OBSERVING RESPONSES MAINTAINED BY CONDITIONAL DISCRIMINATIVE STIMULI

AKIRA OHTA

KYOTO UNIVERSITY, JAPAN

In a conditional discrimination procedure, pigeons' observing responses were analyzed to examine whether two color stimuli (blue or red), conditionally related to whether each of two line stimuli (vertical or horizontal) accompanied reinforcement or nonreinforcement, functioned as conditioned reinforcers. If a variable-interval (VI) 10-s requirement was fulfilled, an observing response produced onset of a color stimulus. A little later, a line stimulus was presented independently of responding, added to the color stimulus to form a compound stimulus. If 55 s elapsed with a response not having occurred either through 55 s or after the variable-interval 10-s had timed out, one of the color-line compound stimuli was presented independently of responding. To control for sensory reinforcement effects and for earlier entrance to the later link, a simple discrimination procedure also was conducted in which reinforcement was not correlated with the color stimuli but with the line stimuli only. As in the conditional discrimination, the observing response also could produce earlier presentation of blue or red. The observing response occurred more frequently during the conditional discrimination than during the simple discrimination. The results were related to different theoretical accounts of conditioned reinforcement, particularly the information hypothesis.

Key words: observing response, conditional discrimination, conditioned reinforcement, information hypothesis, key peck, pigeon

According to Fantino (1977), there are three plausible accounts of conditioned reinforcement: the information hypothesis, the delay-reduction hypothesis, and the reinforcement-density hypothesis. The information hypothesis states that the potency of a conditioned reinforcing stimulus depends on its informativeness about primary reinforcement. The delay-reduction hypothesis assumes that the strength of a conditioned reinforcer is a function of the reduction in time to primary reinforcement that is correlated with its onset. The reinforcement-density hypothesis states that the critical variable is the rate of primary reinforcement in the presence of the conditioned reinforcer. Both of the latter two theories assume that only stimuli correlated with more positive outcomes should have conditioned reinforcing functions. Since Egger and Miller (1962) suggested a role for information in producing conditioned reinforcement, several experiments have examined its generality (see Fantino, 1977, for a review). A popular method for distinguishing predictions of the information hypothesis of conditioned rein-

forcement from those of the other two accounts has been to attempt to show that negative discriminative stimuli (S^+ or S^-) function as conditioned reinforcers (e.g., Lieberman, 1972; Preston, 1985). Unfortunately, no consistent, unimpeachable characterization of an effect of negative information on conditioned reinforcement has been forthcoming from these studies.

Accepting for the moment the validity of the information hypothesis, the failure to demonstrate a conditioned reinforcing function of negative discriminative stimuli may be because the aversive properties of S^- override the conditioned reinforcing function of such negative information. For example, Terrace (1971) demonstrated the aversive properties of S^- through negative reinforcement of escape responses that removed S^- stimuli. He trained pigeons to discriminate between white horizontal and vertical lines and showed that those pigeons who learned the discrimination with errors also would escape from S^- by pecking a second response key which turned off S^- for 5 s; a similar arrangement for escape from S^+ did not maintain responding on the second key.

A possible way to avoid such an aversive influence is to provide a situation in which stimuli are not correlated with reinforcement or nonreinforcement but do provide the infor-

Reprints may be obtained from the author, Department of Psychology, Faculty of Letters, Kyoto University, Sakyo-ku, Kyoto, 606, Japan.

mation about these outcomes. Note that if conditioned reinforcing stimuli are not correlated with more positive outcomes, neither the delay-reduction hypothesis nor the reinforcement-density hypothesis should be applicable. The present experiment describes a conditional discrimination procedure satisfying the above requirements.

