MODIFICATION OF A RESPONSE BIAS THROUGH DIFFERENTIAL AMOUNT OF REINFORCEMENT¹

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A procedure is described for assessing response bias to either the form or color dimension of a compound standard stimulus. Responding was assessed under conditions of equal reinforcement (three tokens) for responding to either the form or color dimension. Under these conditions, the four male subjects (aged 7 to 11 yr) differentially responded to the form dimension. After a bias was assessed, the number of tokens delivered contingent upon form responses was reduced. After a reversal in differential responding, the equal-reinforcement condition was reintroduced. Two of the subjects returned to their initial response bias when equal reinforcement for either dimensional response was reintroduced, and two maintained the reversal established during the differential-reinforcement phase. For the latter two subjects, differential reinforcement was again imposed, in favor of form. This partial replication reinstated their original pattern of response bias.

A "response bias" is here defined as differential responding to one member of a set of environmental events even though the consequences of responding to any member of that set are equal at the time differential responding is observed. The term "response bias" rather than "stimulus bias" was selected primarily to avoid confusion with such terms as "stimulus discrimination", which, at least in the procedural sense, imply differential reinforcement for responding in the presence of various stimuli. Many studies have shown that, when provided appropriate alternatives and equal consequences, children will demonstrate biases to respond to either the dimension of form or color (*e.g.*, Brian and Goodenough, 1929; Doehring, 1960; Kagan and Lemkin, 1961). This bias, which the child may bring into the experimental situation, can be used

as a baseline to assess the effect of variables which may act to reverse a particular type of response bias.

Amount of reinforcement, particularly the differential method in which each subject comes into contact with more than one value of the reinforcing consequence, has been demonstrated to be an effective performance variable (*e.g.*, Pubols, 1960). The present study was concerned with whether differential amount of reinforcement would serve to reverse biases to respond to either the form or color dimension of a compound standard stimulus. Contingencies involving differential amount of reinforcement were introduced after assessment of response bias under conditions of equal amount of reinforcement for responding to either dimension of the compound stimulus.

METHOD

Subjects

Four male children were selected from a university-operated school for exceptional children. The ages (years and months) and diagnostic descriptions of each subject were as follows: Subject 1, 10-0, orthopedically handicapped; Subject 2, 7-10, orthopedically handicapped; Subject 3, 9-5, emotionally disturbed; Subject 4, 10-5, emotionally disturbed. The only initial criteria for inclusion in the study were that the subjects be between 6 and 12

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years old and physically capable of responding to the apparatus. All subjects scored normal or low-normal on intelligence tests.

Apparatus

The response panel is diagrammed in Fig. 1. The apparatus stood 23 in. from the floor and the front panel was 24-in. wide and 18-in. high. All standard and comparison stimuli were presented by means of Grason-Stadler Multiple Stimulus Projectors mounted behind the front panel; the aperture at the face of each projector was 1.5-in. in diameter. Each projector was designed to present a maximum of 12 different stimuli, and the projectors can be wired to present one stimulus superimposed upon another, *e.g.*, a white triangle on a red field. Four projectors were mounted behind the apparatus, as seen in Fig. 1. Each of the three peripheral projectors was equidistant (3 in.) from the projector in the center. Located beneath each of the four projector faces was a red pushbutton; the force required to activate each pushbutton switch was 9 to 14 oz. A pellet dispenser, modified to dispense marbles, was mounted inside the apparatus. Stimuli and reinforcements were programmed using standard relay and timing circuitry and responses were recorded on digital counters. The marble receptacle (Fig. 1) was clearly marked

at three different levels; approximately 175 marbles were required to reach each succeeding level.

Assessment of token effect. The behavioral effect of the tokens was assessed before the experiment as follows: the prospective subject was approached in his classroom and asked if he would like to "earn" some toys. If the subject answered "yes," he was taken to the laboratory and shown the "store" of toys and comic books for which he could exchange the marbles he accumulated during the experimental session. The subject was then taken to the experimental room, seated before the apparatus, and told that, by pushing the red buttons, he could acquire marbles and would be given a toy of his choice if he filled the container to the first mark. The projectors above the buttons were dark throughout the assessment sessions. Reinforcement (one marble per button-press) was available on only one of the four pushbuttons ("scrambled" among the subjects). The subject was permitted 200 button presses, the definition of the marbles as positive reinforcers being that 175 of the 200 responses were on the single button of the four on which marbles were contingent. The accumulation of 175 marbles was sufficient for a subject to obtain one toy. All subjects met this criterion.

