ON CONDITIONED REINFORCING EFFECTS OF NEGATIVE DISCRIMINATIVE STIMULI

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Observing responses by pigeons were studied during sessions in which a food key and an observing key were available continuously. A variable-interval schedule and extinction alternated randomly on the food key. In one condition, food-key pecking during extinction decreased reinforcement frequency during the next variable-interval component, and in the other condition such pecking did not affect reinforcement frequency. Observing responses either changed both keylight colors from white to green (S+) or to red (S-) depending on the condition on the food key, or the observing responses never produced the S+ but produced the S- when extinction was in effect on the food key. Observing responses that produced only S- were maintained only when food-key pecking during extinction decreased reinforcement frequency in the subsequent variable-interval component. The red light conformed to conventional definitions of a negative discriminative stimulus, rendering results counter to previous findings that production of S- alone does not maintain observing. Rather than offering support for an informational account of conditioned reinforcement, the results are discussed in terms of a molar analysis to account for how stimuli acquire response-maintaining properties.

Key words: observing responses, S-, adjusting contingencies, information, conditioned reinforcement, key peck, pigeons

Two major explanations of how previously neutral stimuli come to function as reinforcers have emphasized different conditioning principles or informational mechanisms. Accounts based on Pavlovian conditioning emphasize the pairing of a stimulus with a reinforcer, the rate of reinforcement in the presence of such stimuli, or other Pavlovian conditioning features as critical in establishing stimuli as conditioned reinforcers (Dinsmoor, 1983; Fantino, 1977). These conditioning-based explanations have led to the conclusion that only stimuli positively correlated with already-established reinforcers will maintain behavior. In contrast to such explanations is the information (or uncertainty-reduction) hypothesis, which relates the strength of a conditioned reinforcer to the information a stimulus provides about the availability of an already-established reinforcer (e.g., Hendry, 1969). The information hypothesis asserts that even stimuli paired with the absence of reinforcement should maintain responding because these

stimuli provide information about the availability of reinforcement. Both the conditioning- and information-based accounts share an emphasis on the association of contiguous events, either environmental (in the former case) or cognitive (in the latter case, but cf. Branch, 1983).

Wyckoff's (1952) observing procedure is a primary means for determining the conditions under which stimuli function as conditioned reinforcers (Dinsmoor, 1983; Fantino, 1977). Consequently, it has been the conceptual battlefield between conditioning-based and informational accounts of conditioned reinforcement. In this procedure, observing responses are different from those responses that produce primary reinforcement. Thus, when addressed to pigeons' key pecking, observing responses on a separate key, which have no effect on the temporal distribution of reinforcement, can produce stimuli correlated with one or more conditions of reinforcement (positive discriminative stimuli) or with its absence (negative discriminative stimuli). Observing responses that produce only stimuli that never accompany primary reinforcement generally are not maintained (e.g., Dinsmoor, Browne, & Lawrence, 1972; Jenkins & Boakes, 1973; see Dinsmoor, 1983; Fantino, 1977; and Fantino & Case, 1983, for reviews). This outcome has been offered as evidence against the informa-

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tion hypothesis and supportive of conditioning-based accounts of conditioned reinforcement.

It is often taken that the defining feature of both a discriminative stimulus and a conditioned reinforcer is the contiguous or simultaneous occurrence of the stimulus and primary reinforcement. In its simplest form, a negative discriminative stimulus is defined as one in the presence of which the probability of reinforcement is zero (Fantino & Case, 1983; Holland & Skinner, 1961) and because of this feature it does not maintain observing. Such a definition, however, does not exclude the possibility of accounting for the reinforcing properties of a stimulus in terms of relations among stimuli, responses, and reinforcers over more extended time frames. Perhaps, then, there are other effective stimulus-reinforcer relations, in addition to the contiguous associational relation, that have not been recognized or acknowledged in studies of observing and in discussions of conditioned reinforcement.

The consideration of controlling relations over extended time frames in describing conditioned reinforcement may be particularly relevant in evaluating evidence that is proffered in support of information-based accounts of conditioned reinforcement. For example, such contingencies permit arrangements of conditions in which a conventionally defined negative discriminative stimulus might maintain the observing responses that produced it. In the experiment reported here, we examined whether a putative negative discriminative stimulus would reinforce observing when responding in the presence of the S- affected the frequency of reinforcement during a subsequent S+ presentation.

METHOD

Subjects

The subjects were 3 White Carneau pigeons, maintained at 80% of their free-feeding weights. Each had a history of food-reinforced key pecking.

