

## REDUNDANT INFORMATION IN AN OBSERVING-RESPONSE PROCEDURE<sup>1</sup>

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In three observing-response experiments relevant to the information hypothesis of conditioned reinforcement, the basic procedure was one in which an observing response produced one stimulus on trials that terminated in non-contingent reinforcement and another stimulus on trials that terminated in a brief timeout. In Experiment I, the observing response consisted of a single peck or a short fixed-ratio schedule (FR 3 or FR 6), depending on the type of trial. If the single peck produced the negative stimulus and the fixed ratio produced the positive stimulus, observing responses were maintained. If the single peck produced the positive stimulus and the fixed-ratio produced the negative stimulus, observing responses were not maintained on negative trials. In the second experiment, the response key was either white or dark at the beginning of a trial, indicating whether it was a positive or negative trial. Observing responses continued to be maintained on positive trials but not on negative trials. In Experiment III, only positive or negative trials were scheduled for several sessions. Observing responses extinguished regardless of whether positive or negative trials were scheduled. The results do not support the hypothesis that making the stimuli produced by observing responses redundant will reduce observing responses.

If two or more stimuli are differentially associated with different conditions of reinforcement, an organism may engage in behavior that produces those stimuli. A response of this class is called an observing response (Wyckoff, 1952). The phenomenon is well established, but different theoretical accounts have been advanced by Wyckoff (1959), Perkins (1955), and Berlyne (1960). A statement by Hendry (1969a) attempted to consolidate the position taken by Berlyne and that of Egger and Miller (1962, 1963) into a general hypothesis of conditioned reinforcement, including observing responses. According to this position observing responses are maintained by the production of informative stimuli. There are two parts to the information hypothesis<sup>2</sup>, the Clue hypothesis and the Cue hypothesis. The former states that “. . . stimuli that reliably predict a reinforcer become conditioned reinforcers.” The latter states “. . . stimuli that control the rate of an oper-

ant are conditioned reinforcers.” (Hendry, 1969a, p. 20.)

Implicit in the information hypothesis is the notion that if information is already available, further informative stimuli will not be reinforcing even though they may be closely associated with reinforcement in time. In other words, redundant information is not reinforcing. Hendry (1969a) cited the well-known studies of Egger and Miller (1962, 1963) as evidence that a redundant stimulus will not become a conditioned reinforcer. The question in the present experiment was slightly different. Stimuli were established as conditioned reinforcers first and then made redundant by the addition of other stimuli. The implication of the information hypothesis is that the already established conditioned reinforcers would lose their value when made redundant.

### EXPERIMENT I

Experiments with mixed schedules have shown that responding that produces no exteroceptive stimulus, such as a reinforcer, can control further behavior (*cf.* Kelleher, 1966, pp. 167-171). It might be expected, then, that responding that produces no consequences

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<sup>2</sup>The term “information hypothesis” will refer to Hendry's (1969a) version.

may be informative. Experiment I was arranged so that a stimulus was either produced on FR 1 or on a short fixed-ratio greater than FR 1. The nature of the stimulus could be predicted in the latter case (ratio greater than FR 1) because it would always be the same one over a block sessions. In this case, one response would make the stimulus produced by the short fixed-ratio redundant and obviate the need for further responding. The stimuli produced by responding were key-lights that predicted a subsequent event, either food or timeout, but food reinforcement was not dependent on having produced any stimuli.

#### METHOD

##### *Subjects*

Four experimentally naive female White Carneaux pigeons, designated Nos. 1, 2, 3, and 4, served.

##### *Apparatus*

A commercial (Lehigh Valley Electronics) pigeon chamber was used. The front panel contained two response keys but only the left-hand one was used. The other key was covered by a piece of metal. Electromechanical scheduling and recording equipment was located in an adjacent room. The room in which the pigeon chamber was located was provided with white masking noise.

##### *Procedure*

The general procedure described here was employed in all the present experiments. Specific details vary from experiment to experiment.

The pigeons were trained to peck the response key. The key was not illuminated during shaping. The birds received 3-sec access to grain as a reinforcer during shaping. During operation of the grain hopper, the house-light, which was normally lit, went out and the grain was illuminated by the hopper light.

When the birds had emitted two or three reinforced pecks, observing-response training was initiated. In the observing-response procedure, there were two kinds of trials. Positive trials terminated in a 3-sec presentation of the grain hopper, which was not dependent on a key peck. Negative trials terminated in a 3-sec timeout (TO). During TO, the house-light

went out and no grain was presented. A trial began immediately after presentation of the grain hopper or timeout, whichever occurred on the previous trial. At the beginning of each trial, the key was unlit.

A peck on the response key during a trial turned on one of two lights behind the key. If the bird pecked on a positive trial, a green light was presented; if it pecked on a negative trial, a red light was presented. A light, once produced, remained lit until a trial was terminated. The two colors will be called S+ and S-, even though this violates conventional usage somewhat because no specific behavior was required to produce food on positive trials.

Initially, the trial duration was brief (2 sec) but was lengthened during the first training session to 10 sec. During this stage of training, the experimenter stood by the scheduling equipment and used his judgement as to when to lengthen trials. This judgement was based on how reliably the bird was responding. After the session just described, another session was given with the trial duration set at 10 sec. A peck on the response key during the last 2 sec postponed termination of the trial for an additional 2 sec so that a trial could never terminate within 2 sec of a key peck. After the session with trial duration set at 10 sec, duration was raised to 20 sec for one session and finally to 32 sec. The trial termination postponement contingency was kept in effect and remained at 2 sec throughout this and the two subsequent experiments.

