

*A TEST OF THE NEGATIVE DISCRIMINATIVE  
STIMULUS AS A REINFORCER OF OBSERVING<sup>1</sup>*

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Five pigeons were used to test the hypothesis that the source of reinforcement for observing behavior is the information that it provides concerning the schedule of primary reinforcement. On a variable-interval schedule, pecking the left-hand key produced a 30-sec display of such information. During this 30-sec period, when pecking the right-hand key was reinforced on a random-interval schedule, both keys were green; when no reinforcement was scheduled (extinction) both keys were red. Later, this baseline procedure, in which both red and green were available, was replaced for blocks of sessions by procedures in which either (a) the red was eliminated and only the green could be produced; or (b) the green was eliminated and only the red could be produced. The results were that green maintained rates of pecking on the left key that were as high or higher than when both colors were available and that red maintained no responding. It was concluded that the reinforcing value of a stimulus depends on the positive or negative direction of its correlation with primary reinforcement, rather than upon the amount of information that it conveys.

Since by definition an observing response (Wyckoff 1952, 1969) merely exposes the subject to the stimuli associated with different schedules of reinforcement, without affecting the schedules themselves, it has been assumed that the average frequency of primary reinforcement in the presence of these stimuli is the same as that in their absence. This assumption has made it difficult to account for the ability of such stimuli to maintain the observing response, *i.e.*, for their reinforcing properties, on the usual basis of their selective association in time with the primary reinforcer. Reacting to this difficulty, Berlyne (1957) suggested that the source of the reinforcement must be the reduction in the subject's uncertainty or conflict produced by the appearance of either the positive or the negative discriminative stimulus (*i.e.*, information). Since that time, a number of other writers have suggested, without further elaboration, that in some way the information conveyed by these stimuli provides the reinforcement for observing. The fullest treatment of the hypothesis to date appears to be that presented by Hendry (1969).

The original assumption leading to the in-

formation hypothesis and, consequently, the need for such a mechanism have been questioned in a recent paper by Dinsmoor, Browne, Lawrence, and Wasserman (1971). These authors kept a record of the times during which the pigeon stood on a pedal that produced a display of the positive or negative discriminative stimulus, as scheduled, on the key. They found that when the positive stimulus appeared, the bird stayed on the pedal; but when it encountered the negative stimulus, the bird quickly stepped off the pedal. That is, it observed in a selective fashion. It spent much more time in the presence of the positive stimulus than in the presence of its negative counterpart; as a result, the frequency of primary reinforcement while the bird was observing was substantially higher than when it was not observing. In view of this finding, there would appear to be no need to postulate a new mechanism to account for observing.

Empirical support for the information hypothesis, however, has come from studies by Schaub (1969) and by Lieberman (*in press*) that have been interpreted as showing that S<sup>+</sup> or S<sup>-</sup>, the negative discriminative stimulus, is reinforcing. Such a finding, if substantiated, would be uniquely consistent with an information hypothesis, since previous accounts have assumed that a positive relationship is required with the primary reinforcer for a

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stimulus to become a conditioned reinforcer. The existing data, however, are not entirely convincing.

In Schaub's (1969) study, pigeons produced both food and discriminative stimuli, on different schedules, by pecking the same key. In his Experiment 3a, response-independent presentations of the positive discriminative stimulus (S+) were added to the standard procedure during the variable-interval component of the food schedule and response-independent presentations of S- during the extinction component. The result was that responding during the extinction component was lower than when only the response-produced stimuli were available. Schaub interpreted this result as showing that the added stimuli had made the response-produced stimuli redundant and had thereby eliminated in particular the reinforcing properties of S-. However, the discriminative effects of the added stimuli account quite adequately for his data, and no conclusion is warranted concerning the effect of either stimulus on the response that produced it.