Apparatus

An operant conditioning chamber (Gerbrands Model G7311) was housed in a sound- and light-attenuating enclosure (Gerbrands Model G7210). The chamber contained two response keys, operated by a force of 0.14 N, located 7.5 cm to either side of the midline of

the work panel and 25.5 cm from the floor. The keys were transilluminated red, green, or white except during reinforcement. During all conditions, reinforcement was 3-s access to mixed grain in a hopper located behind a 5-cm square aperture centered on the work panel 8.5 cm from the floor. The aperture was illuminated by two GE 1819 lights operated by 28 V DC during reinforcement. Two similar white 28 V DC lights, located adjacent to each other in the center of the ceiling, were illuminated throughout the session except during reinforcement. A ventilating fan masked extraneous sounds. A PDP 8a[®] computer programmed experimental events and recorded the data.

Procedure

Responses on the right (food) key were maintained by a mixed or a multiple variable-interval (VI) extinction (EXT) schedule in which the components alternated every 45, 60, or 75 s; each of these intervals was equally likely to succeed each other. Responses on the left (observing) key occasionally (according to a VI 15-s schedule) changed the color of both the left and right keys for 30 s from white to red (EXT) or to green (VI) as described below, thereby converting the schedule from a mixed to a multiple schedule (cf. Dinsmoor et al., 1972). A changeover delay (COD) was in effect on the observing-response key. As a result, Pigeons 5152 and 5902 never produced food during the first 2 s after an observing response. This interval was 6 s for Pigeon 1874. Sessions were 60 min long and occurred 6 days per week.

In two of the conditions, an adjusting contingency was used in which responses during the extinction component of the multiple or mixed schedule altered the frequency of food reinforcement in the next VI component. In these two conditions, the absence of responses on the food key during extinction was followed by a VI 7.5-s schedule of reinforcement; 1 to 10 responses during extinction resulted in a VI 15-s schedule; and more than 10 responses in the extinction component resulted in no access to food in the next component. During the red/green-adjusting conditions, observing responses produced both the red and green stimuli, depending on the component in effect on the food key. During the red-adjusting conditions, observing responses produced

Table 1

Sequence of conditions and number of sessions at each condition for each subject. Also shown are mean response rates during extinction and mean reinforcement rates in the VI component (regardless of stimuli present), expressed in units per minute, averaged over the last five sessions of each condition.

Condition	Bird 5902			Bird 1874			Bird 5152		
	Number of sessions	Response rates	Reinforcement rates	Number of sessions	Response rates	Reinforcement rates	Number of sessions	Response rates	Reinforcement rates
RGN	16	11.9	1.9	15	10.7	1.9	—	—	—
RN	14	35.3	1.9	20	49.0	2.0	—	—	—
RGN	10	12.2	1.7	12	14.7	1.8	22	17.5	1.9
RGA	43	4.9	3.4	40	9.9	2.8	32	12.0	2.0
RA	38	20.2	0.8	40	19.6	1.5	24	41.2	0.4
RN	23	40.3	1.9	25	45.9	1.9	12	46.0	1.8
RA	16	16.4	0.9	23	22.7	0.9	20	34.7	0.4
RN	—	—	—	15	64.0	1.9	—	—	—
RA	—	—	—	21	24.4	0.5	—	—	—
RGA	24	10.6	2.4	—	—	—	—	—	—

Note. RGN = red/green nonadjusting; RN = red nonadjusting; RGA = red/green adjusting; RA = red adjusting.

only the red stimulus; the food and observing keys remained white when the VI component was in effect.

In two other conditions, the adjusting contingency was omitted. During red/green-nonadjusting and red-nonadjusting conditions, a VI 30-s schedule alternated randomly with extinction. During the red/green-nonadjusting conditions, observing-key responses changed the colors of both keys to either red or green depending on the component in effect on the food key. During the red-nonadjusting conditions, observing-key responses produced only the red keylights; if the VI schedule was in effect when the observing response requirement was met, both response keys remained white. The sequence of conditions and numbers of sessions in each condition for each subject are shown in Table 1. Conditions were changed when the median numbers of observing-key responses for three successive three-session blocks did not systematically increase or decrease.

RESULTS

Observing response rates for the last five sessions of each condition for each pigeon are shown in Figure 1. The effects across successive conditions and within each type of condition were replicated across individual subjects. In the red-nonadjusting conditions, rates

declined rapidly over successive sessions and became stable near zero. By contrast, in the red-adjusting conditions observing was maintained for the duration of the condition (up to 40 sessions). Observing responses occurred most frequently during the red/green-adjusting conditions.

Response rates on the food key during extinction are shown in Table 1, along with the frequency of reinforcement in the VI component for each condition. Response rates during extinction components were highest during nonadjusting conditions and lowest during the red/green-adjusting conditions. Reinforcement rates were highest during the red/green-adjusting conditions and lowest during the red-adjusting conditions.