A peck on the response key during a trial illuminated the key with the appropriate color but did not otherwise change the trial. Thus, pecks on the key could only (1) produce stimuli correlated with the type of trial or (2) delay termination of a trial. Normally, an experimental session lasted for 60 trials, with 30 positive and 30 negative trials alternating in an irregular sequence.

*Procedure for Experiment I.* Birds 1 and 2 were given 15 sessions of the training described above. On each trial, only one peck was required to produce the stimulus correlated with that trial. Following this procedure, Bird 1 was given 20 sessions in which one peck (FR 1) produced the red light on negative trials, but three pecks were required to produce the green light on positive trials (FR 3). This was followed by 15 sessions of

FR 1 on negative trials and FR 6 on positive trials. Bird 2 was treated in the same fashion except that the ratio was increased to FR 3 and then to FR 6 on negative trials and not on positive trials. After going through these procedures, the birds were returned to the condition with FR 1 on each trial for five sessions and then each bird underwent the kind of training that it had not received in the first phase. For Bird 1, the ratio was increased to FR 3, then to FR 6 on negative trials and for Bird 2 the ratio was increased on positive trials. Fifteen sessions were given at each condition (FR 3 and FR 6).

Birds 3 and 4 were given only one of the above conditions each. These two birds were originally trained with FR 1 on each trial and then with FR 3 on each trial. Following this training (15 sessions at FR 3 on each trial), Bird 3 was given 15 sessions with FR 6 on positive trials and FR 1 on negative trials. Bird 4 was given 15 sessions with FR 1 on positive trials and FR 6 on negative trials.

#### RESULTS

Figure 1 shows the results from Birds 1 and 2 and Figure 2 presents the data from Birds 3 and 4. The data plotted are the relative frequencies of trials on which a stimulus was produced. An "observing response" consists of the entire ratio required to produce a stimulus regardless of whether it was FR 1, 3, or 6, *i.e.*, an observing response was not scored unless a stimulus was produced. Data from positive and negative trials are plotted separately for each bird.

There are two panels each for Birds 1 and 2. The top row shows data taken from the phase of the experiment where the ratio was FR 1 for S- and was FR 1, FR 3, or FR 6 for S+. The bottom two panels show data from the phase where the ratio was changed for S-. As noted in the Method section, the birds did not undergo the treatments in the same order. The data from Birds 3 and 4 are plotted in bar graphs in Figure 2. The first pair of bars for each bird shows data from the condition where the ratio was FR 3 on each trial. The second pair of bars shows data from the condition where the ratios (FR 6 in positive trials for Bird 3 and FR 6 in negative trials for Bird 4) were changed. All data are averaged over the last four sessions under a given condition.

First, consider the data from the phase of the experiment where the ratio was increased on positive trials (upper panels for Birds 1 and 2 and Bird 3 in Figure 2). The relative frequency of observing responses remained high at both FR 3 and FR 6 for all birds. The lowest relative frequency is for Bird 2 at FR 6. As might be expected, the relative frequency of observing responses remained high on negative trials because at least one peck was required to produce any information.

The data from the phase where the FR was increased on negative trials are quite different. The relative frequency of trials on which S- was produced is related to the ratio size. For Birds 1 and 2, the relative frequency of observing responses on negative trials decreased at FR 3 and further decreased at FR 6. In addition, the relative frequency of observing responses on positive trials decreased for Bird 2 at FR 6. This must indicate a decrease in the number of trials on which a single peck was made. The data from Bird 4 are quite similar to the data from Bird 1 at FR 6.

#### EXPERIMENT II

In Experiment I, an exteroceptive stimulus was redundant with the information provided by a single peck when the ratio was increased in one kind of trial. A more straightforward way to add redundancy is to provide a stimulus that signals the consequence of emitting an observing response. If such a stimulus is provided, information theory clearly predicts that observing responses will be discontinued because they are entirely superfluous. The information conveyed by the stimuli produced by the observing response will already be present before an observing response is made. In Experiment II, the consequences of an observing response were signalled at the beginning of a trial.

#### METHOD

##### *Subjects*

Nine birds were used in Experiment II. Birds 1, 2, 3, and 4 from Experiment I were used. These birds were supplemented by Bird 13, a naive male Silver King. These birds will be called Group I. Between Experiments I and II, Birds 1, 2, 3, and 4 had participated in another experiment similar to Experiment

