PUNISHMENT OF OBSERVING BY THE NEGATIVE DISCRIMINATIVE STIMULUS¹

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To determine the effect of a negative discriminative stimulus on the response producing it, two pigeons were each studied in a three-key conditioning chamber. During alternating periods of unpredictable duration, pecking the center (food) key either was reinforced with grain on a variable-interval schedule or was never reinforced. On equal but independent variable-interval schedules, pecking either of the side (observing) keys changed the color of all keys for 30 sec from yellow to either green or red. When the schedule on the center key was variable-interval reinforcement, the color was green (positive discriminative stimulus); when no reinforcements were scheduled, the color was red (negative discriminative stimulus). Since pecking the side keys did not affect grain deliveries, changes in the rate of pecking could not be ascribed to changes in the frequency of primary reinforcement. In subsequent sessions, red was withheld as one of the possible consequences of pecking a given side key. When red was omitted, the rate on that key increased, and when red was restored, the rate decreased. It was concluded that red illumination of the keys, the negative discriminative stimulus, had a suppressive effect on the response that produced it.

There are two contrasting schools of thought concerning the effect of an S^A or S^- , *i.e.*, a stimulus indicating that no reinforcement is available, on the frequency of the response that produces it. One is that it increases the rate of responding, the other that it reduces it. The first hypothesis was instigated by attempts to account for the net reinforcing effect of sometimes producing the positive and sometimes producing the negative discriminative stimulus in an observing experiment (*e.g.*, Wyckoff, 1969). It has been suggested (*e.g.*, Berlyne, 1957; Hendry, 1969) that it is the information these stimuli provide concerning the possibility of primary reinforcement in their presence that reinforces the observing response. Furthermore, evidence interpreted as supporting this interpretation has been offered in experimental studies by Schaub (1969) and by Lieberman (1972).

In Schaub's experiments, the pigeons were provided with only one key, which served both as the observing key and as the food key. Every third peck on this key changed its color for 1.5 sec to either red or green, depending on whether the bird was currently subject to the variable-interval component or to the extinction component of the mixed schedule of food reinforcement. Therefore, these colors served as discriminative stimuli.

In the experiment that led Schaub to the conclusion that S^- was reinforcing (Experiment 3), he added further displays of red and green which were not contingent upon pecking. As his measure of the birds' performance, he used the ratio between the number of responses during the extinction component of the mixed schedule and the total number of responses for the session. He found that the mean ratio declined when the extra presentations were given and increased when these presentations were omitted. He concluded that the response-contingent S^- was reinforcing, due to the information it conveyed, but that this information became redundant when additional presentations were provided on a noncontingent basis. A simpler explanation, however, is that more frequent presentations of S^- enabled the bird to discriminate more

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accurately between those periods when pecking was reinforced (both by food and by S+) and those periods when pecking was not reinforced.

The results obtained by Lieberman (1972) may represent a special case. In the experiment designed to show that S- is reinforcing, his S+ was associated with a schedule in which 50 responses were required, on the average, to produce the primary reinforcer (variable-ratio 50). Previous work by Azrin (1961), Appel (1963), and Thompson (1964) suggests that schedules in which a large number of responses is required per reinforcement are aversive and that under such schedules a change in stimulation may be reinforcing, even though the alternative stimulus is associated with the absence of reinforcement (S-). On the other hand, the stimulus associated with the reinforcement schedule (S+) may be punishing, in spite of the information that it conveys (Thompson, 1965).