DISCUSSION

Observing responses in the red-adjusting conditions were maintained even though observing responses in this condition produced a stimulus that satisfied the formal definition of a negative discriminative stimulus—that is, one in the presence of which food was never available and the probability of a response was less than in its absence (Fantino & Case, 1983; Holland & Skinner, 1961). On the surface, this finding appears to run counter to previous findings with pigeons indicating that stimuli in the presence of which responding is never

Fig. 1. Observing responses per minute during the last five sessions of each condition. (Data from Birds 5902, 1874, and 5152 are shown respectively in the top, middle, and bottom graphs.) Conditions are separated by solid vertical lines, and sequence of the conditions is indicated at the top of the figure. R = red light available; G = green light available; A = adjusting schedule; N = nonadjusting schedule. The omission of data points indicates that the pigeon was not exposed to that condition.

reinforced will not maintain observing. This finding might, therefore, appear to support the information hypothesis. There is no need, however, to appeal to informational accounts for the present maintenance of observing in conditions in which only negative discriminative stimuli were produced.

Although there was no direct dependency between observing responses and rate of reinforcement, an indirect dependency existed in that producing S- resulted in reduced food-key responding that in turn increased reinforcement frequency. Observing responses during the red-adjusting conditions both produced a putative S- and set into operation the complex contingency between observing re-

sponses and reinforcement frequency described in the previous sentence. As a result, responding that might be attributed to the informational value of the S- is more logically attributed to the indirect relation between responding during S- and reinforcement frequency. This interpretation is consistent with previous conditioning-based accounts of S- effects on the maintenance of observing.

Our results suggest that although the contiguity of a stimulus and a reinforcer may be a sufficient condition for a stimulus to function as a conditioned reinforcer, it is not necessary. What is necessary is the contingency or correlation between a stimulus and later reinforcement. Of course, a correlation is an inextricable feature of contiguity (cf. Sizemore & Lattal, 1977), but, as the present results show, a correlation can be arranged that will establish a stimulus as a conditioned reinforcer independent of a contiguous relation with primary reinforcement.

In the adjusting schedule conditions of this experiment, responding in one S- component affected reinforcement frequency in the next S+ component. The range over which such adjusting contingencies might affect observing responses that produce S- remains largely unexplored. Page and Neuringer (1985, Experiment 3), for example, found that pigeons responded with novel sequences when a particular sequence of pecking response keys in a 5- by 5-key matrix was reinforced only if the sequence differed from each of the last 50 sequences. Similarly, perhaps observing responses would be maintained by S- where responding during S- had effects several components removed from the S-.

Within learning theory there have evolved views that describe multiple levels of behavioral control. One example is the delay-reduction hypothesis, which asserts that the strength of a conditioned reinforcer increases as the stimulus is accompanied by greater reductions in the interval between the onset of the stimulus and the onset of an already-established reinforcer (Fantino, 1977). This hypothesis incorporates complex contingencies of the sort studied here into its account of conditioned reinforcement. Yet, the emphasis of the delay-reduction hypothesis in the past has been on contiguous features of stimuli and reinforcement. The results of the present study suggest that the reduction in time to onset of

reinforcement over more extended time frames is an important dimension of the hypothesis that is worth even more prominent consideration.

The sensitivity of observing responses to remote contingencies highlights the control exerted by temporally noncontiguous contingencies not always immediately obvious or easily identifiable. Perhaps such contingencies could be found in other situations in which negative discriminative stimuli have been reported to maintain observing. For example, Perone and Baron (1980) attempted to reconcile learning-based accounts of conditioned reinforcement with their finding that negative discriminative stimuli maintained observing responses of adult humans (see Dinsmoor, 1983, and Fantino & Case, 1983, for alternative accounts of the results of Perone and Baron). Their account emphasized the role of an individual's verbal history, an important dimension of which is a molar relation between classes of responses and classes of other events. Past failures to consider such molar contingencies in the development of conditioned reinforcing properties of a stimulus may have contributed to the promotion and acceptance of cognitive/informational accounts of the maintenance of observing responses by negative discriminative stimuli. Furthermore, because most of the data showing that an S- will not maintain observing have been obtained with pigeons and most of the data showing that an S- will maintain observing have been obtained with primates (e.g., Lieberman, 1972; Perone & Baron, 1980; Schrier, Thompson, & Spector, 1980), it has been proposed by some investigators that perhaps primates are "seekers of information." The present results suggest, however, that cognitive interpretations and appeals to phylogenetic differences obscure the essential relations for producing conditioned reinforcement, and that environmental contingencies remain the appropriate level of analysis for situations in which conditioned reinforcement is said to occur.

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