

ERRORLESS TRANSFER OF A DISCRIMINATION ACROSS TWO CONTINUA¹

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A procedure developed earlier (Terrace, 1963) successfully trained a red-green discrimination without the occurrence of any errors in 12 out of 12 cases. Errorless transfer from the red-green discrimination to a discrimination between a vertical and a horizontal line was accomplished by first superimposing the vertical and the horizontal lines on the red and green backgrounds, respectively, and then fading out the red and the green backgrounds. Superimposition of the two sets of stimuli without fading, or an abrupt transfer from the first to the second set of stimuli, resulted in the occurrence of errors during transfer. Superimposition, however, did result in some "incidental learning". Performance following acquisition of the vertical-horizontal discrimination with errors differed from performance following acquisition without errors. If the vertical-horizontal discrimination was learned with errors, the latency of the response to S+ was permanently shortened and errors occurred during subsequent testing on the red-green discrimination even though the red-green discrimination was originally acquired without errors. If the vertical-horizontal discrimination was learned without errors, the latency of the response to S+ was unaffected and no errors occurred during subsequent testing on the red-green discrimination.

An earlier study (Terrace, 1963) demonstrated that pigeons could acquire a discrimination of color without emitting responses to the stimulus correlated with non-reinforcement (S-). The necessary conditions for the acquisition of a discrimination without the occurrence of responses to S- seem to be (1) the introduction of S- immediately after conditioning the response to the stimulus correlated with reinforcement (S+), and, (2) an initially large difference between S+ and S- that is progressively reduced to a smaller and constant S+-S- difference. The present experiment utilizes the method of progressively decreasing the difference between a pair of discriminative stimuli in transferring from a discrimination of color to a more difficult discrimination of the orientation of a line.

This study is also concerned with an analysis of the decrease in the latency of the response to S+ frequently noted during the acquisition of a discrimination trained by a trial procedure (e.g., Jenkins, 1961; Terrace, 1963). Reynolds (1961a) has studied the equiv-

alent increase in the rate of the response to S+ during the acquisition of a free-operant discrimination and has referred to this increase in rate and to the related decrease in latency as "behavioral contrast". Two alternative, but not mutually exclusive, specifications of contrast were studied: (1) Reynolds' hypothesis (1961c) that differential reinforcement in the presence of two or more discriminative stimuli will produce contrast, and, (2) Terrace's argument (1963) that a necessary condition for contrast is the occurrence of responses to S- during the acquisition of a discrimination.

METHOD

Subjects and Apparatus

Fourteen experimentally naive White Carneau pigeons were each maintained at 80% of *ad libitum* body weight for a period lasting from two weeks prior to the start of the experiment until completion.

The apparatus consisted of an experimental chamber of the type described by Ferster and Skinner (1957, p. 14ff.) and automatic programming and recording equipment. A Gerbrands response key, $\frac{3}{4}$ in. in diameter, was mounted behind a $\frac{3}{4}$ in. hole on a metal panel that separated the subject's compart-

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ment from the compartment housing the stimulus and food presenting devices. A minimum force of about 15 gm was necessary to operate the key.

A stimulus presenting device, adopted from an Industrial Electrical Engineering Corporation display unit, was mounted directly behind the key. This device could transilluminate the key with either a red or a green light, or a white, horizontal or vertical line on a black background, or with any combination of these stimuli. The display unit consisted of four 6.3 volt, 2.2 watt bulbs, a red and a green filter, transparencies of a white horizontal and a white vertical line on a black background, four lenses, and a ground glass screen. The intensities of the red and the green lights were adjusted so that the lights appeared equally bright to the dark-adapted experimenter when they were observed in a darkened room. The intensities of the vertical and the horizontal lines were not modified because they were initially equally bright. The subjects' compartment was illuminated by a diffuse 12 watt houselight. Four inches beneath the key was a 2 × 2 in. opening through which a hopper filled with mixed grain could be made available. The reinforcement was a 4.0 sec period of access to the hopper of grain. During the 4.0 sec reinforcement cycle, the house and the stimulus lights were shut off and the grain hopper was illuminated by two 6 watt bulbs directly above it. White noise was continuously present in the chamber to mask extraneous sounds.