In Experiment 2a, Schaub withheld the S+ and allowed the birds only to produce the S-. The experimental birds responded less during the extinction component of the food schedule than did control birds that received the same temporal distribution of S- presentations on a response-independent (yoked) basis. This result suggests that the performance of the experimental birds was suppressed rather than reinforced by the contingent relationship between the response and the stimulus, *i.e.*, that S- was punishing.

Working with monkeys, Lieberman (*in press*) began his Experiment III with a baseline procedure in which pressing the observing lever produced 6 sec of tone (S+) when a variable-ratio schedule of reinforcement (sucrose) was in effect on the main lever and 6 sec of light (S-) when the schedule was extinction. Further responses during the 6 sec when the stimulus was present had no effect and were not recorded. To show that the light had been functioning as a reinforcer, Lieberman then eliminated it from his procedure and found that this led to a sharp decline in the frequency with which observing responses were recorded during the extinction component. But the situation without the light was not entirely comparable to the situation with the light. During the baseline determination, the

presence of the tone or the light indicated that an observing response would have no consequence; conversely, the absence of the tone or the light set the occasion for observing. When the light was eliminated from the procedure, there was no stimulus to prevent the animal from responding during the 6-sec period when the light would otherwise have been present. To maintain comparability with the baseline procedure, Lieberman did not record these responses. But some of them may have been responses that under the baseline procedure would have been postponed until after the light had terminated and that would therefore have been recorded. Note that Schaub (1969), using a different recording procedure, did not find a corresponding decline in observing when he withheld S- (Experiment 2a). It is difficult to see any way in which the data can safely be compared with and without the light in Lieberman's experiment.

Also, other data appear to be inconsistent with the information hypothesis. For example, Kendall and Gibson (1965) found that a stimulus predicting that the pigeon was on a fixed-interval rather than a fixed-ratio schedule of primary reinforcement was not itself reinforcing, despite the information that it provided. (On the other hand, by the same test, the stimulus predicting the fixed-ratio schedule—and a higher frequency of primary reinforcement—was reinforcing.) Similarly, Dinsmoor, Flint, Smith, and Viemeister (1969) found that a stimulus predicting punishment did not maintain an observing response when the stimulus indicating freedom from punishment (safety signal) was eliminated from the procedure. On the other hand, the safety signal was reinforcing.

Both of these sets of data represent somewhat specialized cases, of course, and further work with a standard discrimination procedure is indicated to settle the issue. In the present experiment, red and green illumination accompany extinction and a random-interval schedule of reinforcement, respectively, on the food key. These stimuli are themselves available, however, only on a variable-interval schedule following pecks on the observing key. This intermittency in the presentation of the stimuli enables us to use rate of responding as our measure of the observing performance and precludes the possibility that failure to produce red or failure to produce green might

come to serve as a discriminative stimulus in its own right. To test the effectiveness of green (S+), red is sometimes excluded from the procedure, and to test the effectiveness of red (S-), green is sometimes excluded. Under these arrangements, the production of red conveys at least as much information as the production of green, since no food is ever delivered while the keys are red. According to the information hypothesis, red should be reinforcing. But according to more conventional treatments, which require a positive association or correlation between the stimulus and the primary reinforcer, only the green should be reinforcing.

## METHOD

### *Subjects*

Five male White Carneaux pigeons were maintained at 75% of their free-feeding weights by regulating the amount of grain provided after each session. All had previous exposure to a variable-interval schedule of reinforcement.

### *Apparatus*

Birds 601, 1858, and 4144 were tested in a two-key version and Birds 469 and 5689 in a three-key version of Lehigh Valley's Model 1519 Pigeon Chamber. The experimental space measured 14 in. (35.6 cm) high, 13 in. (33.0 cm) deep, and 12 in. (30.5 cm) across. In the three-key chamber, the key farthest to the right was covered with tape. The keys could be illuminated from the rear with red, green, or white light. A force ranging from 0.10 to 0.17N was required to operate the switches behind each of the keys, which produced an audible click. The experimental procedure was controlled by solid-state switching modules manufactured by Massey Dickinson, and the data were collected on electromagnetic counters and Gerbrands Type SHS cumulative recorders. A white noise of approximately 50 dB was used throughout the session to mask extraneous sounds.