Consider two pairs of stimuli: S_A/S_B and S_X/S_Y . Further, suppose the value of S_X or S_Y depends on S_A or S_B . For example, if S_A is presented, S_X is positively correlated with reinforcement (i.e., the conditional probability of reinforcement in the presence of S_X with S_A is 1.0). With the S_A/S_Y compound, the outcome is nonreinforcement. Conversely, in the presence of S_B , S_X is negatively correlated with reinforcement whereas S_Y is positively correlated with reinforcement. If S_A or S_B is not compounded with S_X or S_Y but instead is presented alone, it provides information concerning the relation between S_X/S_Y and the outcomes in such a conditional discrimination. Because neither S_A nor S_B , relative to its absence, is correlated with nonreinforcement (i.e., they function only as background stimuli), the aversive influence should not arise. Furthermore, because neither is correlated with reinforcement, the delay-reduction hypothesis as well as the reinforcement-density hypothesis does not apply in a straightforward manner.

To test for conditioned reinforcing functions of information provided by the conditional discriminative stimuli, an observing response procedure was used (Wyckoff, 1969), similar to that of Wilton and Clements (1971). Wilton and Clements arranged a discrete-trials procedure; a trial began with illumination of a pecking key by a white light, and the first observing response to occur after 15 s (fixed-interval (FI) 15-s) changed the light to either a red or a green discriminative stimulus that remained on until the end of the trial. Corresponding to these colors, reinforcement or nonreinforcement occurred independently of the observing response 50 s after the onset of the trial. The trial then terminated, with the key darkened until the onset of the next trial. If the discriminative stimuli were not observed, the outcome occurred as if they had been observed so that the observing could not change the outcome of the trial.

In the present work, this discrete-trial procedure was adapted to a conditional discrim-

ination situation. An observing response, usually defined as an operant that produces discriminative stimuli, produced one class of the conditional discriminative stimuli (e.g., S_A or S_B). First, no conditional discriminative stimulus was presented. If an observing response was made, S_A or S_B was presented alone until the end of the trial. Because the other class of the conditional discriminative stimulus (e.g., S_X or S_Y) was absent at that time, the outcome (delivery or nondelivery of food) was not predictable, but the conditional information was provided. Some time later, S_X or S_Y was added independently of responding, to form a compound discriminative stimulus. Even if S_A or S_B was not observed, S_X or S_Y and the outcome of the trial occurred so that the observing response could not change these occurrences.

Other possibilities, however, remain. First, because stimulus onset has reinforcing effects of its own ("sensory reinforcement"; Kish, 1966), the observing response may be primarily reinforced by S_A or S_B itself and/or the stimulus change from background stimuli to S_A or S_B . Second, considering the present procedure as a chained schedule with S_A or S_B constituting part of the terminal link, the presentation of S_A or S_B implies earlier entrance to the later link so that this may yield the stronger conditioned reinforcing effect because the later link is closer to reinforcement (E. Fantino, personal communication, March 21, 1984). To preclude these interpretations, a control condition was arranged, which also allowed responses to produce earlier onset of S_A or S_B , but with these stimuli kept uninformative as to the relation between S_X/S_Y and the delivery of food. This was done by including a simple successive discrimination, in which S_X/S_Y were correlated with the outcomes and S_A/S_B were not. The observing response could produce S_A or S_B earlier, which allowed for sensory reinforcement and/or earlier entrance to the later link. It did not reduce uncertainty, however, with respect to either the outcomes or the relation between S_X/S_Y and those outcomes. If conditioned reinforcement is stronger in the conditional discrimination than in the simple discrimination, it makes implausible the interpretations in terms of sensory reinforcement and of reductions in time to food delivery. Any obtained differences in maintenance of observing responses by the conditional dis-

crimination versus the simple discrimination procedures can be interpreted as reflecting conditioned reinforcement due to the information concerning the relation between S_X/S_Y and the delivery or nondelivery of food.

A procedural modification was developed during preliminary work: In a pilot phase of experimentation with the conditional discrimination procedure, if S_A or S_B was not produced by an observing response, only S_X or S_Y was presented, independently of responding, and reinforcement followed with a probability of .5. This nondifferential arrangement severely disrupted the conditional discrimination performance. To avoid risk of this disruption in cases where S_A or S_B was not produced by an observing response, one or the other of these stimuli was presented independently of responding, after a fixed period from the trial onset, to form a simultaneous compound with S_X or S_Y . Note that this ensured that a compound stimulus accompanied the end of every trial. The observing response produced earlier onset of S_A or S_B and thus earlier reduction of uncertainty about the relation between S_X/S_Y and the outcomes.