EXPERIMENT I

Procedure

Data were collected from eight pigeons over a six-month period of daily experimentation.

The discriminative stimuli were presented on brief, discrete automatically programmed trials. A trial was defined as the period of time during which the key was transilluminated by any of the discriminative stimuli. All trials were terminated by a single response or by a failure to respond within 5 sec of the onset of the trial. This procedure allowed only one response to occur during each trial. On S+ trials, a correct response was defined as a key-peck that occurred during the trial, while an error was defined as the absence of a key-peck during the trial. On S- trials, a correct re-

sponse was defined as the absence of a key-peck during the trial, while an error was defined as the occurrence of a key-peck during the trial.

Between trials the houselight remained on but the key was dark. Leaving the houselight on between trials allowed a second type of response to S- to occur (responses to the dark key). An earlier experiment (Terrace, 1963), however, showed that with the houselight on, few, if any, responses were made to the dark key. It was also noted that the latencies of responding to S+ became highly erratic when the houselight was turned off between trials. Since the latency of the response to S+ was one of the important dependent variables, it was decided to leave the houselight on between trials.

The duration of the interval between trials (intertrial interval) was randomly selected from a series of intervals with a range of 5 to 30 sec and a mean of 15 sec. Responding during the intertrial interval delayed the onset of the next trial for 10 sec.

During each session, 60 S+ and 60 S- trials, alternating in random succession were programmed. A constraint on the randomization was imposed by a correction procedure whereby trials on which errors occurred were repeated as the next trial. Thus, each error extended the session by one trial. Each session was terminated after 60 reinforcements.

Red-green discrimination training. Six of the eight pigeons used in Exp. I were trained to discriminate between red and green by a procedure that was previously shown to train this discrimination without the occurrence of errors (Terrace, 1963). Its main features are as follows. The key-peck is conditioned to a red key-light (S+). Following each of the first five reinforcements the key-light was always red. After the fifth reinforcement the key was darkened for 2 sec (intertrial interval) after which the red light came on again. Following the next 20 reinforcements the intertrial interval was progressively lengthened until a maximum interval of 30 sec, with a mean of 15 sec, was achieved. At this point, S- was introduced. Initially, S- was a faint green light of 1 sec duration. During successive S- trials the duration and intensity of S- was progressively increased until the duration of S- was 5 sec and the brightnesses of S+ and S- were equal.

Vertical-horizontal discrimination training. Three procedures were used to transfer from the red (S+)–green (S–) to the vertical (S+)–horizontal (S–) discrimination. The different transfer procedures are diagrammed in Fig. 1.

Abrupt procedure. Birds 193 and 194 were given 15 sessions of red–green discrimination training. The 16th session started with a white, vertical line instead of the red light on S+ trials, and a white, horizontal line instead of the green light on S– trials.

Superimposition–only procedure. During the first 10 sessions, Birds 183 and 191 received red–green discrimination training. During sessions 11 to 15, the red and green, and the vertical and the horizontal stimuli were superimposed as follows. On S+ trials, the vertical line was superimposed on the red background; on S– trials, the horizontal line was superimposed on the green background. The 16th session began for Birds 183 and 191 just as it did for the birds of the abrupt group. Only the vertical and horizontal lines appeared as discriminative stimuli.

Superimposition and fading. The training of Birds 145 and 146 of the superimposition and fading group was identical to that of Birds 191 and 183 of the superimposition–only group through the 15th session. However, under the superimposition and fading procedure, the 16th session started with the discriminative

stimuli superimposed as they were during sessions 11 to 15. During the 16th session, the intensities of the red and green lights were progressively diminished until they were no longer visible at which point current was permanently prevented from reaching the bulbs behind the red and green filters. The point at which the red and the green lights were no longer visible was determined in a darkened room by the experimenter, who had been dark-adapted for 20 min.

Each of the six transfer birds received vertical–horizontal discrimination training until they satisfied a criteria of four successive sessions without an error. Following this, each bird was given four sessions during which only the red and the green stimuli appeared. The transfer from the last vertical–horizontal session to the second red–green series was abrupt in all cases.