### *Procedure*

Experimental sessions began at about the same time each day and lasted 90 min. The overall schedule of reinforcement for the right-hand (food) key remained the same throughout the various experimental treatments. A random-interval schedule alternated, at intervals of unpredictable duration, with periods

of extinction. For Pigeons 601, 1858, and 4144 the random-interval schedule was generated by presenting an electrical signal every 10 sec to a probability gate set at 1/12 (mean interval about 120 sec); the reinforcer was 2.5-sec access to the grain; and shifts in either direction from one component of the schedule to the other were arranged by presentation of an electric signal every 9 sec to a probability gate set at 1/5 (mean interval about 45 sec). For Pigeons 469 and 5689 the random-interval schedule of reinforcement was punched into a tape containing 20 intervals with a mean duration of 90 sec; the reinforcer was 3-sec access to grain; and shifts between the two components were arranged by presenting a signal every 4.5 sec to a probability gate set at 1/10 (mean interval about 45 sec).

After five to six sessions of discrimination training, in which the random-interval schedule was accompanied by green illumination (S+) of the right-hand key and extinction by red (S-), a piece of tape that had covered the left key was removed and the observing procedure was instituted. Under this procedure, both keys were normally white. When the bird pecked the left (observing) key, both keys were illuminated during the next 30 sec with either green or red, depending upon which schedule of reinforcement was currently in effect on the right key. If the schedule of reinforcement shifted during this 30-sec observing period, the color changed with it. A changeover delay was used; *i.e.*, reinforcement never occurred during the first 2 sec of green following a peck on the observing key.

During the first 15 sessions on the observing procedure, each peck on the observing key was followed by the 30-sec observing period. For the remainder of the experiment, however, the production of red and/or green was placed on a variable-interval schedule: an opportunity to produce a period of observation arrived either once a minute (for Pigeons 469 and 5689) on the average, or once every 2 min (for Pigeons 601, 1858, and 4144). Pecks at other times had no scheduled effect.

Four experimental treatments were compared during successive blocks of sessions: (1) both red and green were available, as described above; (2) the red was eliminated (S+ only); (3) the green was eliminated (S- only); or, (4) both colors were eliminated. To keep all other features as comparable as possible,

the only change in each case was that when the excluded color would ordinarily have appeared under the standard red-green procedure, the keys simply remained white.

## RESULTS

The typical pattern of performance when both red and green were available on a variable-interval schedule is represented in graphic form in Figure 1, which includes cumulative records of pecking on the food key when it was white and when it was red or green and of pecking on the observing key throughout the session. Vertical displacements on the observing record indicate when periods of red and/or green were presented.

More systematic data are available in Table 1, which contains mean rates for the last five sessions under each successive testing procedure. The pattern of performance on the food

key remained fairly stable throughout these comparisons: high rates in green, low in red, and intermediate in white. The rate of pecking on the observing key, however, depended on its consequences.

When red was eliminated from the procedure for a block of sessions, leaving only green (S+) as a possible reinforcer, a substantial rate was maintained. Indeed, with the exception of Bird 601, the pigeons usually responded more frequently under this procedure than when both stimuli were available.

However, each time that green was eliminated, leaving only red (S-) as a possible consequence of pecking the observing key, the rate of responding declined over successive sessions, as illustrated in Figure 2. As indicated in Table 1, the residual rates were approximately the same as those obtained when no change in color was presented as a consequence of pecking the key. Sometimes, a bird continued for