Other data indicate that S- is not ordinarily reinforcing, even within the context of an observing procedure. Experiments by Kendall and Gibson (1965), Dinsmoor, Flint, Smith, and Viemeister (1969), Kendall (1972), and Dinsmoor, Browne, and Lawrence (1972) in which the positive stimulus (*i.e.*, the one associated with more frequent food or less frequent shock) was eliminated from the procedure and only the negative stimulus (associated with more frequent shock or less frequent food) was offered as a consequence of observing, indicate that the latter type of stimulus is not reinforcing. (See also Jenkins and Boakes, 1973; Katz, 1973.) Similar conclusions were reached by Wilton and Clements, who interpreted their results as being "inconsistent with the hypothesis that observing responses are also reinforced by the stimulus signalling nonreinforcement" (1971, p. 161). Finally, experiments like those by Rilling, Askew, Ahlskog, and Kramer (1969), Terrace (1971), and Rilling, Kramer, and Richards (1973) may also be relevant. Their data indicate that pigeons will peck a key that has as its sole function the termination of S-.

The second hypothesis, that S- suppresses the response that produces it, can be traced to Skinner's suggestion that "withdrawing a positive reinforcer" is a form of punishment (1953, p. 185). Supportive evidence was soon forthcoming from early experiments by

Herrnstein (1955) and by Ferster (1958). Ferster, for example, found that rates of responding in the presence of a warning stimulus were greatly reduced when normal rates would have produced a "timeout", involving the removal of all illumination from the experimental chamber and the withholding of primary reinforcement (Experiment III).

One of the limitations common to Ferster's work and many of the subsequent studies of this phenomenon is that darkness may have effects that go well beyond those of a simple S-. Pigeons, in particular, which were used as the subjects in most of these experiments, are likely to "roost" when the chamber is darkened. It is difficult to separate the effects general to all stimuli indicating nonreinforcement from the effects specific to this particular physical event.

Another difficulty, first pointed out by Leitenberg (1965), is that if S- is to retain its identity as S-, the primary reinforcer must be withheld when it is present. As a result, in all of the studies published up to the time of his review, there was a reduction in the frequency of primary reinforcement when the subject produced S- and an increase in the frequency of primary reinforcement when the subject avoided S-. It was therefore difficult to be sure whether the effects observed in such studies should be attributed to the punishing effect of the S-, *per se*, or to associated changes in the frequency of reinforcement. To deal with this problem, the observing paradigm appears to be an ideal solution, since the schedule of primary reinforcement is not affected by the subject's performance on the observing key. The subject can produce S- only when the extinction component is already in effect on the food key, and therefore no change is required in the food schedule when S- is produced.

Indeed, some evidence suggesting that S- is punishing turned up as an incidental comparison in the previously mentioned study by Dinsmoor *et al.* (1972). When pecking the observing key sometimes produced the negative as well as sometimes producing the positive stimulus, the rate on this key typically was lower than when the negative stimulus was withheld and only the positive stimulus could be produced. But this comparison is not entirely legitimate. Elimination of the negative stimulus reduced the density of pri-

mary reinforcement in the presence of the stimulus that prevailed during the remainder of the session, when neither the positive nor the negative stimulus was present. Reducing the value of this stimulus may have increased the effectiveness of the change to the positive stimulus as a reinforcing event.

In the present study, such confounding is eliminated by substituting a concurrent comparison for the sequential comparison used in the previous study. Two observing keys are available to the subject. One of these produces only the positive stimulus, while the other produces the negative stimulus as well. Whatever the density of reinforcement may be in the presence of the mixed-schedule stimulus, it is the same for both of the keys and therefore does not enter into the comparison. It has no differential effect on the rate of responding on the two keys. If the rate is consistently lower on whichever key it is that produces the negative stimulus during a given block of sessions, then it must be concluded that S- has a suppressive effect on the response that produces it, *i.e.*, that it is punishing.

METHOD

Subjects

Two White Carneaux hen pigeons were used. The amount of grain provided following each experimental session was determined by subtracting the current body weight from the target value of 80% of free-feeding weight, with an upper limit of 10 g.