Vertical–horizontal training only. Birds 106 and 107 received only vertical–horizontal discrimination training with stimuli at full intensity and duration throughout training. No attempt was made to train this discrimination without errors by progressively increasing the duration and intensities of S– because attempts to do so in a pilot experiment proved unsuccessful. Vertical–horizontal training was continued until the criterion of four successive sessions without any errors was satisfied.

SESSION	EXPERIMENTAL GROUP			
	ABRUPT	SUPERIMPOSITION ONLY	SUPERIMPOSITION & FADING	VERTICAL - HORIZONTAL ONLY
1	RED - GREEN ↓	RED - GREEN ↓	RED - GREEN ↓	VERTICAL - HORIZONTAL ↓ TO CRITERION
10				
11		RED & VERTICAL - GREEN & HORIZONTAL	RED & VERTICAL - GREEN & HORIZONTAL	
15		↓	↓	
16	VERTICAL - HORIZONTAL	VERTICAL - HORIZONTAL	RED & VERTICAL - GREEN & HORIZONTAL TO VERTICAL - HORIZONTAL	
17	↓	↓	↓	
	TO CRITERION	TO CRITERION	TO CRITERION	
	RED - GREEN (4 SESSIONS)	RED - GREEN (4 SESSIONS)	RED - GREEN (4 SESSIONS)	

Fig. 1. The sequence of discrimination procedures for the four experimental groups.

Results

Red-green discrimination. Birds 193, 194, 183, 191, 145 and 146 acquired the red-green discrimination without ever responding to S—. In each case no response to S— occurred during the first 15 sessions. Thus, the superimposition of the vertical and red, and the horizontal and green stimuli during sessions 11 to 15, did not affect the discrimination performance of the birds of the superimposition-only (#'s 183 and 191) and superimposition and fading groups (#'s 145 and 146).

The probability of responding to S+ was always 1.0 for each bird, except during the early portion of the first experimental session. Intertrial responses occurred with an average frequency of less than one per session. The total amounts of intertrial responses during the 15 red-green discrimination series, for Birds 193, 194, 183, 191, 145 and 146 were 8, 0, 3, 11, 0, and 3, respectively.

Vertical-horizontal discrimination. Birds 145 and 146 of the superimposition and fading group acquired the vertical-horizontal discrimination without any responses to S—. However, the birds of the other two transfer groups, as well as the birds that received only vertical-horizontal training, all made many responses to S— before satisfying the criterion of four successive vertical-horizontal sessions without any errors. The probability of a response to the vertical S+ was always 1.0 for each bird.

The height of the white bars in Fig. 2 shows the number of responses to S— that each bird emitted before satisfying the vertical-horizontal discrimination criterion. Birds 145 and 146 of the superimposition and fading group made no errors; Birds 183 and 191 of the superimposition-only group made 157 and 188 errors respectively; Birds 193 and 194 of the abrupt group made 404 and 2609 errors respectively, and Birds 106 and 107 who received vertical-horizontal training only, made 472 and 382 errors respectively. The numbers in parentheses, within each white bar in Fig. 2, indicate how many sessions were needed to satisfy the discrimination criterion. It should be noted that almost half of the responses to S— emitted by Bird 194 occurred during the first session (1161 responses to S—).

Second red-green discrimination series. Birds 145 and 146 of the superimposition and

fading group, who acquired both the red-green and the vertical-horizontal discrimination without errors, performed perfectly during the second series of four red-green discrimination sessions. However, the remaining transfer birds who never responded to S— in the first red-green discrimination, but who did respond to S— in the vertical-horizontal discrimination, responded to S— during the second red-green discrimination series. The height of the black bars in Fig. 2 shows the number of responses to S— made by each of the transfer birds during the second series of red-green discrimination training. These data suggest a positive correlation between the number of errors made during the vertical-horizontal discrimination sessions and the number of errors made during the second series of red-green discrimination sessions.