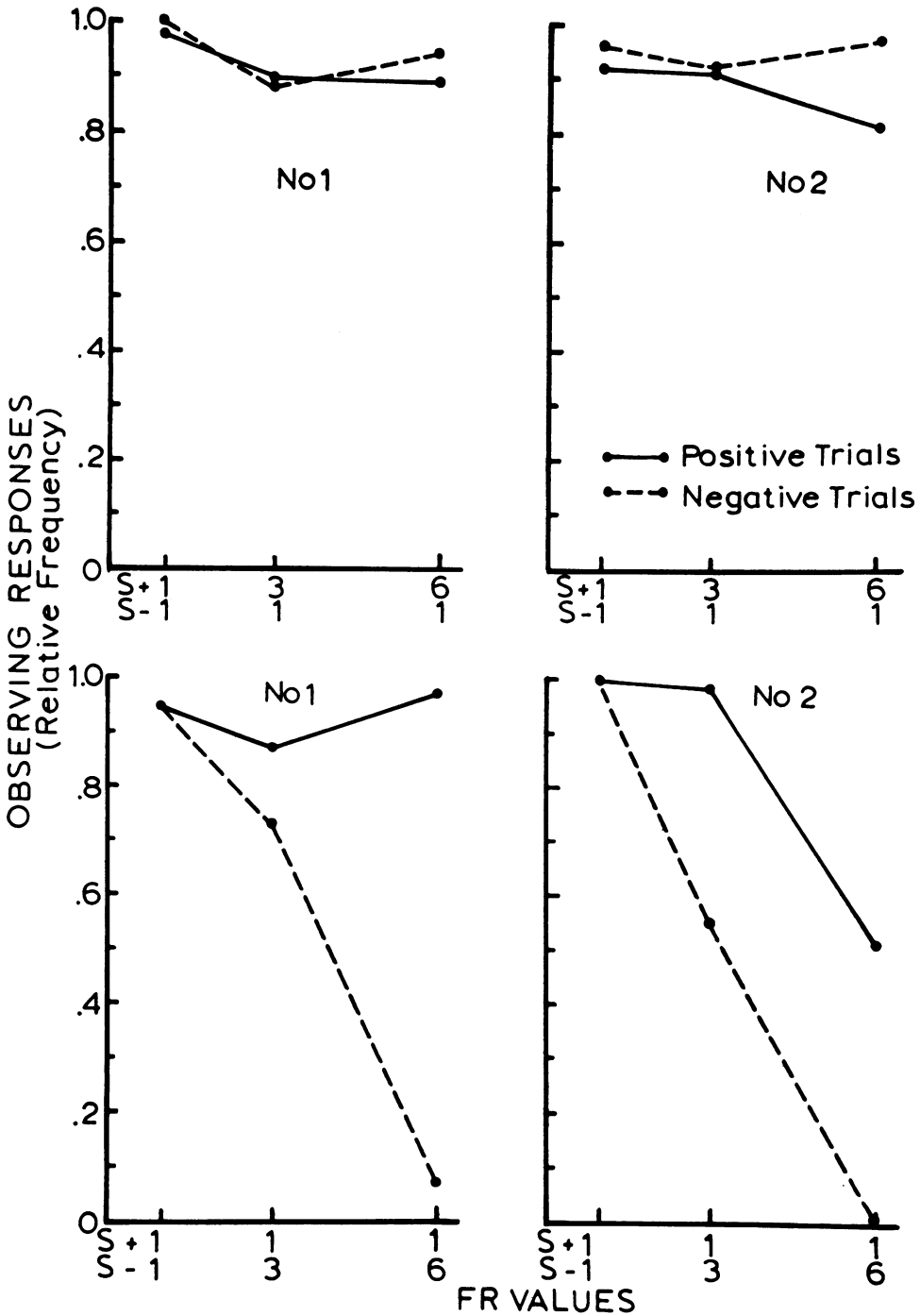


Fig. 1. Relative frequency of observing responses in the various experimental conditions for Birds 1 and 2. The top panel shows data from the condition in which the ratio was increased during positive trials and kept at FR 1 on negative trials. The bottom panels show data from the condition where the ratio was increased on negative trials and kept at FR 1 on positive trials. Relative frequency is the frequency of trials relative to the total number of trials (60 per session) on which an observing response was completed. In order for an observing response to be scored, the entire ratio had to be completed, *i.e.*, an observing response is the entire ratio regardless of whether it was FR 1, FR 3, or FR 6.

