INHIBITORY STIMULUS CONTROL FOLLOWING ERRORLESS DISCRIMINATION LEARNING¹

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Three generalization procedures were used to investigate inhibitory stimulus control following discrimination learning with few errors. Three groups of pigeons acquired a discrimination between a green stimulus (the positive stimulus) and a vertical or horizontal line (the negative stimulus) through differential autoshaping followed by multiple schedule presentation of the two stimuli with gradually increasing stimulus durations. Generalization testing was along a line-tilt continuum. For one group, the test involved a resistance-to-reinforcement procedure in which responses to all line tilts were reinforced on a variable-interval schedule. For a second group, also tested with the resistance-to-reinforcement procedure, the lines were superimposed on the green field that formerly served as the positive stimulus. A third group was tested in extinction with the combined stimuli. Control groups had no discrimination training but responding to green was nondifferentially reinforced. The control subjects responded more to all line tilts during testing than did the comparable experimental subjects, indicating that the negative stimulus had become an inhibitory stimulus. Both resistance-to-reinforcement groups revealed inhibitory gradients around the negative stimulus, but the gradient for the extinction group was relatively flat. These data are consistent with others that modify Terrace's early conclusion concerning the failure of inhibition to develop during errorless training.

Key words: inhibitory stimulus control, errorless learning, resistance to reinforcement, combined-cues, stimulus generalization, generalization gradients, autoshaping, key peck, pigeons

In interdimensional discrimination training, the stimulus correlated with reinforcement, S+, is selected from a stimulus dimension that is orthogonal to the stimulus dimension correlated with extinction, S-. When two dimensions are orthogonal, each stimulus from the S+ dimension is equally distant psychologically from each stimulus on the S- dimension. When a stimulus generalization test follows interdimensional discrimination training, an excitatory or decremental gradient is typically obtained around S+ and an inhibitory or incremental gradient is usually obtained around S-.

Two experiments by Terrace (1966b, 1972) are an apparent exception to the above generalization. When test stimuli from the negative stimulus dimension were presented

during extinction following errorless interdimensional training, a flat stimulus generalization gradient with virtually zero responses to each test stimulus was obtained. An inhibitory gradient with a minimum at or close to S- was obtained when the discrimination was acquired with errors. Terrace drew two conclusions from these data: (1) The S- was a neutral stimulus and not an inhibitory stimulus following errorless learning. (2) Inhibitory stimulus control by the S- dimension was absent following interdimensional training.

Several experiments have convincingly demonstrated that an errorless S- is an inhibitory stimulus. Wessells (1973) obtained errorless learning by autoshaping the pecking response in a differential conditioning paradigm. In Wessells' experiment, a green light on the key was always followed by food, while a vertical line on a black background was never followed by food. Errorless learning was obtained because very few responses occurred

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to the vertical line. In a combined-cues test, S— substantially decreased responding when combined with S+. In a resistance-to-reinforcement test in which the white vertical line was followed immediately by food in an autoshaping paradigm, the previous S— showed slower acquisition of the pecking response than a novel stimulus. Using an errorless autoshaping procedure similar to that employed by Wessells (1973), Wilkie and Ramer (1974) found that an errorless S— was more resistant to autoshaping than an errorful S—. Marsh and Johnson (1968) were the first investigators to suggest that an errorless S— is an inhibitory stimulus. First they established an errorless successive discrimination. When the reinforcement contingencies were reversed in the second phase of the experiment, four of the five subjects did not respond to S+ (the former errorless S—) more than once during five days of reversal training.

In interpreting the stimulus generalization gradients obtained following errorless interdimensional training, Terrace (1966*b*) argued that "a U-shaped gradient, with a minimum at S— would indicate that S— was an inhibitory stimulus, while a flat gradient would indicate the absence of any inhibitory function" (p. 1678). An alternative to Terrace's interpretation was proposed by Deutsch (1967) and by Hearst, Besley, and Farthing (1970, p. 388). They argued that the assessment of stimulus control by the S— dimension is ambiguous when all stimuli on the S— dimension produce zero responding because a "floor effect" prevents detection of less responding at S—. Hearst *et al.* suggested that the assessment of stimulus control by the S— dimension required an elevation in the overall level of responding to each of the stimuli during the stimulus generalization test. If Terrace's interpretation is correct, the elevated gradient should remain flat.