METHOD

Subjects

Four homing pigeons (S6, S5, S4, S1) were used. They had experimental histories of exposure to concurrent chains schedules and an observing response procedure, both of which included nonoverlapping successive conditional discrimination with the same stimuli as in the present experiment. The birds were maintained at 80% of their free-feeding weights. Water and grit always were available in their home cages.

Apparatus

One soundproof operant conditioning chamber was used. Its inside dimensions were 37 cm long, 30 cm wide, and 30 cm high. Three translucent response keys were mounted 8 cm apart and 23 cm above the floor. Only the right key was used. The key required a minimum force of about 0.15 N to be activated. The operation of a microswitch provided auditory feedback for key pecks. The key could be transilluminated by an in-line projector (I.E.E. model 10-0052) with green, blue, red, three vertical white lines, or three horizontal white

Fig. 1. Procedural diagrams showing the temporal relations among the stimuli, key pecking, and the outcomes on a trial, for the training (top panel) and the test (middle and bottom panels) phases of experimentation with conditional and with simple discrimination procedures. Top panel: Pecks in the presence of the positive color-line compound stimuli were reinforced on an FI 5-s schedule; pecks in the presence of the other stimuli prolonged those stimuli (reset contingency), which were followed by 5-s blackout whether or not pecks had occurred. The intertrial interval (ITI) was 60 s. Middle panel: If the key was pecked during green (observing response) after the VI 10-s requirement (shown as 35 s) was fulfilled, the key color changed to blue or red for the rest of the trial. One of the line stimuli was added response-independently 55 s after the trial onset. The ITI was 20 s. Bottom panel: If the observing response was not made after the VI 10-s requirement was fulfilled, green was replaced by one of the color-line compound stimuli response-independently 55 s after the trial onset. The ITI was 20 s. This independent presentation of compound stimuli also occurred if 55 s elapsed with a response not having occurred. The trial outcomes during the test were the same as during training.

lines. The color and line stimuli could be compounded. A solenoid-operated grain hopper was located below the center key and provided 5-s access to grain with a white illumination. No general chamber illumination was provided. White noise was present continuously. A UNITEC UP8® microcomputer, located in

Table 1

Stimuli and reinforcement condition for each subject. B, R, V, and H, respectively, denote Blue, Red, Vertical, and Horizontal. The outcomes, + or −, correspond to whether the specified type of trial ends in reinforcement or nonreinforcement.

	Conditional (first)				Simple				Conditional (second)			
	Stimuli		Out-comes	No. of sessions	Stimuli		Out-comes	No. of sessions	Stimuli		Out-comes	No. of sessions
	Color	Line			Color	Line			Color	Line		
S6	B	V	+	46	B	V	+	23	B	V	+	23
	B	H	−		B	H	−		B	H	−	
	R	V	−		R	V	+		R	V	−	
	R	H	+		R	H	−		R	H	+	
S5	B	V	−	19	B	V	−	19	B	V	−	28
	B	H	+		B	H	+		B	H	+	
	R	V	+		R	V	−		R	V	+	
	R	H	−		R	H	+		R	H	−	
S4	B	V	−	39	B	V	−	15	B	V	−	45
	B	H	+		B	H	+		B	H	+	
	R	V	+		R	V	−		R	V	+	
	R	H	−		R	H	+		R	H	−	
S1	B	V	+	19	B	V	+	32	B	V	+	31
	B	H	−		B	H	−		B	H	−	
	R	V	−		R	V	+		R	V	−	
	R	H	+		R	H	−		R	H	+	

an adjacent room, controlled the experiment and collected data.

