhibitory stimulus control. As such, they have presumably been considered to be concordant. The present experiment examined this assumption by combining the two techniques and comparing their results. This was done by including stimuli along the S– dimension (line orientation) superimposed on S+ (hue) as part of the usual S– generalization test. In addition, this study attempted to compare the effects of two different schedules correlated with S– (variable interval 5-min *versus* extinction), both of which are relatively unfavorable compared to the schedule correlated with S+ (variable interval 1-min).

METHOD

Subjects

Four White Carneaux pigeons, two naive (115, 116) and two experienced (26, 38), were

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maintained at 75% of their free-feeding weights.

Apparatus

The experimental chamber was made of wood and measured 12 by 12 by 14 in. (30 by 30 by 36 cm). No houselight was used except during shaping. A feedback relay operated with each effective peck of 0.135-N (24-g) minimum force. Extraneous sound was masked by white noise and noise from the ventilating fan. Reinforcement was 3-sec access to mixed grain, during which the key was darkened and pecks were ineffective.

Stimuli were projected onto a 1-in. (2.5 cm) translucent key by a Kodak Carousel projector (model 750) with a Sylvania 500-w DEK lamp. The basic stimulus components consisted of a non-monochromatic red surround, a white surround, and a 1/8 in. (3.2 mm) black line in eight orientations designated by their clockwise (positive) or counterclockwise (negative) deviation from vertical (0°) as ± 22°, ± 45°, ± 67°, and ± 90°. The stimulus intensities were reduced by using the 450-w setting of the projector and a neutral density (3.00) filter. Scheduling was accomplished via the stimulus slides projecting upon an array of photocells mounted behind and to one side of the key. Additional logic circuitry and recording equipment were housed in an adjacent room.

Procedure

After the birds had been trained to peck the lighted key, they were placed on a multiple variable-interval 1-min variable-interval 1-min schedule (*mult* VI 1-min VI 1-min). This schedule consisted of two stimuli presented in regular alternation 40 times each per daily session. The stimuli were correlated with identical but independent schedules in which reinforcement followed the first response after irregular amounts of time with a mean interval of 1 min. For the first few sessions each stimulus presentation lasted 45 sec, but the duration was increased to 60 sec for all later training sessions. Due to the operation of the slide changer, there was a brief (< 1 sec) blackout between every stimulus presentation, during which pecks were ineffective.

After 13 sessions of preliminary training the schedules were changed to one of two conditions. In all cases, S+ (red key) was correlated with a VI 1-min reinforcement schedule. But S− (vertical black line bisecting a white key) was correlated with: (1) VI 5-min for Birds 26 and 115; or (2) extinction (EXT) for Birds 38 and 116. After 24 sessions on condition (1), Birds 26 and 115 were changed to condition (2). Transfer tests were separated by an average of 12 training sessions, with the first test occurring 4 to 5 days after the change to unequal reinforcement schedules.

Three types of test stimuli were used: (1) S+ (red) alone; (2) eight line orientations spaced equally along the S− continuum (black lines on white surrounds); and (3) the same line orientations superimposed on S+ (black lines on red surrounds). The first two regular test sessions consisted of a warm-up of at least two presentations each of S+ and S− with responding reinforced according to the usual schedules, followed by 80 test stimuli presented in extinction. The 80 test stimuli were grouped into four blocks, with each block of 20 randomly arranged stimuli including four presentations of S+ alone, one presentation of each of the eight line orientations on white, and one presentation of each of the eight line orientations on red.

The third transfer test was composed of a series of four "probe" tests administered within four nonconsecutive daily training sessions. This change in method of testing was made in an attempt to circumvent the increasing tendency not to respond during regular tests. A probe test session consisted of a block of 20 test stimuli, as described for the first two regular tests, and 60 presentations of training stimuli. The test stimuli were arranged randomly after every third training stimulus, thus occurring equally after S+s and S−s. All test stimuli were presented in extinction, but the training stimuli were correlated with their regular reinforcement schedules (VI 1-min and EXT). Unlike the two earlier test sessions, stimuli changed every 60 sec.