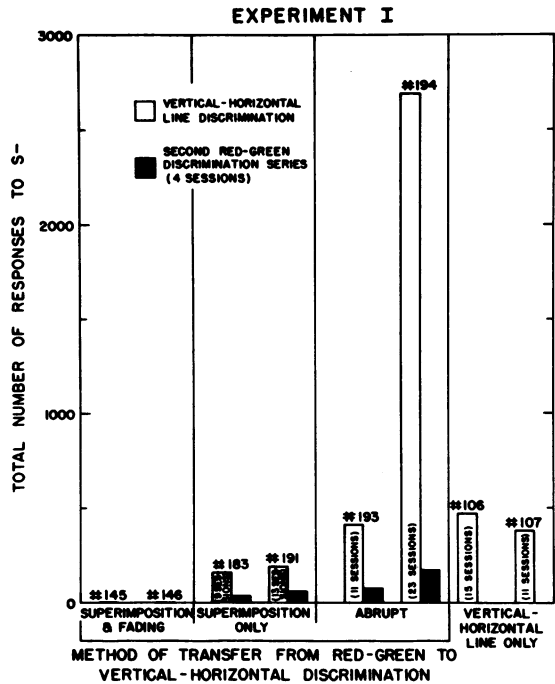


Fig. 2. The number of errors made by each bird of Exp. I in satisfying the vertical-horizontal discrimination criterion of four successive errorless sessions, and during the second series of red-green discrimination sessions.

Latency of responding to S+. Following the shift from the red-green to the vertical-horizontal discrimination, the latency of the response to S+ decreased in all instances in which the vertical-horizontal discrimination

was acquired with responding to S—. If no responses to S— occurred during the acquisition of the vertical-horizontal discrimination, the latency of the response to S+ was unchanged. These results are shown in Fig. 3. The points to the left of the first vertical-dashed line represent the mean latency of the response to S+ of each of the transfer birds during sessions 13 to 15 (last three of the first series of red-green sessions). The points to the right of the first vertically-dashed line represent the mean latency of the response to S+, of each bird, during each of the vertical-horizontal sessions. The different number of points for each bird reflect the different number of sessions that were needed to satisfy the discrimination criterion. The points to the right of the second vertically-dashed line represent the mean latency of the response to S+, of each transfer bird, during each session of the second red-green series.

The top two rows of Fig. 3 show the mean latency of the response to S+ of the birds of the superimposition and fading groups. Both Birds 145 and 146 learned the vertical-horizontal discrimination without errors. The latency of the response to S+ remained unchanged during the last three red-green discrimination sessions, the vertical-horizontal sessions and the second series of red-green sessions.

The next four rows of Fig. 3 show the mean latency of the response to S+ of the birds of the superimposition-only and abrupt groups. In each case, the latency of the response to S+ increased at the start of vertical-horizontal training, and then gradually declined to an asymptotic value that was, in all cases, lower than the latency of the responses to S+ during the last three red-green sessions. During the second series of four red-green sessions the latency of responding to S+ first increased and then declined to the level that prevailed during the vertical-horizontal sessions.

The latency of the response to S+ of the birds that received vertical-horizontal training only, declined continuously to an asymptotic value that fell within the range obtained from the birds of the other three groups.

EXPERIMENT II

In Exp. I it was shown that if the vertical-horizontal discrimination was acquired with