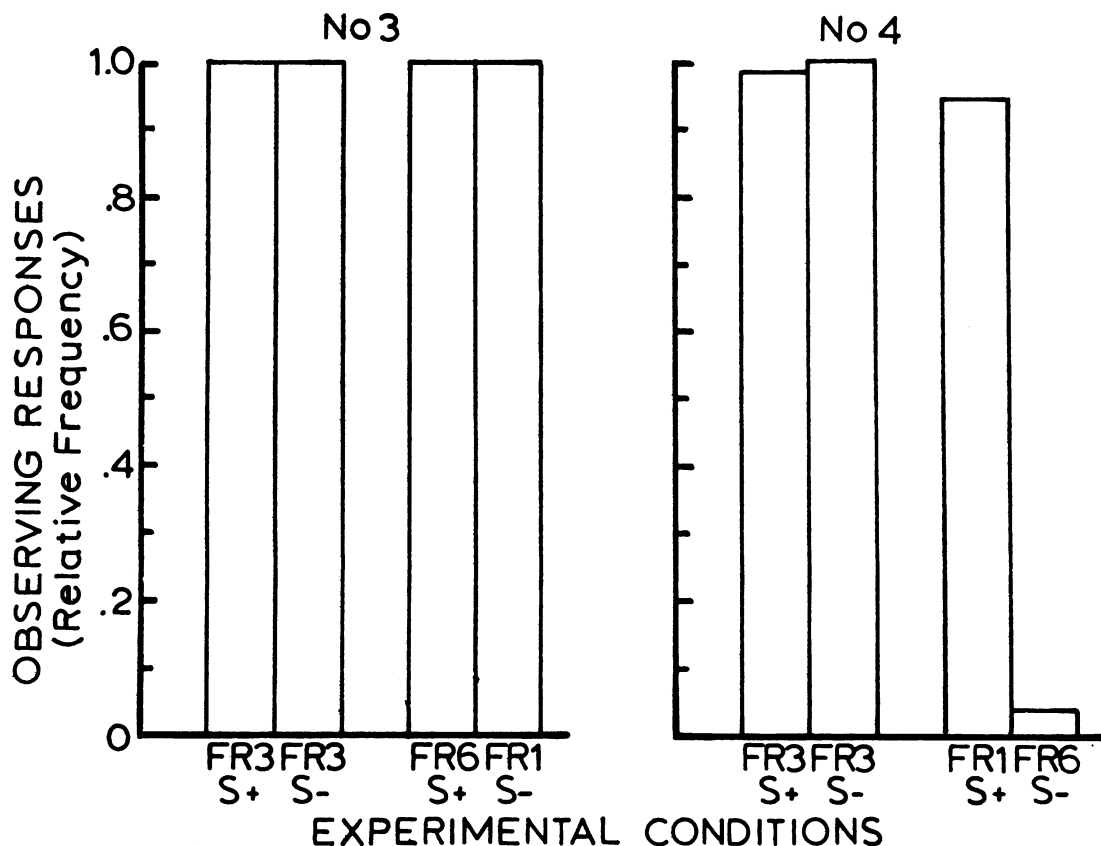


Fig. 2. Data from Birds 3 and 4. The first pair of bars shows the relative frequency of observing responses where the FR 3 was in effect on all trials. The second pair of bars shows the relative frequencies where the ratio was either FR 6 on positive trials and FR 1 on negative trials (Bird 3) or FR 1 on positive trials and FR 6 on negative trials (Bird 4). Relative frequencies and observing responses are defined the same way as for Figure 1.

I. This experiment is not reported here. Its relevance is that a white keylight appeared as a negative stimulus on some trials. Four additional birds, two White Kings and two Silver Kings formed another group. These birds are designated 1A, 2A, 3A, and 4A. They will be called Group II. They had participated in another observing-response experiment using similar procedures to those described here. They had never been exposed to the white keylight.

#### Apparatus

The apparatus was the same as in Experiment I.

#### Procedure

Bird 13 was given the same type of preliminary training previously described. The rest of the birds were already trained.

Birds 1, 2, 3, 4, and 13 were given 10 sessions in which the white light appeared on the response key on alternate trials. FR 3 was in effect on all trials. During this condition, the white light did not predict which stimulus would appear if an observing response were made because the trials occurred in an irregular sequence. Following these sessions, the white light was introduced either on positive trials (Birds 1, 2, and 13) or negative trials (Birds 3 and 4). The light came on at the beginning of the trial and remained lit until either an observing response was completed or the trial terminated. If an observing response was emitted on a trial on which the white light appeared, the appropriate stimulus appeared and the white light went off. Birds 1 and 13 were given 20 sessions of this training, Bird 2 was given 10, and Birds 3 and 4 were given 15 sessions each.

Birds 1A, 2A, 3A, and 4A (Group II) were trained in the same way as the first five birds. Two additional phases were added for these birds. The entire sequence was (1) observing response training as above with the white light appearing every other trial; (2) white light on either positive (one White King and one Silver King) or negative (one White King and one Silver King) trials; (3) green light removed; and (4) return to Condition (2). In Condition (3), responses on positive trials had no consequences except to postpone the delivery of food for 2 sec during the last 2 sec of the trial. Responses on negative trials produced the red light as usual.

### RESULTS

The results from Group I are shown in Figure 3 in which the relative frequency of ob-

serving responses is plotted across sessions. The data points to the left of the vertical dashed line show the data from the last four sessions in which the white light was noninformative. The data to the right of this line show the subsequent sessions in which the white light appeared either on positive (Birds 1, 2, and 13) or negative (Birds 3 and 4) trials. Only the sessions in which the white light was informative are numbered.

There appears to be a difference between Birds 1 and 2, which received the white light on positive trials, and Birds 3 and 4, which received the white light on negative trials. Those that received the white light on negative trials showed a rapid decrease in relative frequency of observing responses on negative trials but the relative frequency of observing responses was maintained at 1.0 on positive

