**THE RELATIONSHIP BETWEEN OBSERVING BEHAVIOR
AND FOOD-KEY RESPONSE RATES UNDER MIXED AND
MULTIPLE SCHEDULES OF REINFORCEMENT¹**

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Pigeons were trained under an observing response procedure in which pecks on one key (food key) were reinforced under a mixed fixed-interval 30-sec extinction schedule. A response on a second (observing) key replaced the mixed-schedule stimulus with either of two multiple-schedule stimuli (red and green keylights) for 5 sec. Observing response rates were positively correlated with food-key response rates in the presence of multiple-schedule stimuli and inversely related to food-key response rates in the presence of mixed-schedule stimuli. These results suggest that observing response output is controlled not only by the stimuli produced by observing responses but also by the stimuli in the presence of which observing responses occur. The possibility that observing responses alter the probability of reinforcement is advanced.

Observing responses are defined as those that result in exposure to discriminative stimuli but that have no effect on the probability of reinforcement (Wyckoff, 1952, 1969). Wyckoff suggested that observing responses were maintained by the net conditioned reinforcing effect of the positive and negative discriminative stimuli (*i.e.*, the stimuli correlated with reinforcement and nonreinforcement). However, since the probability of reinforcement remained the same whether or not the observing response occurred, the stimulus correlated with not making an observing response should have acquired the same reinforcing value and thus cancelled any tendency to make an observing response. Since observing responses did occur, both Wyckoff (1959) and Bower, McLean, and Meacham (1966) later proposed that the conditioned reinforcing value of the discriminative stimuli must be greater than that of the stimulus correlated with not observing. Until recently, however, empirical support for this proposal has been lacking.

Using a Wyckoff-type pedal response, Dinsmoor, Browne, Lawrence, and Wasserman (1971) showed that the amount of observing behavior was greater when the positive discriminative stimulus (S+) was produced than when the negative discriminative stimulus (S-) appeared. This finding was confirmed by Hirota (1972) in a study simulating both Wyckoff's (1969) apparatus and procedure. Since more time was spent in the presence of S+, Dinsmoor *et al.* (1971) concluded that the average frequency of reinforcement was much higher following an observing response than not following an observing response. Consistent with this interpretation, Hirota (1972) reported a direct link between the amount of pedal standing and the response rate on the food key. However, since these two response measures were related even when pedal standing did not control exposure to S+ and S-, it was suggested that the specific location of the floor pedal with respect to the food key may have been responsible for the correlation. Because the pedal was located almost directly below the food key, pedal standing generally accompanied responses on the food key. When pedal standing produced S-, movement away from both the key and the pedal occurred. Consequently, responses on the food key in the presence of S- were less frequent than those in the presence of S+.

It is possible that the results reported by Dinsmoor *et al.* (1971) and Hirota (1972) are

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specific to the Wyckoff-type observing response. Since the overall level of observing behavior was not controlled directly by the production of discriminative stimuli (a defining feature of observing responses), Hirota suggested that a two-key observing response procedure might entail fewer problems. The available data from two-key observing response studies that relate response rates on the food key to observing responses are equivocal. For example, Kelleher (1958) found that responding on the observing key (as well as on the food key) by chimpanzees was much higher when S+ was produced than when S- was produced. However, Kelleher, Riddle, and Cook (1962) reported exactly the opposite effect with pigeons. Furthermore, Kendall (1965) showed that pigeons did not increase the frequency of observing responses per reinforcement even when the opportunity to do so was made available.

The present study was designed to reassess the relationship between observing behavior and response rates on the food key using a two-key observing response procedure. Of particular interest was the possibility that observing response rates are controlled not only by the response rate on the food key during exposure to discriminative stimuli, but also by the rate during exposure to the stimulus in the presence of which observing responses occur. In one experiment (Hirota, 1972), observing responses by pigeons replaced a single stimulus correlated with both reinforcement and non-reinforcement with either S+ or S-. An observing response thus converted a mixed schedule of reinforcement to a multiple schedule. The response rate to the mixed-schedule stimulus and the amount of observing behavior were inversely related when the multiple-schedule stimuli were made nondifferential with respect to reinforcement. Another possible way in which the response rate to the mixed-schedule stimulus may be modified without altering the overall frequency of reinforcement is to decrease the discriminability between the mixed- and multiple-schedule stimuli. In the present experiment, one form of the mixed-schedule stimulus was a compound containing elements of both S+ and S-. A second (control) form was clearly discriminable from both S+ and S-. The appearance of the compound mixed-schedule stimulus was expected to increase or decrease the response rate on the food key through

selective attention to one or the other component and thus generate changes in the frequency of observing behavior.

METHOD

Subjects

Five locally obtained male homing pigeons were maintained at about 80% of their free-feeding weights. All subjects had served previously in a line-tilt generalization study.