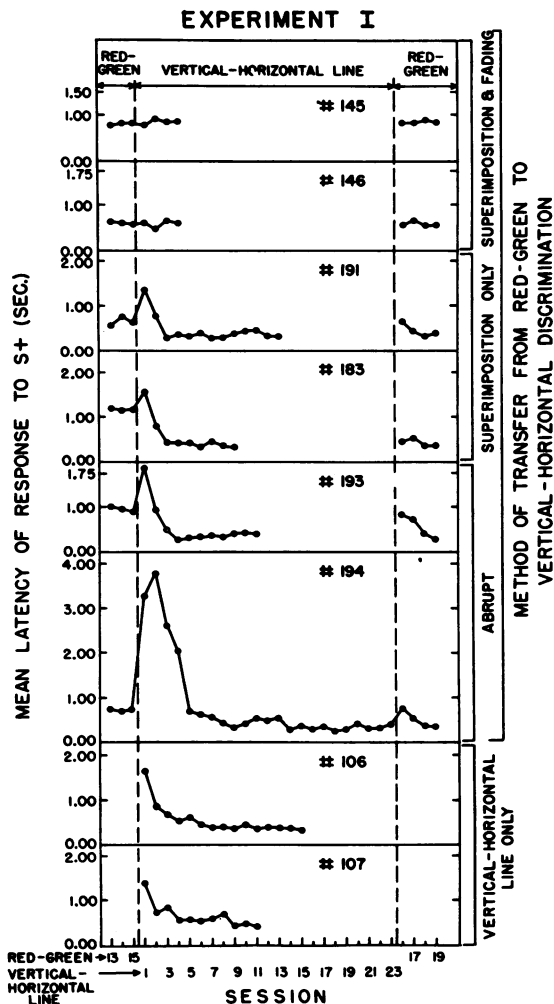


Fig. 3. The mean latency of responding to S+ for each bird of Exp. I during the last three sessions of the first red-green discrimination sessions and the four sessions of the second red-green discrimination series.

errors (responses to S—), errors occurred during subsequent red-green discrimination performance, even though the red-green discrimination was originally acquired without errors. The discrimination criterion used in Exp. I, however, prevents one from specifically attributing errors that occurred during the second red-green series to the occurrence of errors during the acquisition of the vertical-horizontal discrimination. One could, instead, attribute the errors which occurred during the second red-green discrimination series to "interference" from the relatively greater number of intervening vertical-horizontal discrimination sessions resulting from applica-

tion of the discrimination criterion. This source of ambiguity was removed in Exp. II by eliminating the discrimination criterion.

Method

Three groups of two pigeons each were used. Each group was trained under one of the three transfer procedures described in Exp. I: abrupt (Birds 75 and 242) superimposition-only (Birds 217 and 253) and superimposition and fading (Birds 100 and 334). Data were collected over a four-month period of daily experimentation.

The procedure differed from that of Exp. I in only one respect. Instead of ending vertical-horizontal discrimination training after a criterion of four successive sessions without an error was satisfied, training was, in each case, carried out for 23 sessions. This corresponds to the largest number of sessions needed to satisfy the discrimination criterion in Exp. I.

Results

Red-green discrimination. As in Exp. I, the red-green discrimination was acquired by each of the six birds without any responses to S—. No response to S— occurred during the first 15 sessions. Except for the first portion of the first session, the probability of a response to S+ was always 1.0 for each bird.

Vertical-horizontal discrimination training. The number of responses to S—, of each bird, during the 23 vertical-horizontal discrimination sessions is shown by the height of the white bars in Fig. 4. The height of each black bar in Fig. 4 shows the number of responses to S— that was emitted by each bird during the second red-green series. Neither bird of the superimposition and fading group responded to S—. However, each of the other four birds of the superimposition-only and abrupt groups, responded to S— during the second red-green discrimination series. The correlation noted in Exp. I between the number of responses to S— during vertical-horizontal discrimination training and the second red-green discrimination series held for the two birds of the abrupt group. It did not, however, hold for the two birds of the superimposition-only group.

Latency of responding to S+. As in Exp. I, the latency of responding to S+ decreased following the acquisition of the vertical-horizontal discrimination if responding to S—

occurred during the acquisition of the vertical-horizontal discrimination. If no responses to S— occurred, the latency of the response to S+ was unaffected by the transfer from the red-green to the vertical-horizontal discrimination.