Hearst *et al.* (1970) and Hearst (1972) proposed two methods for elevating responding by modifying the procedure for obtaining the stimulus generalization gradient. (1) In the combined-cues test, stimuli from the S— dimension are combined with S+ and the two stimuli are presented simultaneously to the organism as a compound stimulus during extinction. Since the presentation of S+ alone controls responding, this test assumes that the simultaneous presentation of S+ and S— will

control a higher rate of responding than the presentation of S— alone. (2) In the resistance-to-reinforcement test, responding during each test stimulus is reinforced on an identical schedule of reinforcement, rather than extinguished, as is usually the case. This test assumes that the presence of an inhibitory stimulus retards conditioning.

The present experiment assessed stimulus control by the S— dimension following errorless interdimensional discrimination training. The factorial combination of resistance-to-extinction *versus* resistance-to-reinforcement with noncompounding *versus* compounding produces four conditions for obtaining a stimulus generalization gradient: resistance-to-extinction without compounding, resistance-to-extinction with compounding, resistance-to-reinforcement without compounding, and resistance-to-reinforcement with compounding. Terrace's experiments employed resistance-to-extinction without compounding. The present experiment extends Terrace's research by comparing the three other procedures for measuring stimulus generalization following interdimensional errorless learning. Each of the three procedures was designed to elevate the rate of responding during the stimulus generalization test.

To increase the probability of obtaining errorless learning, operant discrimination training was preceded by autoshaping, using a differential conditioning paradigm similar to that developed by Wessells.

METHOD

Subjects

Experimentally naive White-Carneau pigeons, maintained at 80% of their free-feeding weights, were divided into five groups. None of the birds was dropped from the experiment after the pecking response was acquired in the autoshaping procedure.

Apparatus

A Lehigh Valley Electronics test panel with two keys was mounted in an experimental chamber with inside dimensions of 33.3 by 33.3 by 33.3 cm. The stimuli were presented only on the left key using a Kodak Carousel 800H projector. The stimuli were illuminated by a 300-W Quartzline lamp. The projector was controlled by a Lehigh Valley Electronics

111-10 Carousel control panel with the stimulus intensity set at 3.4 log cd/m² as measured by an SEI photometer. The positive stimulus (S+) was a homogeneous green light on the key produced from a Kodak Wratten filter #99 that had a maximum transmission at approximately 555 nm. The negative stimulus (S-) was a black vertical or horizontal line, with a width of 0.125 in. (0.32 cm), presented on a white background. The test chamber was illuminated by dim houselights on the front and rear panels. A photoelectric cell mounted behind the hopper entrance was employed to control presentation of the food tray.

Procedure

The experiment was carried out in three phases: Phase 1, errorless differential auto-shaping; Phase 2, errorless discrimination training; and Phase 3, generalization testing.

Phase 1, errorless differential autoshaping. The subjects were first trained to eat grain from the food tray. This training was complete when the bird had eaten for 3.5 sec three consecutive times from the food tray within 10 sec after the hopper had been raised.

The procedure for obtaining errorless differential autoshaping paralleled that of Wessells (1973). Each session consisted of 100 trials, with 50 S+ trials and 50 S- trials presented in a pseudorandom series in which each stimulus did not appear successively more than three times. An 8-sec stimulus presentation occurred randomly within each 30-sec trial. The key was dark at times when S+ and S- were not presented. A 4-sec intertrial interval in which the stimulus key was dark, but the houselights remained on, separated trials.