Apparatus

A Grason-Stadler experimental chamber (Model E3125AA) contained a three-key pigeon panel (Model E6446C). The right key was covered throughout the experiment. The center (observing) and left (food) keys could be transilluminated from behind by digital display units. Each key required a minimum force of 15 g (0.15N) for operation. A click accompanied an effective response on either key. The left key could be transilluminated with a red, green, or blue light, or either of two compound stimuli. Each of the compound stimuli contained a red and green half-disk. One compound stimulus contained the red component in the upper half of the key and the green component in the lower half. In order to control for position effects, the location of the color components was reversed for the other compound stimulus. To reduce the possibility that a bird would peck specifically at one or the other component, a black plastic plate containing a 0.25-in (0.6-cm) diameter hole was placed directly in front of the left display unit but behind the response key. This plate reduced all projected colors to a small spot in the center of an otherwise dark key. The effective response, however, could be made on any part of the key. The center key could be transilluminated with a white light. A feeder light replaced the houselight during the presentation of a reinforcer. The reinforcer consisted of 4-sec access to a grain mixture. Continuous white noise in the test chamber masked extraneous sounds. Scheduling and recording were controlled by standard relays, timers, and counters located in an adjoining room.

Procedure

Discrimination training only. All birds received six sessions of discrimination training

on the left key. The center (observing) key was covered at this time. Daily discrimination sessions consisted of a random alternation of 72 fixed-interval 30-sec (FI 30-sec) components correlated with a red keylight and 72 thirty-sec extinction (EXT) components correlated with a green keylight. Successive components were separated by 4-sec blackouts in which both the houselight and keylight were extinguished.

Initial observing response training. Following discrimination training, the center key was uncovered and subjects were trained over a single session to make an observing response. An observing response converted a mixed (*mix*) FI 30-sec EXT schedule on the food key to a multiple (*mult*) FI 30-sec EXT schedule. The session began with the appearance of a white light on the center (observing) key. A single response on the observing key extinguished the white light and lit the left (food) key with red (S+) or green (S-) for 5 sec, depending on which schedule was then in effect. At the end of 5 sec, the food key became dark and the white light reappeared on the observing key. A delay contingency of 3 sec was imposed on the food key so that a response could not be reinforced within 3 sec of an observing response. To ensure an adequate rate of observing responses, responses on the food key during the first session were never reinforced when the key was unlit. During all subsequent sessions, however, reinforcement did not depend on an observing response. Observing response training with the unlit food key continued for six consecutive sessions to ensure reliable acquisition of the observing response.

Observing response training with the mixed-schedule training stimulus. Observing response training with the unlit food key as the mixed-schedule stimulus continued on odd-numbered sessions for 12 more sessions. These sessions provided a performance baseline to assess the effects of interpolated mixed-schedule test stimuli on the 12 alternate test sessions. Figure 1 (upper panel) depicts the stimulus conditions in effect on the food key during the odd-numbered training sessions as well as during the preceding six consecutive training sessions.

Observing response training with the mixed-schedule test stimuli. On the 12 even-numbered sessions, the half-red and half-green or the blue keylight appeared on the food key

as the mixed-schedule stimulus. Both mixed-schedule stimuli appeared equally often in a semi-random order within sessions. As before, each observing response replaced the mixed-schedule stimulus with S+ or S- for 5 sec. Figure 1 (lower panel) depicts the stimulus conditions in effect on the food key during even-numbered test sessions.

Extinction test. On the day after the last training session, the observing response key was covered. Food-key responses to the red, green, blue, and the half-red and half-green keylights were extinguished to determine the extent of stimulus control by the mixed- and multiple-schedule stimuli in the absence of observing responses. The four keylights were presented 12 times each in a semi-random order during 30-sec "stimulus-on" periods. Successive periods were separated by 4-sec blackouts.

RESULTS

Food-Key Response Rates

Figure 2 shows the response rates on the food key for individual birds during observing response training and testing sessions. The data points for Session 7 are shown separately to indicate the single session in which reinforcers depended on observing responses. Data points for Sessions 14 to 36 and 15 to 37 repre-

ODD-NUMBERED TRAINING SESSIONS

EVEN-NUMBERED TEST SESSIONS

Fig. 1. The design of the experiment showing the mixed-schedule stimulus (unlit key) on training sessions and the two mixed-schedule stimuli (half-red and half-green and blue keylights) on testing sessions. The two multiple-schedule stimuli (red and green keylights) are also shown.

Fig. 2. Responses per minute on the food key during observing response training and testing. When the curves for the mixed-schedule stimuli (dotted lines) are omitted, zero or near-zero responding had occurred. Note that data points for Sessions 14 to 36 and 15 to 37 represent alternate sessions.

sent response rates for alternate and not consecutive sessions. Differential response rates to S+ and S- were well established during initial observing response training (Sessions 8 to 13). Responding on the unlit key during both positive and negative components was virtually zero for all birds and is not shown. Response rates to S+ tended to decrease across/subsequent training sessions (Sessions 15 to 37) for all birds except P 24. The decline in the S+ response rate was accompanied by an increase in the response rate to the mixed-schedule stimulus (unlit key) during positive components of the schedule. For P 24, responding on the unlit key during both components was at or near zero and is not shown.