Procedure

Because each subject had a prior experimental history, preliminary training was not required. The experiment consisted of three phases, each of which involved discrimination training followed by 15 sessions of an observing response test. Throughout the experiment, one session of 50 trials was conducted daily, 6 or 7 days per week. Types of trials were randomized with the restriction that neither the same color, the same line stimulus, nor the same outcome appeared in three successive trials. Table 1 shows the stimulus–reinforcement conditions and the numbers of discrimination training sessions for each subject. The order of the phases was as follows: the first conditional discrimination, followed by the simple discrimination, and finally the second conditional discrimination. The session numbers in Table 1 do not include the 15 test sessions following each training phase.

Conditional Discrimination

Training. The top panel of Figure 1 provides a schematic diagram of the training procedure.

A trial began with the simultaneous onset of one of the color discriminative stimuli (blue or red) and one of the line discriminative stimuli (vertical or horizontal). If their combination was positive, the first peck after 5 s had elapsed (FI 5 s) resulted in 5-s presentation of grain. If the stimulus combination was negative, pecking was not reinforced and a 5-s blackout occurred instead of 5-s reinforcement. A reset contingency was in effect during the negative compound stimulus such that any peck postponed the stimulus offset until 5 s passed without any pecking. The intertrial interval (ITI) was 60 s. Conditional probability of positive or negative trials on each color stimulus and each line stimulus, considered independently, was .5.

Each subject was transferred to the observing response test after the following criteria were met: (a) at least 15 sessions were conducted; (b) throughout the last five sessions, an overall discrimination ratio (i.e., the sum of the response rates in the two types of negative trials divided by sum of the response rates in all the kinds of trials) was less than .20, with a further stipulation that each discrimination ratio calculated separately for trials ending with the vertical or with the horizontal

line should be .25 or less (cf. Honig & Wasserman, 1981).

Test. The middle and bottom panels of Figure 1 schematically diagram the observing response test. A trial began with the onset of the green stimulus. Pecks on the key during the green stimulus were defined as "observing responses." A VI 10-s schedule (range, 1 to 49 s) provided for observing responses to change green into one of the color conditional discriminative stimuli, as indicated in the middle panel of Figure 1. The blue or red stimulus was presented from that point to the end of the trial. Fifty-five seconds after the trial onset, one of the line discriminative stimuli was added independently of responding. If their combination was positive, a key peck could produce a 5-s presentation of grain on FI 5 s. If their combination was negative, pecks were not reinforced and a 5-s blackout occurred. If 55 s had elapsed since the beginning of the trial and no peck had occurred either through 55 s or since completion of the schedule interval, green terminated independently of responding (converting the schedule to FT 55 s), and a blue or red color-line compound appeared simultaneously (see the bottom panel of Figure 1). The ITI was 20 s. The test was conducted for 15 sessions, and no discrimination criterion was used in this phase.

Simple Discrimination

Training. A trial began with one of the same four possible compound stimuli as was used in the conditional discrimination (see the top panel of Figure 1). Reinforcement, however, depended solely on the line stimuli; the color stimuli were not discriminative, in that reinforcement and nonreinforcement occurred with equal probability in the presence of each color stimulus. Other features of the procedure, such as reinforcement schedule, ITI, and so on were the same as in the training of the conditional discrimination. The observing response test was begun after the following criteria had been met: (a) a minimum of 15 sessions was conducted; (b) the discrimination ratio, based on the line stimuli, did not exceed .20 throughout the last five sessions.

Test. A trial began with presentation of the green stimulus. As specified by the VI 10-s schedule (see middle panel of Figure 1), an observing response could replace green with one of the color stimuli. The blue or red stim-

ulus was then present from that point to the end of the trial. One of the line discriminative stimuli was added 55 s after the trial onset independently of responding. If the line was positive, key pecking was reinforced with 5-s presentation of grain on an FI 5-s schedule. If the line was negative, the 5-s reset contingency was operative, and the trial ended in a 5-s blackout. If 55 s elapsed with no observing response having occurred either through 55 s or after the VI timed out, the arrangement was the same as described above for the conditional discriminations (see bottom panel of Figure 1). The ITI was 20 s. Fifteen sessions were conducted; no discrimination criterion was in effect.