On S+ trials, a green light was presented on the key for 8 sec and termination of the light coincided with presentation of the food tray. The tray fell to the resting position 3.5 sec after the photocell beam in the magazine was broken. The subjects were randomly assigned either a vertical or a horizontal line as S-. On S- trials, a black vertical or horizontal line on a white background was presented on the key for 8 sec, but was never paired with food. Differential autoshaping was completed when a bird pecked the key at least 100 times during S+ or when the subject completed five days of training.

Phase 2, errorless discrimination learning. In the preceding phase, the stimuli and food

were presented independently of the bird's pecking on the key.

In this phase, reinforcement became dependent upon responding on the key. Duration of both S+ and S- was increased from 8 to 30 sec during the first session of discrimination training. At the beginning of the session, the first five stimuli were presented for 8 sec. Then the duration was increased by 1 sec to 9 sec for the next block of five trials, continuing in this manner until the duration of S+ and S- reached 30 sec. Reinforcement occurred at the end of S+ only if the subject pecked the key at least once during the green light regardless of the time of the response. If the subject failed to peck the key during S+, the opportunity for reinforcement was lost. When the duration of S+ reached 30 sec, the schedule of reinforcement was changed to a standard VI 30-sec schedule. A 4-sec intertrial interval separated trials.

Each subject received eight days of discrimination training with the stimuli at the full duration of 30 sec. The stimuli were presented in a pseudorandom sequence during 30-sec trials with a 4-sec intertrial interval separating trials. Responding was reinforced during S+ on a VI 30-sec schedule. During each session, 50 presentations of S+ and 50 presentations of S- occurred.

Phase 3, generalization testing. Before generalization testing, each group received identical discrimination training. The groups differed with respect to the type of generalization test employed. For each animal, each session of generalization testing began with 28 additional trials of discrimination training followed by the generalization test.

Resistance-to-Reinforcement without Compounding

Seven stimuli, six line orientations on a white background and the green key, were presented in each of 10 randomized blocks for a total of 70 stimulus presentations. As in discrimination training, 30-sec presentations of the test stimulus were separated by a 4-sec interval during which the key was dark. Responding in the presence of all stimuli was reinforced on a VI 30-sec schedule. If the bird failed to respond during the test stimulus in which reinforcement became available, reinforcement remained available throughout each presentation of the test stimuli until a re-

sponse occurred. Each of the nine birds in this condition received 15 days of generalization testing.

Resistance-to-Reinforcement with Compounding

The conditions of generalization testing for this group were identical to the preceding group, except that the six line orientations were superimposed upon a green background to produce a compound of the line with S+. This group of five subjects received five days of generalization testing.

Resistance-to-Extinction with Compounding

The conditions of generalization testing for this group of six pigeons were identical to the preceding group, except that the stimuli were presented during extinction. Generalization testing was conducted for five days.

Control procedures. Hearst (1972) suggested a novel-stimulus control group to evaluate the extent to which the test stimuli influence responding independently of the correlation with extinction. Any decrement in responding during the test for these groups is presumably produced by factors extraneous to the differential reinforcement procedure employed for the experimental subjects. The control groups differed from the experimental groups in the following respects. In Phases 1 and 2, a vertical or horizontal line was not presented. The control sessions consisted of presentations of S+ only during autoshaping in Phase 1. A 4-sec intertrial interval separated trials. In Phase 2, the subjects received 50 presentations of S+ alone each day. In Phase 3, for six subjects the procedure of generalization testing was identical to that of the experimental group for compounding with resistance-to-extinction, and for five subjects the procedure of generalization testing was compounding with resistance-to-reinforcement.

RESULTS

For the 20 birds that received identical discrimination training, the mean number of errors during acquisition of the discrimination was 30.75, with a range between one and 117. The mean response rate during S- averaged across the eight sessions of discrimination training was 0.105 responses per minute, with

a range between 0.005 and 0.585. Errorless discrimination learning may be defined as the class of discriminations in which the rate of responding during S- approaches zero from the first session of discrimination training. Although individual differences in the rates of responding to S- were obtained, the procedure was effective in producing errorless discrimination learning for many of the subjects.