RESULTS

Results obtained in each stimulus control test are shown in Fig. 1. It should be noted that the ordinates have been expanded in some cases to gain a higher degree of resolution. This should not obscure the fact that there was a general tendency in all the birds to respond less in later test sessions.

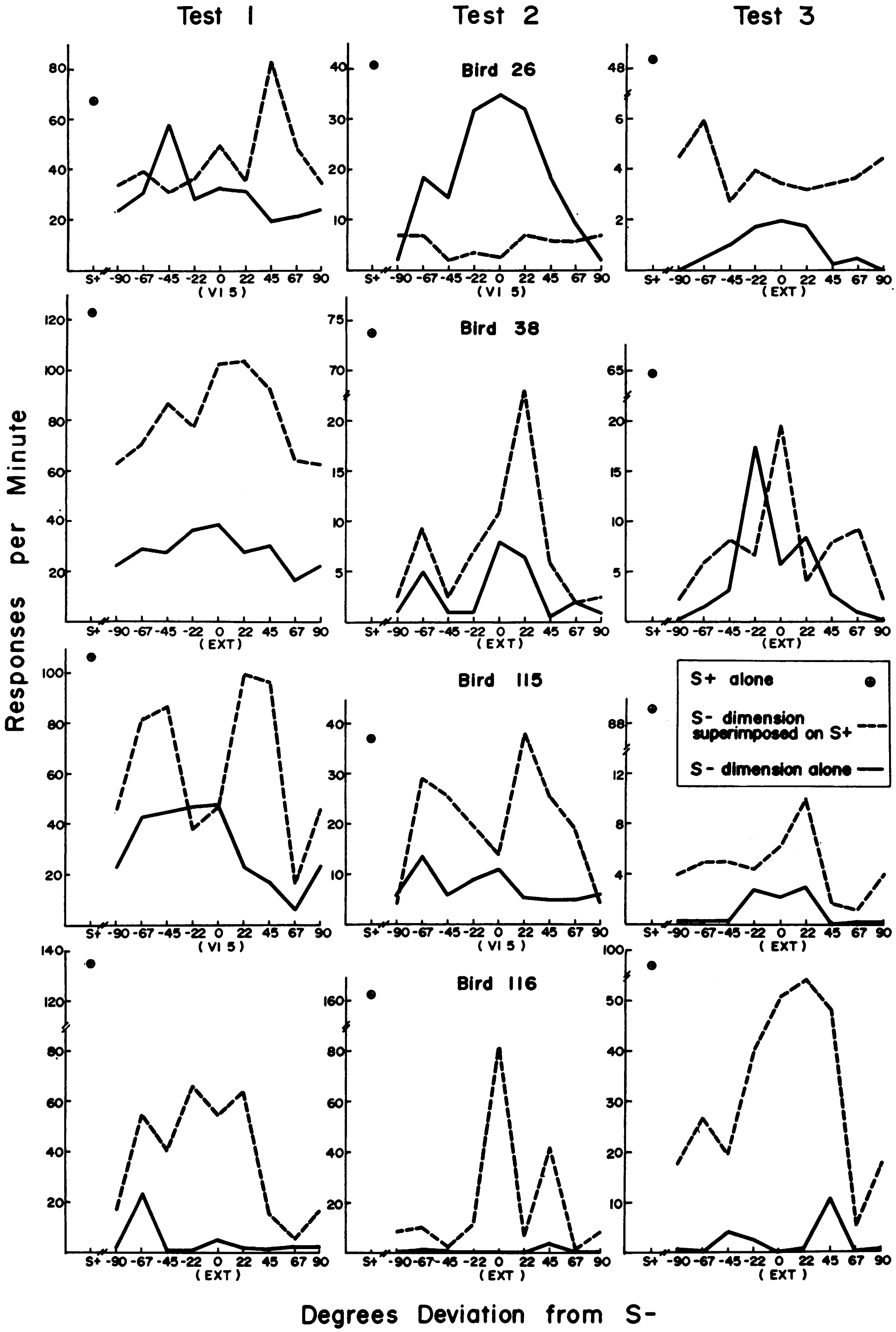

Fig. 1. Individual response rates during each of three transfer tests. The schedule correlated with S— at the time of testing is indicated in parentheses.