Procedure

The subject was presented a standard stimulus on the center projector. The standard stimulus was a combination of one solid white form (triangle, square, or circle) and one color (red, blue, or green) as the field. Each form stimulus was 8-mm high, and each color encompassed a field 38 mm in diameter. A response on the pushbutton beneath the standard stimulus immediately illuminated two of the three comparison stimuli, the third remaining dark or blank. A response on the blank comparison stimulus pushbutton darkened the other two, requiring another press on the standard stimulus pushbutton which reilluminated the other two comparison stimuli. One comparison stimulus was illuminated with the white geometric form of the standard stimulus with a dark field; a second comparison stimulus was illuminated with the color of the standard without any superimposed form. A response on one of the illuminated comparison pushbuttons darkened all the pro-

Fig. 1. Diagram of the apparatus, showing the location of the standard stimulus and the comparison stimuli. The subject responded to a particular stimulus by pressing the pushbutton located beneath it. The number of toys a subject received at the end of a session was determined by the level on the token receptacle reached by the total number of marbles accumulated during a session.

jectors, including the standard, for 1.5 sec (intertrial interval). At the end of 1.5 sec a different standard stimulus appeared, with the new pair of comparison stimuli remaining blank until a response was again made on the standard. A response on any comparison push-button before a response on the standard had no programmed consequences. Counts of the number of presses on each pushbutton were recorded during each session, providing an assessment of the degree to which position responding occurred.

Nine possible combinations of the three forms and three colors were used (*i.e.*, nine standard stimuli). Each combination was presented as comparison stimuli at each position (left, above, and right of standard) an equal number of times per session. Eighteen different conditions comprised a set which was repeated continuously until the session was terminated. The same set of stimulus conditions was used throughout the experiment.

For all phases, a session was terminated when either of the two following criteria was met: (1) the end of 20 min after the onset of the first standard stimulus; or (2) the completion of 10 sets of the 18 conditions (*i.e.*, 180 trials). If the 20-min time elapsed within a set of conditions, the subject was allowed to complete that set. Sessions were scheduled every weekday for each subject. Table 1 presents an outline of the experimental phases and sub-phases and also shows the number of sessions required by each subject for each condition.

First equal-reinforcement phase. At the beginning of the session after the one described above, each subject was told to press the button beneath the illuminated standard stimulus, which immediately illuminated the comparison stimuli. He was then told to "press the button under the picture that looks like the one in the center." If he pressed the button beneath an illuminated comparison stimulus, three marbles were dispensed into the receptacle and the subject was told again that he would be able to choose one item for each mark on the receptacle he reached with his accumulated marbles. The experimenter then told the subject that he would return when the session had been completed, reminding the subject that the more marbles he earned, the more toys he would be able to select. Subjects who completed all 180 trials during the first equal-reinforcement sessions acquired enough marbles to warrant selection of three toys. The same instructions were given before each session during the first phase but were discontinued for the following phases.

Subjects were allowed to continue through the next two phases on the basis of their performance during the first equal-reinforcement phase. Only subjects who made 80% or more of their responses to comparison stimuli of the same dimension (form or color) over the last three of the five equal-reinforcement phase sessions were retained. If a subject had not met the criterion for inclusion during this phase, he was dropped from the study and another subject was introduced until a total of

Table 1

Number of sessions in each condition for each subject. (The number of marbles following a response to either form (F) or color (C) comparison stimuli is indicated.)

Subject	Equal Reinforcement F = 3, C = 3	Differential Reinforcement		
		F = 2, C = 3	F = 1, C = 3	F = 2, C = 3
1	5	3	5	4
2	5	3	4	5
3	5	3	5	4
4	5	3	5	4

Subject	Equal Reinforcement F = 3, C = 3	Partial Replication		
		F = 3, C = 2	F = 3, C = 1	F = 3, C = 3
1	6	—	—	—
2	5	6	4	5
3	7	—	—	—
4	5	4	—	5

four subjects had met the differential responding criterion. Only one subject was eliminated from the study for failure to meet the criterion of differential responding during the first phase. Response bias to either form or color was defined, then, as at least 80% of the total responses to comparison stimuli of one dimension for the last three successive sessions during the first equal-reinforcement phase.

Differential-reinforcement phase. During the second phase, the relative amount of reinforcement was manipulated. A response to a comparison stimulus of the dimension which received a high frequency of responses during the first equal-reinforcement phase, received fewer marbles than a response to a comparison stimulus of the low-frequency dimension. Whereas the ratio of marbles for form and color responses was 3:3 during the first phase, the ratio during the initial differential-reinforcement manipulation was 3:2 for low-frequency and high-frequency dimensional responses. After three sessions in which no response frequency reversal was shown (*i.e.*, 80% of comparison responses to the first phase low-frequency dimension), subsequent sessions were under a 3:1 marble-ratio condition in favor of the first phase low-frequency dimension until a stable reversal in dimensional responding developed. At the beginning of the session following four sessions of response reversal under any ratio condition, a return to conditions of equal reinforcement was begun (except for Subject 2 who was held in the 3:1 condition for five sessions).