Figure 1 presents the average response rate to each of the test stimuli during Days 1 to 5 of generalization testing for each of the groups. Following the convention established by Farthing and Hearst (1968), the same data point is plotted at +90° and -90° to produce a more symmetrical gradient. An inhibitory gradient with a minimum at S- was obtained for the two groups tested with the resistance-to-reinforcement procedure. A trend analysis was performed on the response rates to each angle (omitting S+) with significant results in order to obtain information about the form of the relationship between the angle of the line and the rate of responding. For the group tested with compound stimuli, best fit was found for the quadratic trend, $F(1,20) = 5.0$, $p < 0.05$. For the group tested without compound stimuli, the quadratic trend also provided the best fit for the data, $F(1,40) = 4.0$, $p < 0.05$. Therefore, stimulus control was acquired by the S- dimension, even though the discrimination was acquired with a very low rate of responding to S-. More responses were obtained during the compound test than the noncompound test because compounding produced responses early in generalization that were reinforced on the VI schedule. Several of the birds tested without compound stimuli failed to respond to any of the line angles during the early sessions of resistance-to-reinforcement testing.

Comparison of the resistance-to-reinforcement compounding group with its control, in which novel lines at various angles were superimposed on the green key, showed that the experimental group responded at a significantly lower rate to the mean of the line angles than to S+, $t(4) = 2.776$, $p < 0.05$, while the control group's responding to the line angles was not significantly different from S+, $t(4) = 0.138$, $p > 0.10$.

A flat gradient with an average rate to each stimulus of approximately four responses per minute was obtained for the experimental group that was tested during extinction with

Fig. 1. Average rate of responding for the experimental and control groups to each of the test stimuli during Days 1 to 5 of generalization testing.

the compound stimuli. Since an average of approximately 30 responses per minute was obtained to S+ alone during extinction, the superimposition of the lines on the green stimulus significantly decreased subjects' responding, $t(5) = 4.6$, $p < 0.01$. The decrement for each of the test stimuli was virtually identical, so that stimulus control by the angle of the line was not obtained for this condition of testing.

The control group for resistance-to-extinction showed a significantly higher response rate during testing than the corresponding experimental group, $t(10) = 3.19$, $p < 0.01$. Therefore, for the experimental group tested during extinction with compound stimuli each test stimulus was an inhibitory stimulus.

Figure 2 shows the absolute gradients for the nine birds in the group tested without compound stimuli while responding was maintained with the resistance-to-reinforcement procedure. Each data point represents the rate of responding to each test stimulus during the 15 days of generalization testing. The arrow indicates whether the vertical or horizontal line was employed as S— and is designated as 0°. Other orientations of the line are indicated as clockwise (+) or counterclockwise (–) deviations from 0°. The number in parentheses beside the number of the bird indicates the total number of responses to S— during acquisition of the discrimination. The number above each data point indicates the rate of reinforcement per minute obtained in the presence of that stimulus during the generalization test.

Except for Bird 5189, each gradient was U-shaped and the minimum was located at S— for Birds 2760, 3087, 99, 3686, and 4589. Visual inspection of Figure 2 indicates that the number of errors during acquisition did not predict the slope of the inhibitory gradient, nor was the slope dependent on whether a vertical or horizontal line was employed as S—. Substantial individual differences were observed in the total response output during the generalization test. Very low rates of responding and reinforcement were obtained for Birds 5189 and 2760, indicating that the resistance-to-reinforcement procedure was least effective in elevating responding for these birds. The group average, represented by the open circles in the lower right panel, shows an inhibitory gradient with the minimum at S—. The main

effect of the line angle was statistically significant, $F(5,40) = 3.0$, $p < 0.05$ and a trend analysis revealed a significant quadratic component, $F(1,40) = 6.8$, $p < 0.05$. Therefore the resistance-to-reinforcement testing without compound stimuli demonstrated statistically significant incremental gradients around S—. However, the slope of the gradients was shallow so that stimulus control of responding by the S— dimension was weak.