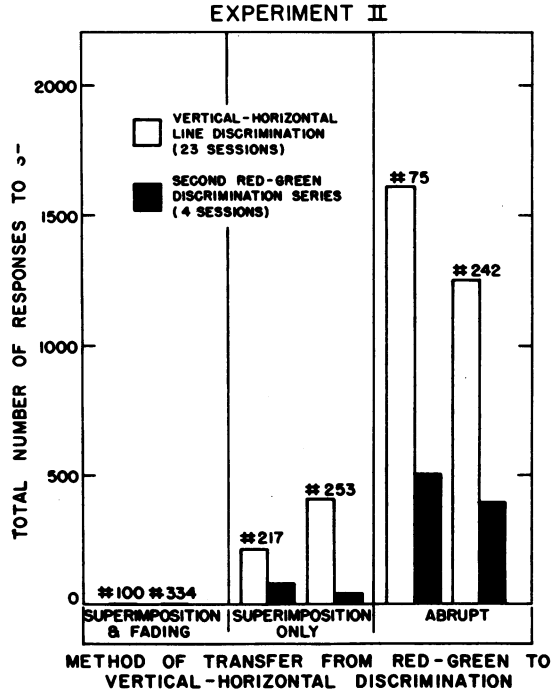


Fig. 4. The number of errors made by each bird of Exp. II during the 23 vertical-horizontal discrimination sessions and during the subsequent four red-green discrimination sessions.

Figure 5 shows the mean latency of the response to S+ of each bird during the last three sessions of the first red-green discrimination series (points to the left of the first vertically-dashed line), during the 23 sessions of vertical-horizontal discrimination training (points between the two vertically-dashed lines) and during the four sessions of the second red-green discrimination series (points to the right of the second vertically-dashed line). The latency of responding to S+ of Birds 100 and 334 of the superimposition and fading group was the same during the two red-green discrimination series, and the intervening series of vertical-horizontal discrimination sessions. Neither of these birds ever responded to either the green or the horizontal S—. The latency of responding to S+ of the remaining birds,

who did respond to the horizontal S—, increased at the start of vertical-horizontal training, and then declined to an asymptotic value that was in each case lower than the value of the latency of responding to S+ during the preceding red-green discrimination sessions.

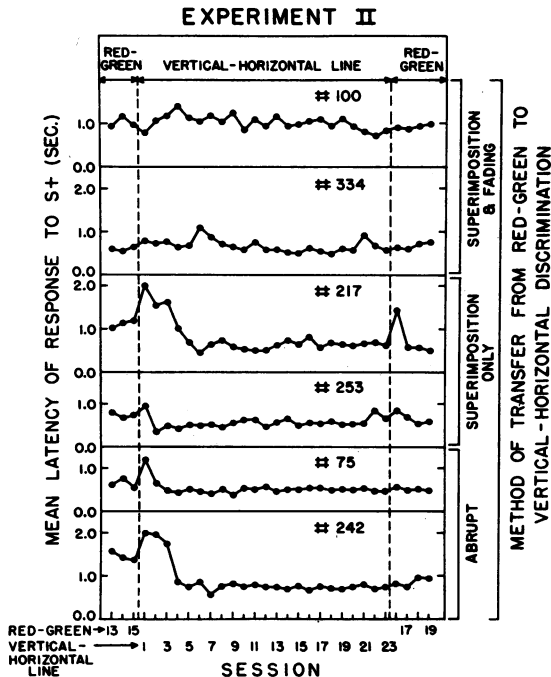


Fig. 5. The mean latency of responding to S+ for each bird of Exp. II during the last three sessions of the first red-green discrimination sessions, all of the vertical-horizontal discrimination sessions and the four sessions of the second red-green discrimination series.

DISCUSSION

The results of both experiments clearly show that a pigeon can learn, in successive order, an easy discrimination of color and a more difficult discrimination of the orientation of a line without making a single error in either case. The crucial aspect of the training procedure that results in errorless discrimination learning seems to be the slow transition from the easy to the difficult discrimination. It was also shown that "behavioral contrast" as well as the disruption of a previously perfect performance on a red-green discrimination, were directly and specifically related to the occurrence of errors during the acquisition of the vertical-horizontal discrimination. Neither of these phenomena

occurred when the vertical-horizontal discrimination was acquired without errors. These findings then raise two important questions regarding discrimination learning: (1) why does the slow transition from an easy to a difficult discrimination result in errorless learning, and, (2) what is the relationship between the occurrence of errors and behavioral contrast?