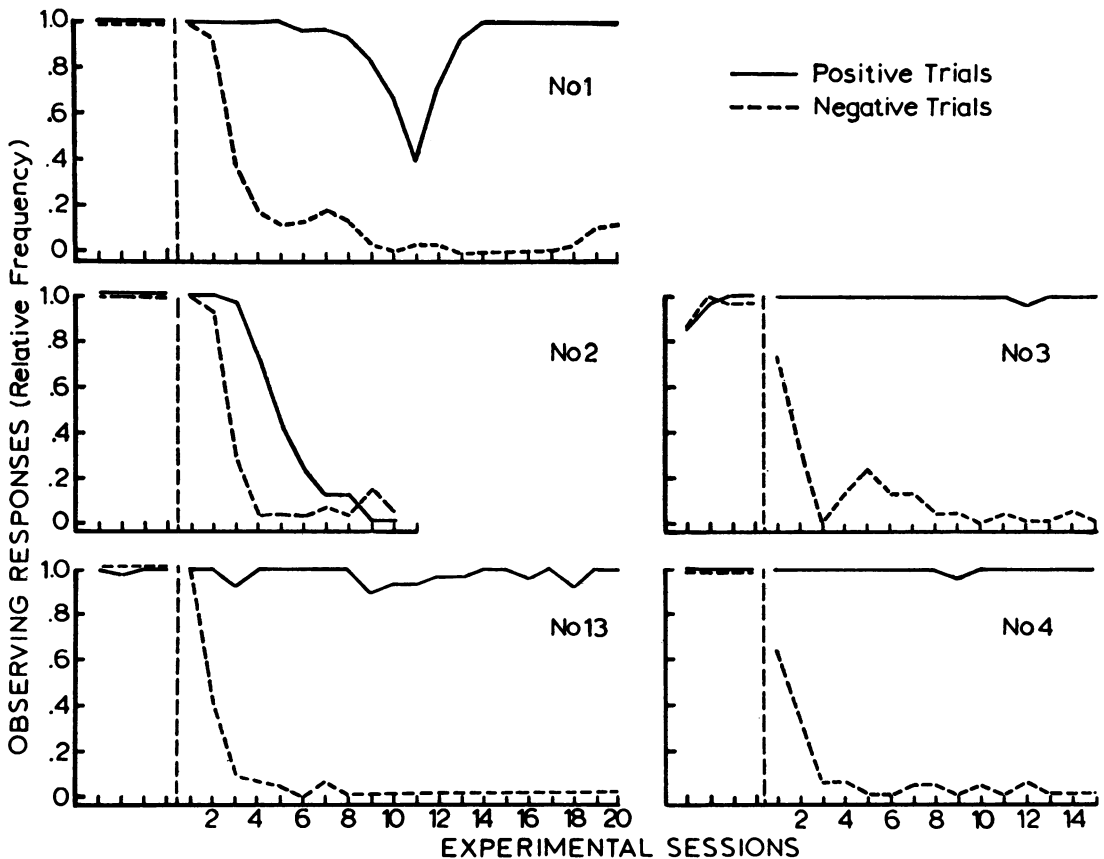


Fig. 3. Relative frequencies of observing responses on positive and negative trials across experimental sessions. For Birds 1, 2, and 13, the white light appeared at the beginning of positive trials and the key was dark on negative trials. For Birds 3 and 4, the key was dark at the onset of positive trials and the white light appeared on negative trials. The data points to the left of the vertical dashed line show relative frequencies of observing responses from the baseline condition where the white light appeared on alternate trials.

trials. Birds 1 and 2 also showed a decrease on negative trials. Bird 2, however, also showed a decrease on positive trials. Bird 1 showed a decrease on positive trials followed by a recovery.

It was mentioned in the Method section that Birds 1, 2, 3, and 4 had participated in an experiment where a white light had served as a negative stimulus. This might account for the difference between the subjects. Another factor could be the greater similarity between the white light and one or the other of the lights produced by observing responses than between the dark key and one of these lights. Bird 13 was added to the experiment to help decide on one of these possibilities. The data are similar to Birds 3 and 4. Although its observing behavior was not maintained at 1.0 over the 20 sessions, it never fell below 0.9. Bird 13 also showed a fairly rapid decrease in the presence of the dark key.

The data from Group II are shown in Figure 4. The first panel shows the last four sessions of the original baseline condition with no differential stimuli at the beginning of the trial. The second panel for each bird, labelled 1, shows the data from the phase where white was added at the beginning of positive or negative trials. The procedure under which these data were taken is the same as for Group I. Three of the four birds replicate the findings of Group I. The performance of Bird 2A was erratic, showing decreases and increases in observing responses on both positive and negative trials. Generally, observing behavior was stronger on positive than on negative trials, but not always.

The panel labelled 2 shows data from the phase where the green light was removed. Pecks on positive trials had no consequences, except to postpone the end of the trial if they occurred during the last 2 sec. Three of the birds showed a clear decline in the relative frequency of observing responses on positive trials in this phase. Observing responses did not cease during this phase, however. In the panel labelled 3, the green light was replaced and conditions were the same as in 1. Only one bird, 3A, showed complete recovery of observing responses on positive trials. All birds, including 2A, showed some recovery in this phase, however.

The data from Group II indicate that the green light was mainly responsible for the

maintenance of observing behavior when the redundant stimuli were added, although some behavior remained when the green light was removed.

### EXPERIMENT III

In Experiments I and II, the stimuli produced by observing responses were made redundant in the context of a situation involving both positive and negative trials. If only one type of trial were scheduled following observing-response training then again the observing response would produce no information because all trials would be of the same type. An experiment of this sort was done by Hendry (1969*b*). In Hendry's experiment, observing responses originally produced the stimuli correlated with one of a pair of fixed-ratio schedules, either FR 20 or FR 100. Following this training, a series of sessions was conducted during which one of the fixed-ratio schedules was removed from the situation. Hendry found that observing responses declined regardless of which schedule was removed from the experiment, but the decline was more rapid if FR 100 was removed, leaving FR 20.