Second equal-reinforcement phase. The conditions during this post-manipulation phase were identical with those in effect during the first equal-reinforcement phase; that is, responses to both color and form received three marbles.

Partial replication. The experiment was then terminated for those subjects who returned to their initial, or first equal-reinforcement phase, pattern of response bias. For those subjects who maintained a reversal of response bias during the second equal-reinforcement phase, differential amount of reinforcement was again imposed in an attempt to return the subjects to their original response bias. This procedure was a partial replication of the previous one in that it employed the same procedure that had earlier established the reversal of differential responding. The ratio

of number of marbles following either a form or color response was changed until differential responding similar to the response bias of the first equal-reinforcement phase was observed; at this point, conditions of equal reinforcement were again imposed.

RESULTS

All four subjects showed a bias to respond to the form dimension of the standard stimulus (more than 80% for the last three of five sessions) during the first equal-reinforcement phase (Fig. 2 and 3). When the token ratio was first shifted to 3:2 in favor of the color dimension during the differential-reinforcement phase, none of the subjects showed a reversal of their previous response bias to the form dimension. However, when the token ratio was changed to 3:1, all subjects responded more than 80% to the color dimension after the first session under that contingency. When the 3:2 ratio was reinstated, the reversal was maintained. Thus, a 3:2 ratio was not sufficient to produce a reversal in response bias, but it was sufficient to maintain a reversal once established.

Figures 2 and 3 separate the subjects into the two (Subject 1 and Subject 3) who returned to their original response bias to form during the second equal-reinforcement phase and the two (Subject 2 and Subject 4) who maintained a reversal of response bias. No distinguishing feature(s) of the data before the second equal-reinforcement phase seems to be related to a subject's either returning or not returning to his initial pattern of response bias.

The subjects' position responding was analyzed for all sessions. Since the blanks and the form and color stimuli were distributed with equal frequency across the left, above, and right comparison projectors, the expected frequency for responding on each of the three comparison pushbuttons was 60 for a full 180-trial session. A subject was said to be responding to the position, rather than to the programmed form or color dimensional features of the stimuli, when the probability of the observed distribution of responses to the three positions could have occurred by chance less than 5% on the basis of the χ^2 test. During the first three phases, only one subject, Subject 2, distributed his responses in such a pattern that position-responding could be said

Fig. 2. Dimensional responding data for Subject 2 and Subject 4. During the first and second equal-reinforcement phase, three marbles were delivered after a response to either form (F) or color (C). The dashed line at 80% indicates the minimum percentage of dimensional responding required to define "a response bias;" the dashed line at 20% indicates the upper limit defining "reversal" of a response bias. Since the percentage of color responses is the mirror image of the form percentage (100%-form), only the percentages for form responses were plotted.

to have occurred, according to the above definition. Subject 2 responded to position during the last two sessions when the 3:2 token-ratio condition was first introduced. When it occurred, Subject 2's position responding consisted of relatively few responses to the comparison pushbutton above the standard stimulus with the remainder of the responses distributed about equally on the left and right pushbuttons.

Sessions for the two subjects who returned to their original pattern of differential responding were terminated at the end of the second equal-reinforcement phase. The experiment was continued for the other two subjects in an attempt to replicate the data before the second equal-reinforcement phase was completed. The ratio of tokens for form and color responses was changed until the subject was again responding to form in more

Fig. 3. The dimensional responding data for Subject 1 and Subject 3 who did not return to their original response bias to form during the second equal-reinforcement phase. The right part of the figure shows the course of the partial replication in effecting a return to the original response bias to form.

than 80% of the trials for four successive sessions. At that point equal reinforcement conditions (three tokens for either form or color responses) were reintroduced. Using the behavior during the second equal-reinforcement phase as the baseline for the partial replication, the right part of Fig. 2 shows that both Subject 2 and 4 returned to their initial pattern of responding to form when the relative amount of reinforcement favored form. Subject 4 returned to form responding when the token ratio was 3:2 in favor of form and continued to respond differentially to form when the consequences were again equal. Under the same ratio, Subject 2 responded about 50% to form (except for one session). Subject 2's behavior during the 3:2 condition again appeared to be under the control of the position of the comparison stimuli rather than the form or color dimensions of the standard. When the token ratio was changed to 3:1 in favor of form responses, Subject 2 responded differentially to form for four consecutive sessions. The next

five sessions were conducted under the baseline condition of equal number of tokens for either form or color responses. During Session 36 (Fig. 3), Subject 2 was position-responding to a significant degree; this was the one session of the final baseline in which the percentage of form responses dropped below the 80% criterion level. Of the 37 sessions given to Subject 2, he showed significant position-responding during seven. In addition to replicating the prior data, the contingency reversal procedure also served as a final check on the functional effect of the tokens as positively reinforcing consequences of the two subjects' responding.