At present, the effectiveness of the slow transition from an easy to a difficult discrimination is perhaps best described in terms of specific instances rather than in terms of a general principle. The following results illustrate this point. After each instance in which the vertical and the horizontal lines were superimposed upon the red and the green backgrounds the vertical and the horizontal lines themselves were shown to have exerted some control over discrimination performance. The best control was achieved when the red and green backgrounds were slowly faded out (superimposition and fading group). However, the fewer responses to S— emitted by the superimposition group, as compared with the number emitted by the abrupt group, indicate that superimposition *per se* resulted in some horizontal-vertical discrimination learning. This demonstrates that "incidental learning" may be obtained by superimposing a new pair of stimuli on a pair of stimuli that have already been discriminated.

These results should be compared with those from less successful attempts to train the vertical-horizontal discrimination without errors by gradually varying the dimensions of the stimuli. In a pilot experiment, vertical-horizontal discrimination training began shortly after the response to a vertical S+ had been conditioned, with a horizontal S— that was dimmer and of shorter duration than S+. This technique is a direct application of the "early progressive" procedure previously used to train red-green discriminations without errors (Terrace, 1963). In six out of six instances, responses to S— *did* occur during the final steps of reducing the intensity difference between S+ and S—. This indicates that intensity, rather than the orientation of the line was controlling performance. It should also be noted that each of these birds made as many responses to S— in learning this discrimination as did birds that started their training with no S+—S— intensity dif-

ference. In the training procedure of the present experiment, however, the same early-progressive method of introducing S— was successfully used in 12 out of 12 attempts to train a red-green discrimination without any responses to S—.

Conflicting situations thus arise in which slowly changing certain dimensions of S— leads to quicker, if not errorless, discrimination learning, and in which a similar application of this procedure results in no facilitation of discrimination learning. These findings then pose, but leave unanswered, the question of what are the rules by which discriminative stimuli acquire control over responding as a result of varying their properties along certain dimensions? This question, of course, is not a new one. Numerous instances have been reported which show that only certain features of a complex stimulus affect the acquisition and the performance of a discrimination (Lashley, 1938; Ehrenfreund, 1948; Reynolds, 1961c). These experiments, along with the present one, suggest that, contrary to Hull's (1950) and Spence's (1936) theoretical assertions, all aspects of a stimulus that impinge upon an organism prior to reinforcement do not acquire an equal degree of control over the conditioned response. When only certain properties of a complex stimulus control a response, the relation between the controlling properties and the response has been called "attention" (Skinner, 1953, pp. 122ff.). It should be emphasized, however, that *explaining* the results in terms of attention, or related concepts, (e.g., observing responses) would simply be begging the question. One is still left with the question of what are the necessary conditions for getting an organism to pay attention to, or to observe, the relevant attributes of a stimulus?

One of the most reliable criteria for distinguishing between discrimination performances following acquisition of the discrimination with and without errors is the rate or latency of the response to S+. Only if a discrimination is acquired with errors does the rate or latency of the response to S+ change in a direction opposite to the change in the rate or latency of the response to S—.

Reynolds has studied the increase in the rate of responding to S+ that occurs during the formation of a discrimination in an extensive series of experiments (1961a, b, d;

Reynolds and Catania, 1961). This increase in rate is cited as an example of behavioral contrast: "Behavioral contrast is a change in the rate of responding during the presentation of one stimulus in a direction away from the rate of responding prevailing during the presentation of a different stimulus." (Reynolds, 1961a). Elsewhere Reynolds (1961b) states that the rate of responding in the presence of each discriminative stimulus in a multiple schedule of reinforcement is determined by the relative frequency of reinforcement that occurs in the presence of each discriminative stimulus. The relative frequency of reinforcement for a given stimulus is the number of reinforcements occurring in the presence of that stimulus divided by the total number of reinforcements occurring in the presence of all discriminative stimuli. In a later paper Reynolds (1961d) concludes that "the necessary condition for contrast is differential reinforcement or discrimination, although not necessarily extinction."

In an earlier study, the author (Terrace, 1963) has argued that the occurrence of contrast is specifically correlated with the occurrence of responding to S— during the formation of a discrimination and not necessarily to the relative frequency of reinforcement. Contrast did not occur in this experiment when a discrimination was learned without errors. It was not possible, however, to specify the relative frequencies of reinforcement in the presence of each discriminative stimulus. These results, therefore, could not be used to test the generality of Reynolds' relativistic specification of contrast.