Experiment III followed this procedure, using the observing response situation of the first two experiments.

### METHOD

#### *Subjects*

Four experimentally naive White Carneaux pigeons, designated Nos. 5, 6, 7, and 8, served.

#### *Apparatus*

The apparatus was the same as in the previous two experiments.

#### *Procedure*

Preliminary training was given to all birds and was similar to that described for Experiment I.

When all birds had been trained, the number of pecks required to produce a stimulus on any trial was increased to FR 3. The birds were trained on FR 3 for 10 sessions. Sixty trials were given per session. Following this training, positive trials were removed from the situation for Birds 5 and 6. Negative trials were removed for Birds 7 and 8. Removing a trial means that during a session, only one

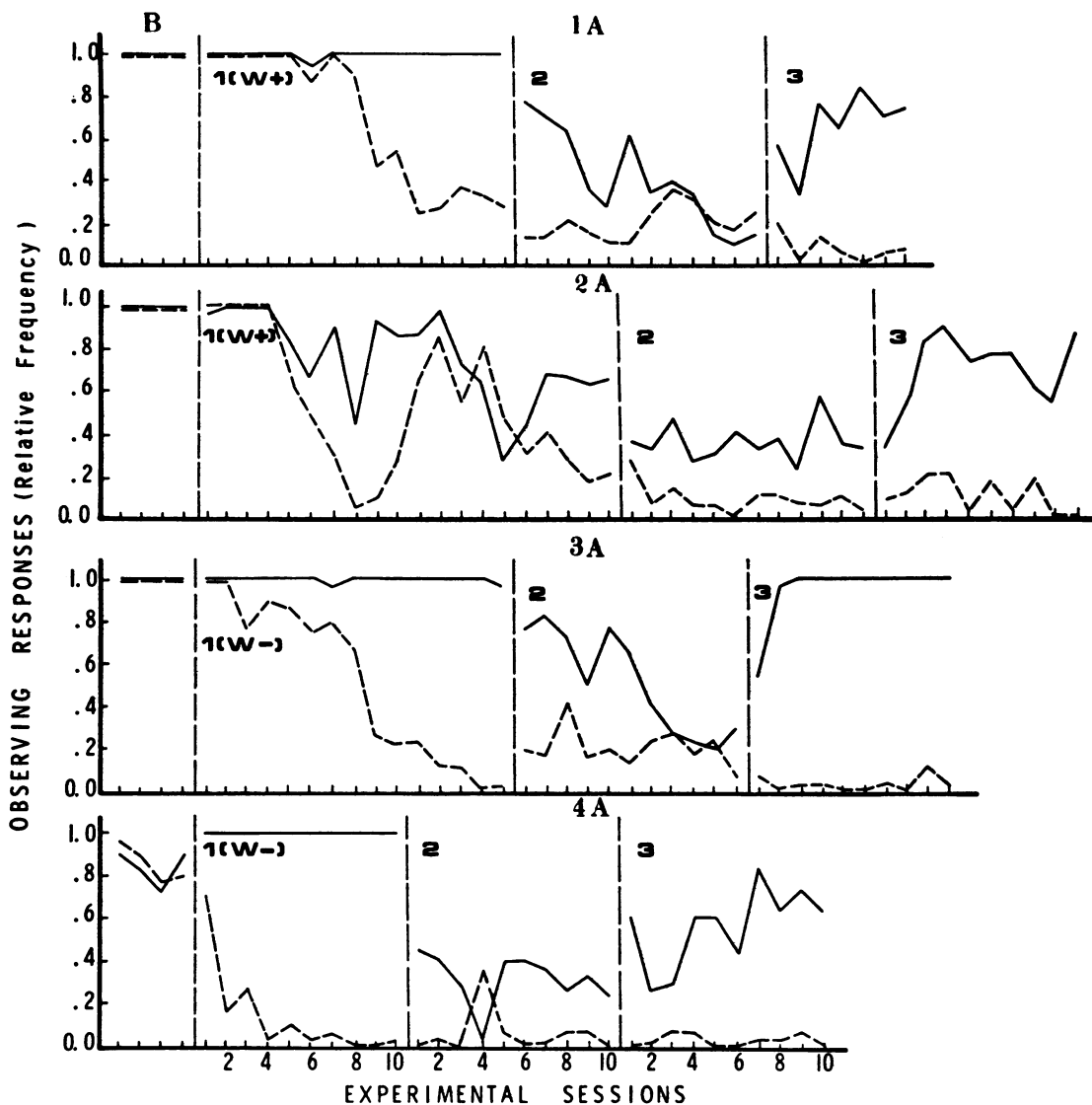


Fig. 4. Relative frequencies of observing responses on positive and negative trials across sessions for Birds 1A, 2A, 3A, and 4A. For Birds 1A and 2A, the white light appeared on positive trials in the panel labelled "1". The white light appeared on negative trials for Birds 3A and 4A. In the panel labelled "2", the green light was removed on positive trials for all birds. In the last panel (3), the green light was replaced. The data points to the left of the vertical dashed line show observing-response relative frequency for the baseline condition where the white light appeared on alternate trials.

kind of trial occurred that terminated in food presentation or TO. An observing response during a trial produced the stimulus correlated with that kind of trial. Due to the increased number of reinforcements for Birds 7 and 8, only 40 trials were given to all birds during these sessions. Birds were run either (1) for 15 sessions or (2) until there were no observing responses in two successive sessions.