DISCUSSION

The present data indicated that biases to respond to certain dimensions of compound stimuli are members of a manipulable operant response class; it has yet to be demonstrated whether response biases, as defined here,

originate as a result of the environmental consequences of responding. The present study showed, however, that dimensional discriminative control over responding can be shifted from one dimension to another through systematic manipulation of response consequences.

The control of the dimensional stimuli could be shifted without either extinguishing or punishing responding to the dimension which originally controlled the greater frequency of responses. It appeared, though, that some critical difference in the relative amount of reinforcement for responding to either dimension had to be programmed to obtain such a shift. The exact ratio of relative amount of reinforcement at which dimensional control was shifted may have been situation or apparatus-specific; for instance, the location of the marble receptacle and the rate at which the marbles fell into it may have been parameters on the discriminability of amount of token reinforcement. In the present study the effective ratio was not subject-specific; all four subjects reversed their differential responding at the same ratio.

The present data may be related to two historically important areas of investigating stimulus control: attention and preference. Reynolds (1961) studied attention in the pigeon by alternating reinforcement for responding to a compound stimulus, composed of a white triangle with a red background, and extinction for responding to a stimulus composed of a white circle on a green background. The pigeons learned to discriminate the two compound stimuli. Under conditions of extinction, each component of the two compound stimuli (red, green, triangle, circle) was presented independently. One pigeon responded to the triangle and not to the red component of the discriminative stimulus; the other pigeon responded to the red and not to the triangle component. Neither bird responded to the circle or to green. The probability of reinforcement for responding to (or "attending to") either component of the discriminative stimulus was equal. The variables that produced the observed differential responding have not been identified.

A search for some procedural commonality among all the studies of "preference" is difficult. In most studies of human preference, the subject is presented several objects and asked to arrange or select them according to some

criterion. For example, the subject may be asked to select one of several objects that "looks like" a standard object, (*e.g.*, Brian and Goodenough, 1929; the present study) or to select the object he "likes best" (*e.g.*, a red object *vs.* a blue object). In any case, the consequences of responding to all the alternatives are assumed to be equal. In other "preference" studies the observed differential responding is to different consequences. Two different brands of dog food are placed before a beagle and it is observed that he consumes all of Brand A but none of Brand X. The statement is then made that the beagle "prefers" Brand A. The difference between this example of a "preference" study and the one given above is that if Brand A were made contingent upon responding, the rate of the responding would accelerate. However, it is not known whether making a "preferred" red object response-contingent would have any behavioral effect. (Studies investigating "preferences" for various concentrations of sucrose, *e.g.*, Guttman, 1953, fall within the second category.) To avoid some of this confusion, Irwin (1958) suggested that the term "preference" be limited to only those data which show differential responding to differential consequences. When the consequences of responding to any member of a set of events are the same, and differential responding to one member of that set is observed, that pattern of responding may be described as simply "biased." It may be that the variables that generate response biases are not the same as those that generate consequence "preferences." In addition, it appears that the notion of "attention" (at least in the way Reynolds uses the term) can be best described as a response bias. For the present study, it may be said that the subjects showed an initial response bias to the form dimension and later demonstrated a "preference" for three tokens over one token.

The present method of establishing a baseline of differential responding provides an opportunity for the analysis of functionally defined stimulus classes (Skinner, 1935). Skinner suggested two primary defining features of a stimulus class: (1) membership in a stimulus class is based upon a common correlation with a particular response; and, (2) induction (generalization) occurs among the other members of the class if the rate of responding to one member is modified. The present data

met the first criterion; that is, form can be called a stimulus class since there was an equally high probability of making a response to a triangle, a circle, or a square when they appeared. Skinner's (1935) second criterion for defining a stimulus class was not tested in the present study, as the consequences of responding to all members of a stimulus class were simultaneously changed or held constant. The experiment was not designed to observe induction. Further analysis of stimulus classes is needed to determine whether, using a baseline of response bias such as that described here, induction would occur following contingency manipulation for responding to n members of a stimulus class.

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