The number above each data point in Figure 2 indicates the rate of reinforcement produced by responding to each test stimulus during the stimulus generalization test. There is no basis for rejecting the hypothesis that equal rates of reinforcements were obtained during each test stimulus, because the result of an analysis of variance on the rates of reinforcements was not statistically significant, $F(5,40) = 1.82$, $p > 0.10$. Therefore, differences in the response rates to each stimulus during the generalization test were not attributable to differential reinforcement of responding during the generalization test. The observed rate of reinforcement in the presence of the test stimuli was substantially lower than the theoretical maximum rate of reinforcement of 2.0 reinforcements per minute.

Figure 3 shows the daily gradients for two representative birds during each of 15 successive generalization tests. When the birds were presented with stimuli from the S— dimension without compounding, zero response to each test stimulus were often obtained during the first day or two of generalization testing. This pattern was observed for Bird 4589 during Sessions 1 and 2. In contrast, Bird 5199 responded to stimuli from the S— dimension from the first day of testing. For Bird 5199, the rate of responding to each stimulus increased during the second session and the slope of the inhibitory gradient remained essentially unchanged throughout the second through the fifteenth session. While individual variability was observed in the shape of the gradient during the daily sessions, the inhibitory gradients did not invert to excitatory gradients with extended testing, as was reported by Hearst *et al.* (1970). Birds 5189 and 2760 responded at such low rates during the generalization test that the daily gradients were virtually flat, with few responses to each test stimulus.

Fig. 2. Rate of responding to each test stimulus during Days 1 to 15 of generalization testing for the nine birds tested without compound stimuli and the resistance-to-reinforcement procedure. The arrow indicates whether the vertical or horizontal line was employed as $S+$ and is designated as 0° . Other orientations of the line are indicated as clockwise (+) or counterclockwise (-) deviations from 0° . The number in parentheses beside the number of the bird indicates the total number of responses to $S-$ during acquisition of the discrimination. The number above each data point indicates the rate of reinforcements obtained in the presence of that stimulus during the generalization test.

Fig. 3. Rate of responding to each test stimulus during each of the 15 days of generalization testing with the resistance-to-reinforcement procedure for Birds 4589 and 5199.

The results for the individual birds of the resistance-to-reinforcement test with compound stimuli are presented in Figure 4. Except for Bird 3498, each gradient was U-shaped, but the minimum was located at S— only for Bird 3511. For each bird, compounding S+ with a stimulus from the S— dimension decreased response rate as compared with S+ alone. The number above each data point in Figure 4 indicates the rate of reinforcement to

each test stimulus during the five days of generalization testing. An analysis of variance of the rates of reinforcement was not statistically significant, $F(5,40) = 0.46$, $p > 0.10$. Therefore, stimulus control by the angle of the line cannot be attributed to differential reinforcement of responding during the stimulus generalization test. A comparison of the rate of reinforcement for the group average in Figure 4 with that in Figure 2 indicates that the rate

Fig. 4. Rate of responding to each test stimulus during Days 1 to 5 of generalization testing for the group tested with compound stimuli and the resistance-to-reinforcement procedure.

of reinforcement was higher during the compound test, reflecting the higher rates of responding.

Figure 5 shows the absolute gradients for the six birds in the group tested with the compound stimuli during extinction. Responding to S+ alone was also extinguished during the generalization test. Each data point indicates the response rate to each stimulus during the five days of generalization testing. Compounding the stimuli was effective in increasing the response rate to S— from the rate of zero responses per minute that prevailed during the final sessions of discrimination training, but the magnitude of the increase was quite small for most of the birds. It is clear from these data that this test failed to indicate stimulus control over responding by the angle of the line. However, each test stimulus inhibited responding, as indicated by the lower rate of responding to the various angles as compared with S+ alone.