In every case except one (test 2 for Bird 26), response rates were lowest for the S— dimension alone, a little higher or intermediate for the S— dimension superimposed on S+, and highest for S+ alone. The only indication of an incremental gradient was along the S— dimension superimposed on S+ in test 2 for Bird 26; otherwise, the gradients for the compounds of the S+ and S— dimensions were generally decremental and the gradients for the S— dimension alone were either decremental or of zero slope. Worth noting are the "M-shaped" compound stimulus gradients of Bird 115. Although this form of gradient was peculiar to Bird 115 in this experiment, other studies in this laboratory have often found similarly shaped gradients for compounds of stimuli correlated with unequal variable-interval schedules of reinforcement.

DISCUSSION

The present results demonstrate that two current operational definitions of inhibitory stimulus control are not necessarily consistent with one another. If the sole criterion for inhibitory stimulus control is the presence of an incremental gradient around the stimulus value used in training, then S— was not an inhibitory stimulus in this experiment. Since there were in fact decremental gradients along the S— dimension in some instances, the commonly accepted definition that equates stimulus control with the form of the generalization gradient (Terrace, 1966 a, b) presumably requires that S— sometimes be identified here as an excitatory stimulus. Yet, on every occasion, the addition of S— to S+ resulted in a lower response rate than that for S+ alone. Thus, S— was always inhibitory in the sense that it was capable of reducing a given response rate.

A further difficulty with the generalization-gradient definition of stimulus control is illustrated by the results of Bird 116. Since this bird's S— gradients were all of zero slope, an analysis of selective attention of the type made by Newman and Baron (1965) would lead to the conclusion that line orientation was not the controlling dimension in learning the discrimination between S+ and S—. Rather, it could have been that the bird formed the discrimination on the basis of intensity or hue differences between S+ and S—. But examination of the compound stimulus gradients for Bird 116 reveals rather well-defined decremental gradients around the line orientation value used in training, thus indicating some sort of "stimulus control" along the nominal S— dimension and, presumably, some attention to that element of the total S— configuration during training (*cf.* Farthing and Hearst, 1970).

A control group in a study by Lyons (1969) provides an incidental but virtually direct comparison with the present experiment. Confirmed here by the results of Birds 38 and 116 was Lyons' finding of a decremental gradient along the S— (line orientation) dimension superimposed on S+ (555 nm surround) after training on a *mult* VI 30-sec EXT schedule. Notably absent here, however, were the typical incremental gradients that Lyons found along the S— dimension; indeed, in some cases there were even decremental gradients in their place. Notwithstanding the absence of incremental S— gradients, one point seems clear just from an examination of the compound stimulus gradients in Lyons' study as well as the present one: a decremental pattern of responding to variations of a stimulus dimension (line orientation, superimposed on constant hue) does not necessarily mean that that dimension is excitatory in nature. In fact, as was shown here, the dimension may serve an inhibitory function by its ability to lower a given response rate when superimposed on S+.

The only consistent difference between correlating either VI 5-min or EXT with S— was found not in the S— gradients but in the relative response rates for S+ alone. When S— had been correlated with EXT, response rates for S+ alone in tests were relatively higher than when S— had been correlated with VI 5-min. This was true not only between birds (26 and 115 *versus* 38 and 116) but within birds (before *versus* after the change from VI 5-min to EXT in Birds 26 and 115). Thus, the relative inhibitory quality of S— was not accurately gauged by either the form or the absolute height of the gradients along that dimension; rather, it appears to have been reflected in an effect akin to positive behavioral contrast (Reynolds, 1961), *i.e.*, an increase in responding to one stimulus (S+) correlated with a given reinforcement schedule due to a reduction in reinforcement for responding to another stimulus (S—).

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