Apparatus

The birds' performance was observed in a Lehigh Valley Model 1519 pigeon chamber. The experimental space measured 13 in. (33.0 cm) long, 12 in. (30.5 cm) wide, and 14 in. (35.6 cm) high. Each of the three keys was equipped with an Industrial Electronics Engineers display unit, which could be used to illuminate it from the rear with red, green, or yellow light. A force ranging from 0.10 N (left and center keys) to 0.15 N (right key) was required to register a response. The scheduling of all experimental events was controlled by BRS-Foringer logic modules, and the data were displayed on Gerbrands Model C3-SHS cumulative recorders and on electromagnetic counters. A blower provided ven-

tilation for the chamber and masked external sounds.

Procedure

Experimental sessions began at about the same time each day and lasted for 2 hr. During the initial training sessions, the side keys were covered with black tape. Pecking was shaped on the center key and was maintained on a variable-interval schedule with a mean of 30 sec. During discrimination training, reinforcement was available on the same schedule while the key was green (positive stimulus) but was not available while the key was red (negative stimulus). The color of the key and the accompanying schedule of reinforcement switched at intervals ranging from 10 sec to 4 min, with a mean duration of 2 min. At this stage, reinforcement consisted of 3 sec of access to mixed grain.

After four sessions of discrimination training, the tape was removed from both side keys, the mean interval between reinforcements was increased to 45 sec, and the duration of each presentation of grain was increased to 6 sec. Normally, the keys were yellow. During the initial training on the side keys, a peck on either of these keys (observing response) produced a 30-sec display of red or green, as determined by the current schedule of reinforcement, on all three keys. If the schedule of reinforcement shifted during the 30-sec period, the color of the keys changed accordingly. In other words, pecking a side key transformed the procedure on the center (food) key from a mixed to a multiple VI EXT schedule. Once observing was established, separate but equal variable-interval 30-sec schedules for production of the stimulus displays were employed concurrently for each of the side keys. A changeover delay was interposed between observing responses and the presentation of grain: pecking the center key was not reinforced until at least 6 sec had passed since the last peck on a side key.

When the rates of pecking had stabilized and had been approximately equal on the two side keys for 10 successive sessions, the experiment proper began. For the first time, the consequences of pecking the two side keys were different. Pecking the right key continued to produce both red and green, as before, but pecking the left key was effective only if green was scheduled. On those occasions when red

would otherwise have been produced, the 30-sec display was cancelled, and the keys remained yellow. After 19 sessions on this procedure, the roles of the two side keys were interchanged. Pecking the right key produced only green illumination, as scheduled, while pecking the left key sometimes produced green and sometimes produced red. Finally, for the last nine days of the experiment, the previous relationship was restored. Once more, pecking the left key produced only green illumination, while pecking the right key produced whichever color was currently appropriate. Except for the omissions when

red was scheduled, the contingencies remained the same for the two observing keys throughout these comparisons.

RESULTS

Figure 1 shows the typical pattern of responding during a session in which pecking the left key produced only the positive stimulus, green, but pecking the right key at some times produced the positive stimulus and at other times produced the negative stimulus, red. The top record shows responding on the left key, the middle record responding on the

Fig. 1. A complete set of cumulative records for one session. The top record shows responding on the left key, which produced only the positive discriminative stimulus (green) in this session, and the second record shows concurrent responding on the right-hand key, which sometimes produced the negative stimulus (red). On these records, depressions of the response pen indicate periods when the positive stimulus appeared on the keys, and depressions of the bottom (event) pen indicate periods when the negative stimulus appeared. The bottom record shows responding on the middle key. Pips on the response record indicate the delivery of grain, and depressions of the bottom pen indicate periods when the positive stimulus appeared.

BIRD 2560 B

Fig. 2. Rate of responding by Pigeon 2560B on each of the observing keys on each of the sessions. The solid line indicates the rate on the left key, the broken line that on the right key. A given key always produced the positive discriminative stimulus (green), as appropriate, but produced the negative stimulus (red) only as indicated in the panel headings. During baseline, both keys produced the negative stimulus. A: error in procedure. B: apparatus failure.

right key, and the bottom record responding on the center key, which on occasion was reinforced with access to the grain. In the top two records, depressions of the response pen indicate the presence of the positive stimulus and depressions of the bottom (event) pen indicate the presence of the negative stimulus. The bird rarely pecked either observing key in the presence of either of these stimuli.