The means and standard deviations for the data in each group are presented in Table 1. In Table 1, the phrases "with Days 1 to 5 M", and "without Days 1 to 5 M", refer to the presence or absence of compound stimuli during

the generalization tests. The standard deviations for the group tested on resistance-to-reinforcement with compounding were substantially smaller than the standard deviations for the group tested on resistance-to-reinforcement without compounding, because some of the birds tested without compounding failed to respond to any of the test stimuli, other birds in this condition responded at rates comparable to the group tested with compound stimuli.

DISCUSSION

This experiment compared resistance-to-reinforcement and combined-cues tests as procedures for elevating responding to stimuli from the S— dimension following errorless discrimination training. Inhibitory or incremental gradients were obtained with the resistance-to-reinforcement procedure and flat gradients were obtained when the stimuli were compounded during extinction. Inhibitory gradients were also obtained when the two procedures were combined. Therefore, the resistance-to-reinforcement procedure was the more sensitive index of inhibitory stimulus

Table 1

Mean response rates and standard deviations to each stimulus during generalization tests with and without compound stimuli.

Group	Stimulus						
	±90	−60	−30	0	+30	+60	S+
<i>Resistance to Reinforcement</i>							
Experimental							
with ^a (Days 1 to 5) Mean	37.7	35.9	33.8	33.6	34.2	35.3	45.8
with (Days 1 to 5) SD	4.8	4.3	4.8	4.3	4.5	5.2	4.1
Control							
with (Days 1 to 5) Mean	41.9	42.1	42.9	41.2	41.1	41.6	40.1
with (Days 1 to 5) SD	17.2	18.5	20.0	17.2	19.8	17.1	20.0
Experimental							
without ^b (Days 1 to 5) Mean	19.5	17.6	16.1	15.9	17.7	17.2	61.7
without (Days 1 to 5) SD	19.9	19.4	17.1	18.4	18.4	18.1	22.1
Experimental							
without (Days 1 to 15) Mean	36.64	37.45	35.56	33.35	34.5	37.6	56.4
without (Days 1 to 15) SD	23.1	24.4	23.3	21.3	23.0	24.9	20.2
<i>Resistance to Extinction</i>							
Experimental							
with (Days 1 to 5) Mean	4.5	4.5	5.7	3.9	5.1	3.2	29.2
with (Days 1 to 5) SD	5.1	4.2	4.5	3.7	4.8	2.6	21.5
Control							
with (Days 1 to 5) Mean	9.3	9.3	9.8	9.6	10.0	10.7	19.3
with (Days 1 to 5) SD	5.2	4.3	4.1	3.4	3.7	4.7	6.1

^a*I.e.*, with compound stimuli present during testing.

^b*I.e.*, without compound stimuli present during testing.

Fig. 5. Rate of responding to each test stimulus during extinction for the pigeons tested with compound stimuli.

control. Using a resistance-to-reinforcement procedure, Karpicke and Hearst (1975) also obtained inhibitory gradients following errorless interdimensional discrimination training.

In the present experiment, inhibitory stimulus control by the angle of the line was weaker than that obtained by Farthing and Hearst (1968) after an equivalent amount of training. In Farthing and Hearst's experiment, the discrimination was more difficult because the only difference between S+ and S- was the presence of a vertical line on the key during S-. Therefore, the presence of the line was likely to control response cessation. To obtain errorless learning in the present experiment, it was necessary to employ discriminative stimuli that differed in more than one property. Features of S-, such as the white background, that were not varied during the generalization test, may also have acquired inhibitory stimulus control during acquisition of the discrimination. Therefore, in this experiment, the relatively weak inhibitory stimulus control by the angle of the line during the generalization test may have occurred because stimulus control by the line was not essential for acquisition of the discrimination.

Using a combined-cues test, several experiments (Davis, 1971; Lyons, 1969; Yarczower and Curto, 1972) have demonstrated the absence of inhibitory stimulus control by the angularity dimension, even though S- significantly decreased responding when superimposed upon S+. The present experiment confirmed these results by obtaining a flat stimulus generalization gradient when the compound test was conducted during extinction. It is not clear why inhibitory stimulus control fails to emerge when the stimuli are combined during extinction. These data clearly demonstrate that the detection of inhibitory stimulus control depends upon the procedure for obtaining the stimulus generalization gradient. The weakest procedures are resistance-to-extinction either with or without compound stimuli; the resistance-to-reinforcement procedures, either with or without compound stimuli, are the most sensitive indices of inhibitory stimulus control.