Following the training described above, all birds were retrained in the original observing-response situation and given sessions removing the type of trial that had not been removed in the first phase. Retraining usually involved at least one session with the observing requirement set at FR 1 and five sessions at FR 3. Sessions were given exactly as described above.



RESULTS

The results are presented in Figure 5. To facilitate comparison of extinction rates within a subject, the two plots have been

superimposed across sessions, although the data for them were gathered at different times. The points to the left of the dashed vertical line give the relative frequency of observing responses for the last day of training

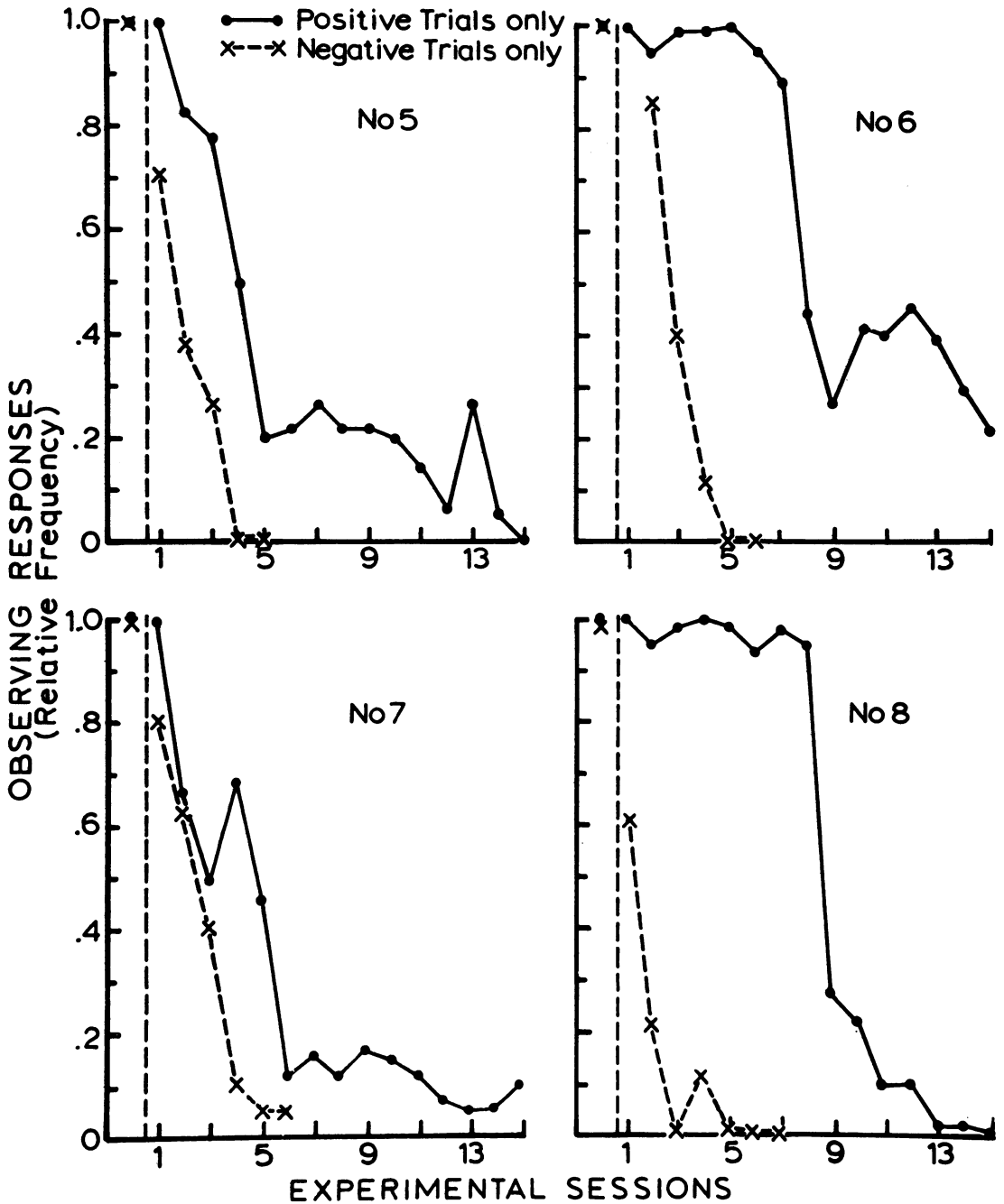


Fig. 5. Relative frequencies of observing responses across sessions when only positive (solid line) or negative (dashed line) trials were given. The dashed-line data (only negative trials) were collected first for Birds 5 and 6 and the solid-line data (positive trials only) were collected first for Birds 7 and 8.

with both positive and negative trials. For Birds 5 and 6, the data for negative trials only were gathered first. Data for positive trials only was gathered first for the other two birds. The data for negative trials only are incomplete for Bird 7 due to an error made on Day 7 of that procedure.

It may be seen that extinction is more rapid when only negative trials were scheduled for all birds regardless of the order in which they underwent the two procedures. None of the birds reached the criterion of two successive days of no responding when they were given positive trials only, although two birds made no observing responses on their fifteenth session. All of the birds, with the exception of 7, met this criterion with negative trials only. Part of the retardation of the extinction curves for positive trials seems to be due to a plateau or period of several days without much decline. These plateaus occur in different places for different birds.