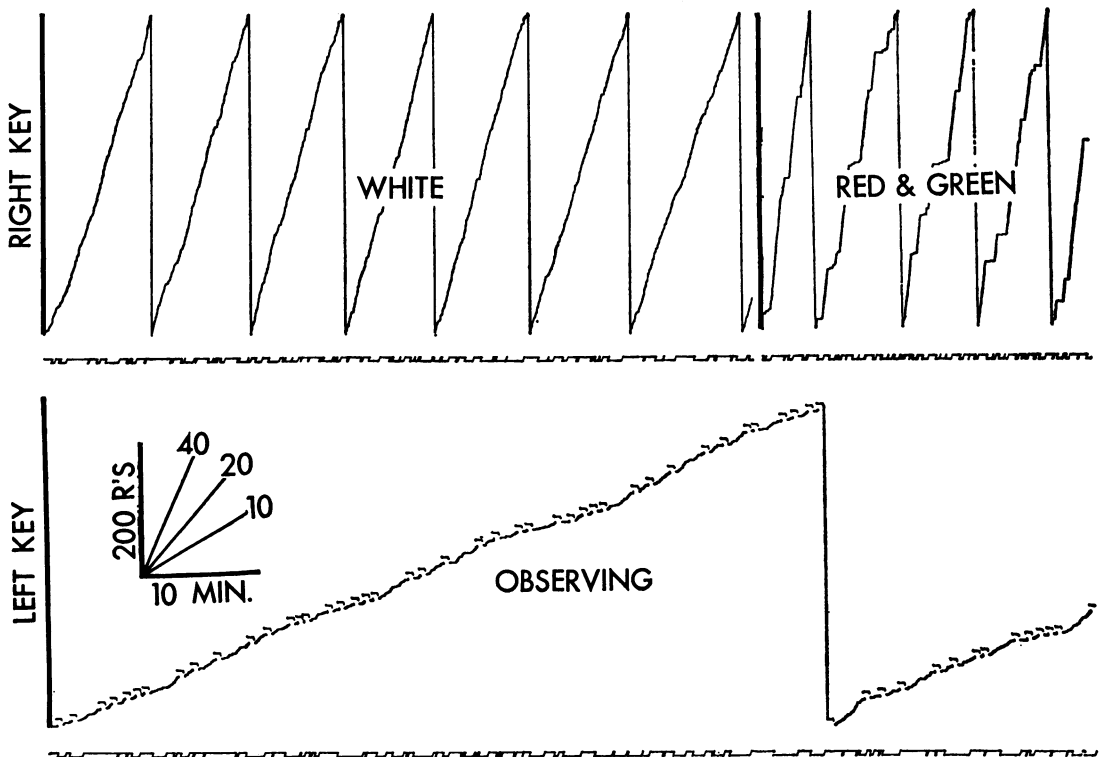


Fig. 1. Cumulative records, obtained from Bird 1858, illustrating the typical pattern of performance. Responses on the right-hand (food) key when it was illuminated with white light (mixed schedule) are recorded in the upper half, to the left. Responses on the same key when it was red (S-) or green (S+) are recorded to the right. Responses on the left-hand (observing) key are recorded in the lower half, together with upward displacements of the response pen, which indicate periods when red and/or green were displayed on the keys. When the baseline (event pen) is up, pecking the right key was reinforced on a random-interval schedule; when it is down, no reinforcement was scheduled.

Table 1

Number of sessions for each bird under each procedure; responses per minute on food key when green, when red, and when white; responses per minute on observing key when white; and reinforcements per minute when white. All rates are means for the last five sessions under each procedure.