Several experiments have demonstrated that a stimulus correlated with extinction is inhibitory even though the rate of the nonreinforced response during S- is very low throughout acquisition of the discrimination. Wessells

(1973) demonstrated that S- was an inhibitory stimulus following errorless differential auto-shaping by testing for inhibition with resistance-to-reinforcement and combined-cues measures. Wilkie and Ramer (1974) confirmed Wessell's results with a resistance-to-reinforcement procedure. In the present experiment, the inhibitory properties of S- were demonstrated by the combined-cues test in which the decrement in responding obtained when S- was superimposed upon S+ was greater than the decrement obtained for a novel vertical or horizontal line. In addition, the inhibitory properties of S- in the resistance-to-extinction test with compounding generalized equally to other orientations of the line that were never correlated with extinction.

When inhibition is measured by a resistance-to-reinforcement test, the data indicate that an S- in the presence of which no responding has occurred is more inhibitory than an S- in the presence of which some responding has occurred. Wilkie and Ramer (1974) compared the acquisition of autoshaped responding to an errorless S- with acquisition to an S- learned with errors. They found that an errorless S- was more resistant to autoshaping than an S- in the presence of which responses had occurred. Therefore, the data of Wilkie and Ramer also support the interpretation that when inhibition is measured with a resistance-to-reinforcement procedure, an errorless S- is more inhibitory than an errorful S-.

In the present experiment, inhibitory gradients were obtained after five days of testing for the group in which resistance-to-reinforcement was employed simultaneously with the combined cues, yet more days of training were required to demonstrate inhibitory stimulus control from the majority of the birds tested with noncompound stimuli on the resistance-to-reinforcement procedure. Combining S+ with S- increased the probability of responses that were reinforced on the VI schedule.

These results emphasize that flat gradients with zero responses to each test stimulus, such as those obtained by Terrace (1966*b*, 1972), are an equivocal outcome. A rate of responding to the test stimuli greater than zero is necessary for the assessment of inhibitory stimulus control. The results, especially the data for Bird 4589 in Figure 3, suggest that Deutsch (1967) and Hearst *et al.* (1970) were correct in their initial criticism of Terrace's experiments

that a "floor effect" prevented the detection of inhibitory stimulus control.

Terrace's (1966a and b, 1972) explanations of the inhibitory process assigned a large role to nonreinforced responding as a determinant of conditioned inhibition. However, many experiments, including the present one, have demonstrated that S- may become a conditioned inhibitor even though the nonreinforced response does not occur in the presence of S-. Therefore, an alternative explanation is needed for the development of conditioned inhibition in these experiments. In the analysis of conditioned inhibition in classical conditioning, Rescorla (1969) focused upon the correlation between the CS and the UCS. He suggested that conditioned inhibition develops when there is a negative contingency between the CS and UCS, i.e., when the CS predicts the absence of the UCS. In the research on errorless differential autoshaping, Wessells (1973) and Wilkie and Ramer (1974) employed negative contingencies to demonstrate that an errorless CS- inhibited responding. In a successive operant discrimination, a negative contingency is also present between S- and the reinforcer. This contingency is sufficient to account for the development of conditioned inhibition and inhibitory stimulus control in operant discriminations.

The present experiment began with a differential autoshaping procedure in which the food was presented independently of pecking and then the procedure was switched to one in which the occurrence of food was dependent upon the pecking response. No data are available on generalization of stimuli associated with extinction in an autoshaping paradigm. It would be of interest to compare generalization of excitation and inhibition following equal amounts of discrimination training with conventional operant and autoshaping procedures. Such data would help to determine if the laws of discrimination learning are independent of whether the discrimination is acquired with a classical or operant procedure.

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