RESULTS

Figure 2 shows the number of observing responses (total pecks during green) in the 50 trials of each test session for each of the 4 subjects. On the whole, the observing response occurred more frequently in the conditional discrimination procedure than in the simple discrimination. S6 and S5 showed large performance differences between the first conditional discrimination and the simple discrimination, whereas S4 showed its larger performance difference between the second conditional discrimination and the simple discrimination. The difference between the first conditional discrimination and the simple discrimination was not necessarily larger than that between the second conditional discrimination and the simple discrimination. There was no entirely consistent trend as a function of test sessions, although each bird showed a decreasing trend in at least one condition.

Even though there seem to be clear differences in observing response frequency between the simple and conditional discrimination, the absolute rate of observing was low. These small numbers might lead one to question the robustness of the phenomenon of observing. Hence, it is useful in assessing the strength of the observing response to show how often the subjects produced the color stimuli relative to the number of opportunities to do so; the discrete-trial feature of the procedure enables this assessment. Figure 3 shows the number of trials with response-produced presentation of the color stimuli per 50-trial session for all subjects. Similar to the data based on total re-

Fig. 2. Each panel compares the number of observing responses in the conditional discrimination with that in the simple discrimination as a function of successive test sessions in each condition.

sponses, the color stimuli were response produced more frequently in the conditional discrimination than in the simple discrimination. Note, however, that even in the conditional discrimination, the color stimuli were not produced on every trial of each session. S4 produced no color stimulus during Sessions 12 through 14 in the second conditional discrimination. S5 showed its largest performance differences between the first conditional discrimination and the simple discrimination, whereas S4 showed its largest differences between the second conditional discrimination and the simple discrimination. There was no consistent trend across subjects as a function of test session; neither was there a consistent direction of difference between the initial condition with conditional discrimination and the subsequent replication.

Because no explicit criterion was set during the observing response test, it is necessary to ensure that each discriminative performance

was maintained in each condition. Figure 4 represents the discrimination ratios on each test session for all subjects. They are shown separately in terms of the line stimuli during each conditional discrimination. In general, the conditional discrimination and the simple discrimination remained intact during the observing response test. However, just after the shift to the observing response test, discrimination performances slightly deteriorated in the first conditional discrimination and the simple discrimination of S5, in the first conditional discrimination of S4, and in the simple discrimination of S1. Although conditional discrimination performances with the horizontal line temporally deteriorated in the second conditional discrimination of S5, S4, and S1, those involving the vertical line were maintained quite well.

Figure 5 shows the response rate in the presence of the color stimuli during successive test sessions for all subjects. Subjects 5 and 6 tended

Fig. 3. Each panel compares the number of response-produced presentations of the color stimuli during the conditional discrimination tests with that during the simple discrimination tests, both as functions of successive test sessions.

to respond more frequently during the first and second conditional discrimination conditions, respectively, than in the simple discrimination condition. No other subject showed a consistent difference, in these measures, between the conditional discrimination and the simple discrimination.

Figure 6 shows the relation between the number of observing responses per test session and the corresponding response rate in the presence of the color stimuli for each subject. Each panel includes all the data points in the conditional and the simple discrimination. Points in the panels for S5 and S4 scattered in the vicinity of the origin. The points in the panels for S6 and S1 scattered widely. Although S4 showed a positive correlation, no explicit correlation appeared between the observing response number and the response rate in the presence of the color stimuli. When calculated by excluding the trials in which nei-

ther color stimulus was observed, Spearman rank correlation coefficients were .12, .16, .47, and .09 for S6, S5, S4, and S1, respectively.