#### GENERAL DISCUSSION

Experiments I and II showed that pigeons would continue to respond and produce the positive stimulus in an observing-response situation even though, due to the experimental arrangement, that stimulus could have been a redundant predictor of food. This was not the case with the negative stimulus. Responding ceased on negative trials when the stimuli produced by observing responses were made redundant. In addition, the data from Group II in Experiment II showed that green light was primarily responsible for maintaining behavior on positive trials. Observing responses did not cease altogether when the green light was removed, however. In addition, only one bird showed complete recovery when the green light was replaced.

In Experiment I, the information that could have made the stimuli produced by the observing response redundant was supplied by key pecking. When key pecks produced the positive stimulus on FR 6 and the negative stimulus on FR 1, pecking on positive trials was maintained. This was not the case when the negative stimulus was produced on FR 6 and the positive on FR 1. When the negative stimulus was produced on FR 3 and the positive on FR 1, some observing behavior was maintained on negative trials. This might be

taken as evidence that the negative stimulus was reinforcing, but not as much so as the positive stimulus. It might also be taken as evidence that the birds could not distinguish three pecks from one peck as well as they could six pecks from one peck. Experiment I did not provide any evidence as to which of these alternatives is correct. In Experiment II, however, observing responses dropped to a very low level on negative trials when the requirement was FR 3.

Two possibilities for accounting for the behavior maintained in Group II (Experiment II) when the green light was removed are (1) delay of primary reinforcement and (2) the process responsible for the maintenance of behavior in auto-shaping procedures (Brown and Jenkins, 1968). Neither possibility can be ruled out by the data at hand. In either case, the amount of behavior maintained was not as great as when the green light was left in the situation.

When the green light was replaced for Group II, only one bird showed complete recovery. Since the white light or dark key was more directly paired with primary reinforcement in the condition where the green light was removed, it is somewhat surprising that there was any recovery at all. The results of Experiment II lead to the conclusion that it was close pairing that led to the green light becoming a conditioned reinforcer. When the white light or dark key becomes similarly associated with food, it too should become a conditioned reinforcer. It can be obtained, however, by doing nothing. The results from replacing the green light showed that it retained greater value than the white light or dark key.

One hypothesis accounting for the findings of Experiments I and II is the one stated above, that close pairing of the stimulus with food led to the stimulus becoming a conditioned reinforcer. Another hypothesis might be that behavior was maintained by delayed primary reinforcement. The results of Group II in Experiment II rule out the delayed primary reinforcement hypothesis as one that can account for all of the data. In addition, delayed primary reinforcement did not maintain responding in Experiment III, where all trials ended in food presentation. Observing responses declined in this experiment when all trials terminated in either food or timeout.

There remains one discrepancy between the results of Experiments I and II on the one hand and Experiment III on the other. Observing responses were maintained in Experiments I and II under redundant conditions but not in Experiment III. Experiments II and III might be viewed as variants of each other. Experiment II could be seen as a version of Experiment III in which data on the extinction of observing responses could be obtained over one block of sessions instead of two by providing discriminative stimuli at the outset of each trial to indicate whether the trial was positive or negative. In terms of the data obtained, the two experiments are clearly not two ways of carrying out the same procedure.

In Experiments I and II, observing behavior was maintained on positive trials in a situation where positive and negative trials alternated. In Experiment III, only positive or negative trials were scheduled over a block of sessions. The omission of negative trials in Experiment III might be the factor that led to the cessation of observing responses when only positive trials were scheduled. A response is really only an observing response when it can produce one of two or more stimuli correlated with different conditions of reinforcement. The present results indicate that both conditions must be present in a session for observing responses to be maintained and that if both conditions are present, behavior that produces the positive stimulus may be maintained even though the stimulus produced is redundant.

Previous research has indicated the importance of one of a pair of stimuli in maintained observing responses. Dinsmoor, Flint, Smith, and Viemeister (1969), Kendall and Gibson (1965), and Kendall (1972) all performed experiments where one of the stimuli was removed from the observing response situation but the reinforcement schedule correlated with that stimulus was not removed. During the time when that schedule was in effect, the observing response had no consequence. The stimulus that will maintain observing responses is the one associated with the most favorable reinforcement condition, *i.e.*, shortest delay to reinforcement, no punishment, *etc.* The alternate stimulus, associated with the less favorable reinforcement schedule, will not maintain observing behavior.

Results similar to those of Experiment III were obtained by Hendry (1969*b*) who also showed that observing responses would not be maintained with only one reinforcement condition in effect. Hendry established observing responses in a situation where a response on the observing key produced stimuli associated either with FR 100 or FR 20. One of the ratio schedules was then removed from the situation, along with its correlated stimulus. The results showed that observing responses extinguished regardless of which schedule was removed.

The present results extend the generality of the principle that only one of the stimuli in an observing response experiment is responsible for the maintenance of observing behavior by demonstrating that the stimulus does not lose its value when made redundant. In addition, the results of the present experiments support an interpretation in terms of conditioned reinforcement, rather than in terms of the information hypothesis, because redundant information should not be reinforcing.

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