The rate at which Bird 2560B pecked each of the observing keys on each session is shown in Figure 2. The corresponding data for Bird 2701B are shown in Figure 3. In each figure, the first panel (Sessions 68 to 72) shows the performance when the schedules on the left and the right key were the same. On either key, pecking sometimes produced green and sometimes produced red. During these sessions, the rates on the two keys were very nearly the same. The second panel in each figure (Sessions 73 to 91) shows the perform-

ance when pecking the right key still produced both green and red, as occasion warranted, but pecking the left key produced only green illumination of the keys. Throughout these sessions, the rate was higher on the left key. The role of the two keys was interchanged for the third panel in each figure (Sessions 92 to 110). Bird 2560B reversed its preference immediately and Bird 2701B within a few sessions. Finally, the role of the two keys was interchanged a second time for Sessions 111 to 119, and once again the rate increased on the key that did not produce red and decreased on the key that did.

DISCUSSION

In recent studies by Kaufman and Baron (1968), Baron and Kaufman (1969), and Carlson (1970, 1972), an alternative to the present technique has been used to separate the effect

BIRD 2701B

Fig. 3. Rate of responding by Pigeon 2701B. Details same as in Figure 2. C: apparatus failure.

of an S- or a timeout from the effect of a change in the frequency of reinforcement. In each of these studies, a chain of some kind was employed, which included as consequences both the timeout and the primary reinforcer. The frequency with which each of these stimuli appeared was proportional to the rate of responding. If the animal reduced its frequency of responding, as a result of encountering the timeout, it also reduced, rather than increased, the frequency of reinforcement. Since the two factors that had in earlier studies been confounded were now placed in opposition to each other, the suppressive effect of the timeout could no longer be attributed to the change in the frequency of reinforcement.

The difficulty with the Kaufman and Baron (1968) and Baron and Kaufman (1969) procedures, however, was that imposition of the timeout delayed receipt of primary reinforcement, and the effects of the timeout could not be separated from the effects of this delay. In the Carlson (1970, 1972) studies, an attempt

was made to remedy this confounding. The timeout was delivered following completion of the requirements for the first component of a two-component chain. To compensate for the resulting delay of primary reinforcement, a corresponding amount of time was added in the control procedure to the interval required for completion of the second component. Although these two operations were equivalent in terms of the time that elapsed between the recorded response and the primary reinforcer, in another respect they were not equivalent. The timeout procedure involved the imposition of a delay between the recorded response and its conditioned reinforcer, while the control procedure involved merely an increase in the mean duration of the second component. These operations do not appear to be comparable, and it is not clear that a difference in their effects must be attributed to the presentation of a timeout stimulus during the delay.

In the present work, we attempted to avoid the ambiguities associated with earlier studies

of the issue. The design is quite different. To determine the effects of S—, we employed separate keys that have no influence on the scheduling of grain deliveries and made the stimulus contingent during some sessions on one of these keys and during other sessions on the other. There seems to be no way in which differences in rate between the two keys can be attributed to changes either in the immediacy or in the frequency of primary reinforcement. In its physical characteristics, the stimulus we chose to serve as the S— is in common use for that purpose in other experiments; no mechanical interference, such as removal of a response lever, has been employed.

Nevertheless, our data show a systematic relationship between the colors produced by a particular observing key and the frequency with which the birds pecked it. Whenever red was eliminated as one of the consequences of pecking a given key, the rate on that key increased, and whenever red was restored as one of the possible consequences, the rate on that key declined. Comparing the two keys, the one that currently produced red consistently showed a lower rate than the one that currently produced only green. These data provide more solid support than has hitherto been available for the conclusion that S— has a suppressive effect on the response that precedes it, *i.e.*, that it serves as a form of punisher.

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