no. of sessions available	stimuli	observing rate	food key rate			reinf. rate	no. of sessions available	stimuli	observing rate	food key rate			reinf. rate
			green	red	white					green	red	white	
<i>Pigeon 601</i>						<i>Pigeon 4144—continued</i>							
15	RG	5.83	56.9	2.5	36.6	0.305	15	R	0.18	—	12.9	67.2	0.314
30	R	0.36	—	0.6	39.0	0.278	15	—	0.01	—	—	68.4	0.317
15	—	0.05	—	—	30.9	0.281	15	R	0.00	—	—	66.3	0.316
15	R	0.06	—	—	37.0	0.283	15	G	5.58	104.9	—	55.1	0.231
20	G	10.84	92.9	—	29.8	0.254	15	RG	2.09	139.7	5.9	77.4	0.304
15	RG	13.20	106.9	6.4	31.6	0.352	15	G	5.25	111.4	—	67.6	0.252
15	G	9.52	86.5	—	32.1	0.262	15	RG	2.63	189.2	2.3	77.5	0.275
15	RG	12.76	79.6	1.9	32.7	0.256	15	G	6.23	158.4	—	59.8	0.210
15	G	10.54	103.7	—	38.1	0.272	18	RG	4.06	151.1	1.4	62.5	0.234
15	RG	9.89	122.3	2.3	37.5	0.270	15	G	5.36	103.1	—	41.1	0.198
15	G	3.86	153.8	—	42.9	0.219	20	R	0.02	—	—	44.1	0.292
15	RG	3.50	106.0	1.6	46.9	0.283	15	RG	3.97	78.7	0.93	49.2	0.289
15	G	2.64	102.6	—	48.6	0.281							
15	RG	5.31	79.8	4.7	34.0	0.297	<i>Pigeon 469</i>						
20	G	11.92	82.2	—	30.1	0.184	35	G	10.3	53.8	—	42.1	0.262
20	R	0.47	—	1.9	31.7	0.284	15	R	0.4	—	0.0	52.7	0.387
15	RG	8.68	63.5	1.7	29.9	0.306	15	RG	3.3	63.9	0.4	49.5	0.296
<i>Pigeon 1858</i>						15	G	1.1*	59.0	—	53.0*	0.499*	
15	RG	3.74	172.2	2.7	61.0	0.266	15	RG	3.5	57.9	0.5	43.0	0.297
30	G	4.65	112.7	—	36.9	0.193	25	G	10.2	59.4	—	43.6	0.210
20	RG	2.93	134.6	4.9	67.3	0.354	15	RG	6.7	54.1	0.2	42.9	0.241
30	R	0.02	—	0.0	78.4	0.265	15	G	8.0	64.3	—	37.1	0.229
15	—	0.00	—	—	68.1	0.316	15	RG	7.7	59.5	0.4	45.2	0.300
15	R	0.00	—	—	70.2	0.285	15	R	0.1	—	—	50.0	0.379
45	G	8.24	135.6	—	55.1	0.258	15	G	4.1	54.1	—	36.8	0.222
15	RG	5.38	139.1	8.5	85.9	0.306							
15	G	9.44	129.7	—	60.7	0.275	<i>Pigeon 5689</i>						
15	RG	6.27	129.0	2.7	63.4	0.250	40	G	16.6	80.3	—	19.3	0.216
15	G	9.16	139.0	—	47.6	0.235	15	R	0.0	—	—	43.9	0.365
20	RG	7.10	88.5	5.8	49.3	0.269	15	G	10.5	97.4	—	24.6	0.186
20	R	0.05	—	2.4	63.8	0.304	20	RG	8.5	70.8	0.3	47.3	0.364
15	G	4.97	87.6	—	49.6	0.267	20	G	15.5	70.1	—	30.7	0.306
<i>Pigeon 4144</i>						15	RG	18.6	71.8	0.2	41.6	0.265	
15	G	2.19	78.9	—	54.7	0.276	15	G	24.6	79.1	—	34.7	0.237
15	RG	1.65	89.8	3.4	72.1	0.271	15	RG	14.5	82.3	0.7	54.3	0.283
30	G	2.30	99.0	—	47.5	0.286	20	G	29.6*	72.3	—	9.2*	0.115*
							15	R	0.1	—	0.0	41.8	0.267

\*Data affected by erroneous operation of circuit.

several sessions without once pecking the observing key, although it was concurrently responding thousands of times on the food key.

When green (S+) was restored to the experimental procedure, either alone or in addition to red, the bird pecked the observing key at a substantial rate again. As illustrated in the right-hand panel of Figure 2, once the bird made contact with the new contingency reconditioning was quite rapid.