DISCUSSION

In general, observing responses occurred more frequently in the conditional discrimination than in the simple discrimination condition. Comparable results are indicated by data based on the number of trials in which the observing response produced the color stimuli. Response rates in the presence of the color stimuli alone (without the superimposed lines) were not necessarily higher in the conditional discrimination than in the simple discrimination. No subject except S4 showed a positive correlation between the number of observing responses and the response rate in the presence of the color stimuli alone.

The absolute number of observing responses

Fig. 4. Each panel shows discrimination ratios for each test session for an individual subject. The discrimination ratio was calculated separately for the line stimuli in each conditional discrimination; lower values indicate greater degrees of discrimination.

and the number of trials in which observing responses occurred were not high even in the conditional discrimination. Also, because no consistent trend appeared as a function of successive test sessions, the low frequency of observing appears not to have been caused by loss of conditioned reinforcing properties of stimuli as each testing phase progressed. Two ancillary points may be relevant. In the observing response test, if no observing response occurred either for 55 s or after the programmed interval lapsed, green terminated independently of responding (an FT 55-s schedule), and one of the color stimuli and one of the line stimuli were presented simultaneously as a compound. Thus, even when the subject made no observing response, the color conditional discriminative stimuli were presented independently of responding. Furthermore, in discrimination training, they were presented independently of responding under these same conditions. These contingencies may have lowered the frequencies of observing.

If the compound stimulus was positive, key

pecking was reinforced on an FI 5-s schedule. Because the observing response and the response required for food delivery were of the same topography (key peck), differences in observing between the conditional and the simple discrimination may be due to more vigorous responding on the FI component in the conditional discrimination than in the simple discrimination. Moreover, if response strength of a discriminative stimulus corresponds to conditioned reinforcing effectiveness (cf. Wyckoff, 1959), the observing response might be maintained by stronger conditioned reinforcement by the compound discriminative stimuli in the conditional discrimination. These observations might explain why key pecking was more frequent during the color presentation in the conditional discrimination. However, response rates during the color presentation were not necessarily higher in the conditional discrimination than in the simple discrimination. Green was so temporally distant from the FI component that the lack of a response-rate difference during the color presentation, more

Fig. 5. Each panel shows response rates during the color stimuli, for an individual subject during successive test sessions. These response rates (per second) were computed by dividing the accumulated responses during the blue and red stimuli by the accumulated duration of those stimuli in the absence of added line stimuli.

contiguous to the FI component, could hardly be accounted for by the more vigorous responding on the FI component in the conditional discrimination.

It is possible that the observing responses in the conditional discrimination were maintained by the presentation of blue or red itself and/or the stimulus change from green to blue or red (cf. Kish, 1966). Such sensory reinforcement was, however, equally operative in the simple discrimination. Thus, differences in the observing response frequency between the conditional discrimination and the simple discrimination cannot be attributed to sensory reinforcement. Nor is it plausible that observing was directly maintained by the grain presentations, because the reinforcement schedule was the same in both the conditional and the simple discrimination, whether or not the color stimuli were observed.

The present observing response procedure could be regarded as a chained schedule. Because the later link is closer to primary reinforcement, the earlier presentation of blue or

red, which is part of the terminal link, may be more reinforcing. In consideration of this, the observing response difference might be accounted for by the delay-reduction hypothesis or reinforcement-density hypothesis (Fantino, 1977), assuming that production of blue or red accompanies a reduction in the delay to reinforcement by 20 s on the average (i.e., $60/.5 = 120$ s in green and $50/.5 = 100$ s in blue or red; see Fantino, 1977, pp. 324–325) or increases reinforcement frequency. Either factor was, however, equally operative in the simple discrimination, so neither hypothesis provides a straightforward account of the present results.