In the present study the relative frequency of reinforcement in the presence of each discriminative stimulus was kept constant throughout both experiments. All responses were reinforced in the presence of each S+. It was clearly shown that contrast (in this instance, a decrease in the latency of responses to the vertical S+) occurred only when the vertical-horizontal discrimination was learned with errors.

Reynolds (1961a) has also reported a discrimination obtained without extinction of the response to S—. This was accomplished by a "time-out" procedure (TO) whereby *all* of the illumination in a pigeon chamber was eliminated during the S— component of a multiple schedule (Reynolds, 1961a). In this

experiment no responding occurred during TO, yet the rate of responding to S+ increased. From this result Reynolds concluded that extinction of the response to S- was not a necessary condition for the occurrence of contrast. The validity of this example of discrimination learning without responding to S- can, however, be questioned on the grounds that the TO procedure eliminated the opportunity for the pigeon to emit a response. Since a pigeon will not normally respond to a key in total darkness without special training, it would seem that the TO procedure was functionally equivalent to removing the key, or alternatively, removing the pigeon from the experimental chamber during S-. This interpretation of Reynolds' procedure is supported by the performance of his pigeons during the next stage of the experiment in which adequate illumination of the experimental chamber was provided during S-. In both relevant instances an extinction curve of responding to S- was obtained. Thus, it would seem that the type of errorless discrimination learning represented by Reynolds' data on TO, was functionally different from the errorless discrimination learning reported in this experiment.

Recent experiments on the aversiveness of TO and the relationship between contrast and punishment suggest an explanation of the contrast that occurred in Reynolds' TO experiment. Ferster (1957, 1958) has shown that TO has aversive properties by demonstrating that positively reinforced behavior can be suppressed in the presence of a warning stimulus where responding to S+ results in the appearance of TO. Brethower and Reynolds (1962) have shown that contrast occurs during the first component of a two-component multiple variable interval-variable interval schedule of reinforcement if responding was punished during the second component. Since the frequency of reinforcement during each component was essentially the same, the contrast effect that occurred during the first component was specifically attributable to the punishment that occurred during the second component. These data suggest that the contrast found in Reynolds' previously described TO experiment (1961a) may be attributable to the aversiveness of TO.

The best conclusion to be drawn from the available data on contrast, seems to be that a

necessary and a sufficient condition for contrast is the occurrence of responses to S- during the formation of a discrimination. For a discussion of the significance of the close correlation between responses to S- and the occurrence of contrast, the reader is referred to the author's (Terrace, 1963) earlier discussion of contrast where it was suggested that contrast reflects the aversiveness of S-. Presumably, an S- in the presence of which no extinction has occurred, is less aversive than an S- in the presence of which responses were extinguished. When no extinction in the presence of S- occurs, S- may, in fact, act as a neutral stimulus.

An unexpected result of these experiments was the occurrence of responses to the green S- following those instances in which the vertical-horizontal discrimination was learned with errors. This result was especially surprising in view of the fact that no responses to S- were made prior to vertical-horizontal discrimination training.

In an earlier experiment the author (Terrace, 1963) has noted a permanent difference in the accuracy of discrimination performance between pigeons that had learned a red-green discrimination with and without errors. If the discrimination was learned with errors, occasional bursts of responding to S- were observed in (1) successive S+-S- sessions long after responding to S- had declined to a stable low value, and also in (2) the first S+-S- session following a series of sessions in which only S+ was presented. On the other hand, no responses to S- were observed in either situation if the discrimination was learned without errors. These findings are similar to the present finding with the exception that errors to the green S- occurred after errors occurred on a *vertical-horizontal* discrimination. This suggests that once errors occur during the formation of a discrimination, subsequent performance is permanently affected on that, and also on related discriminations. This generalization should prove to be of prime importance in analyzing discrimination performance. It is also directly relevant to programming techniques for teaching machines in that it provides evidence for the importance of learning a program with the fewest possible errors (*c.f.* Skinner, 1958).

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