DISCUSSION

A stimulus that indicates that no food will be delivered should produce a reduction in uncertainty at least as great as that produced by a stimulus that indicates that food will be available more often, but still on an intermittent basis. Therefore, if information is held to be reinforcing, the negative member of a pair

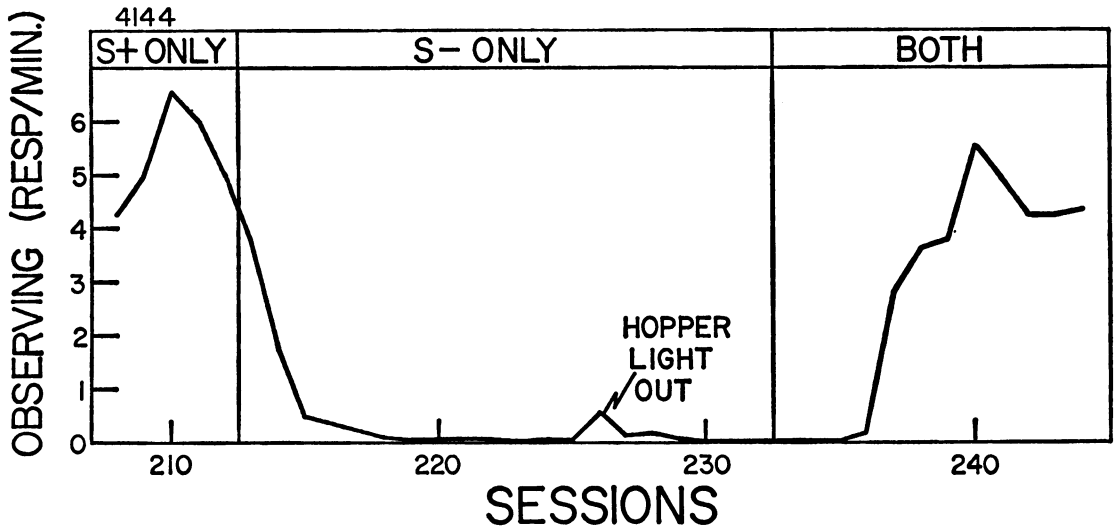


Fig. 2. Rate of pecking the observing key on successive sessions by Pigeon 4144 when this produced S+ only (left panel), S- only (middle panel), or both stimuli (right panel).

of discriminative stimuli (S-) should acquire reinforcing properties. Furthermore, unless such a claim is made it is difficult to see how the information hypothesis can be distinguished from earlier accounts of the circumstances under which a stimulus gains reinforcing properties or what additional contribution this hypothesis can make to the explanation of observing behavior. Yet, the present data are completely in accord with traditional interpretations (see Kelleher and Gollub, 1962) that ascribe reinforcing properties only to those stimuli that have been positively associated with the primary reinforcer and not to those that have been negatively associated. The birds pecked the observing key when this produced a stimulus associated with a higher rate of reinforcement (green) but stopped when the pecking produced only a stimulus associated with the absence of primary reinforcement (red).

Some comment should also be made on the difference between the rate of responding when green was the only color that could be produced by pecking the observing key and the rate when either red or green might appear on a given occasion. All birds but 601 showed lower rates of observing when red was sometimes produced than when green was the only possibility. This might suggest that S- acted as a punisher. Such a conclusion should be treated with considerable caution, however, on the basis of the present data. When red was

eliminated from the procedure, the keys remained white during those periods of time when red would otherwise have appeared. This increased the total amount of time that the bird spent in the presence of white. But since grain was never delivered in the presence of red, the extra time in white did not include any such deliveries either. This meant that the rate of reinforcement in white declined and, perhaps, that green became more effective as a conditioned reinforcer. Similarly, when red was restored as a possible consequence of pecking the observing key, the rate of primary reinforcement in white increased and green perhaps became less effective as a conditioned reinforcer. These changes in the density of reinforcement in white may account for the reduction in rate when red was added to green as a possible consequence of pecking the observing key.

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