Studies of compound conditioning report "overshadowing" in which stimuli that are only moderately correlated with the outcomes lose their control over behavior when accompanied by more highly correlated stimuli (Mackintosh, 1977; Wagner, Logan, Haberlandt, & Price, 1968). In the present simple discrimination, the line stimuli were more highly correlated with the outcomes than the color stim-

Fig. 6. Each panel shows, for an individual subject, the relation between the total number of observing responses and the response rate (resp/sec) in the presence of the color (blue and red) stimuli, with each data point representing one test session. All the data points in the conditional and the simple discriminations are included.

uli were, so the former may have overshadowed the latter. Ward (1971) suggested that predictiveness is important in observing as well as in other forms of conditioning. Perhaps the higher predictive features of the line stimuli rendered the less highly correlated and less predictive color stimuli ineffective in supporting observing at more than moderate levels. In the conditional discrimination, the color stimuli were followed by reinforcement with a probability of .5. The line stimuli also appeared, but the correlation of these stimuli with reinforcement was no greater than that of the color stimuli. The line stimuli could not overshadow the color stimuli, to which conditioning should occur. Reinforcement frequency was about 0.5 per minute in blue and in red, compared to zero in green. From the perspective of delay reduction, the 20-s reduction in delay on the average would yield a similar advantage to blue and red over green. In short, the color

stimuli might be effective conditioned reinforcers to predict the delay reduction or the reinforcement-frequency increment in the conditional discrimination procedure, whereas the overshadowed color stimuli in the simple discrimination procedure might not predict either.

An analysis of observing in terms of overshadowing requires a correspondence or parallel between conditioned reinforcement and conditioning. The present results offer two relevant data. First, the response rate in the presence of the color stimuli did not differ except between the first conditional discrimination and the simple discrimination of S6 and between the second conditional discrimination and the simple discrimination of S5. Second, with the exception of S4, no positive correlation was found between the number of observing responses and the response rate in the presence of the color stimuli. No clear correspondence was obtained.

Mackintosh (1977) suggested that predictive stimuli overshadow background stimuli only in discrete-trial procedures. Wagner et al. (1968, Experiment 1), Turner and Mackintosh (1972, Experiment 2), and Gray and Mackintosh (1973) allowed subjects to respond only once in each S+ trial and demonstrated overshadowing in the discrimination condition with the least dominant response-produced stimulus. According to Mackintosh (1977), response-produced stimuli occur so frequently in free-operant procedures that they are overshadowed by the more predictive discriminative stimuli. Consequently the stimulus control of the other irrelevant background stimuli would be explicit in a free-operant procedure, whereas the other irrelevant background stimuli are overshadowed in the discrete-trial procedure with the less dominant response-produced stimuli. In the present simple discrimination procedure, multiple key pecks were possible and were observed to occur. If the delay-reduction hypothesis or the reinforcement-density hypothesis is applicable on the assumption of overshadowing, it needs to specify the precise conditions under which the more predictive line stimuli overshadow the response-produced stimuli.

The information hypothesis does not require such elaborate assumptions. During the observing response test, the color stimuli were effective as conditional discriminative stimuli, and thus were informative in predicting the relation between the line stimuli and the outcomes, reducing uncertainty. Although the color stimuli were presented response-independently in a simultaneous compound with the line stimuli, if they had not been produced by an observing response, the observing response could produce them earlier to reduce the uncertainty.

Fantino (1977) noted that conditioned reinforcement by S- is strong evidence for the information hypothesis. Previous experiments (Blanchard, 1975; Browne & Dinsmoor, 1974; Dinsmoor, Browne, & Lawrence, 1972; Mulvaney, Dinsmoor, Jwaideh, & Hughes, 1974) found that S- did not function as a reinforcer. One positive demonstration by Lieberman (1972) was criticized by Mueller and Dinsmoor (1986), who showed that if S- occurred response-independently in addition to response-dependent S+ presentation, pigeons' observing was as frequent as in the case where

both S+ and S- were presented response-dependently. Although strong evidence has not yet been obtained, this should not necessarily rule out the information hypothesis of conditioned reinforcement. Clearly, S- has aversive properties that can punish the observing response that produces it (Blanchard, 1975; Mulvaney et al., 1974). It therefore is necessary to examine whether the stimulus that is neither positive nor negative but informative can reinforce the observing response. The present experiment suggests that the conditional discrimination is a useful procedure for such an approach.

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