The introduction of the two mixed-schedule stimuli on alternate test sessions (Sessions 14 to 36) had little effect on the pattern of responding to S+ and S-. Response rates to S+ tended to decline as in training sessions. On the other hand, response rates to the half-red and half-green mixed-schedule stimulus during positive and negative components were well above zero from the first test session (Session 14) and differed depending on the schedule in effect for all birds except P22. By contrast, the response rates to the blue mixed-schedule stimulus during the positive and negative components did not begin to separate for several sessions (P 21, P 23, and P 25) or remained undifferentiated (P 24). The response rates to the two mixed-schedule stimuli by P 22 showed clear control by color in Session 14 (*i.e.*, a moderate response rate to the half-red and half-green stimulus during both positive and negative components and a low response rate to the blue stimulus during both components). In subsequent sessions, however, differentiation of both mixed-schedule stimuli into positive and negative components was achieved more rapidly than for P 21, P 23, and P 25.

Observing-Key Response Rates

Figure 3 presents the number of observing responses per session across training and testing sessions for individual birds. The separate data points for Session 7 indicate the session in which an observing response was required for reinforcement. The differentiation of observing responses into S+ and S- components was attenuated (P 21) or completely disappeared (P 22, P 23, and P 25) for four of five birds

during the first two to six training sessions. This effect was due entirely to a decrease in the frequency of observing responses producing S+. The one exception, P 24, maintained a stable difference in response rate throughout training and testing sessions. The frequency of observing responses during the first four to six sessions for P 21, P 23, and P 25 in the presence of the blue mixed-schedule stimulus paralleled the pattern established during the early phase of training sessions. By contrast, observing responses that replaced the half-red and half-green mixed-schedule stimulus with S+ were considerably less frequent and occurred no more often than those that produced S-. Except for the first test session, P 22 showed virtually no differentiation in observing behavior.

Relationship Between Food-Key and Observing-Key Response Rates

Figures 2 and 3 show a consistent pattern between food- and observing-key response rates for P 21, P 23, and P 25. First, a decrease in the response rate to S+ during training sessions was accompanied by an increase in response rate to the mixed-schedule stimulus, and both changes in rate were related to a decrease in the frequency of observing responses. Second, the differentiation in food-key response rates in the presence of the half-red and half-green mixed-schedule stimulus during testing sessions was correlated with non-differential response rates on the observing key. When the response rates to the mixed-schedule stimulus were not differentiated, as was the case during the first four to six test sessions with the blue mixed-schedule stimulus (P 21, P 23, and P 25), the differentiation of observing response rates was clearly evident. Subsequent differentiation of food-key response rates to the blue mixed-schedule stimulus during positive and negative components eliminated differences in observing response frequency. When the mixed-schedule stimulus was differentiated rapidly into positive and negative components (*e.g.*, P 22), differences in observing response rates did not appear. When the response rates to the mixed-schedule stimulus remained undifferentiated (*e.g.*, P 24), differential observing response rates were maintained.

Figure 3 indicates that P 24 produced approximately 200 observing responses per session

Fig. 3. Number of observing responses per session during observing response training and testing. Note that the data points for Sessions 14 to 36 and 15 to 37 represent alternate sessions.

in the positive component during all training sessions and a similar level in the presence of the blue mixed-schedule stimulus during test sessions. Since close to 216 observing responses could be made during each session (*i.e.*, six 5-sec exposures per FI 30-sec component times 36 components), the frequency of observing responses by P 24 ensured almost total exposure to S+ and, with little or no exposure to the mixed-schedule stimulus during training sessions, a near-zero response rate on the unlit key. The approximately 100 observing responses per session by all birds during both positive and negative components when observing responses became nondifferentiated indicate that the amount of exposure to the mixed- and multiple-schedule stimuli was about equally distributed.

The total number of responses to the mixed- and multiple-schedule stimuli during the extinction test in the absence of observing responses was consistent with the pattern of responding when observing responses were required for exposure to the multiple-schedule stimuli.

DISCUSSION

The frequency of observing responses in the present experiment depended on two conditions, whether the response rate to the mixed-schedule stimulus was high or low, and whether the response rate to the multiple-schedule stimuli was high or low. When an observing response produced a stimulus controlling a high response rate (*i.e.*, S+), subsequent observing responses ensured continued exposure to that stimulus until the positive component terminated with a reinforcer. Consequently, exposure to the "positive" mixed-schedule stimulus was minimal. When an observing response produced a stimulus controlling a low response rate (*i.e.*, S-), observing responses were less frequent. Thus, the "negative" mixed-schedule stimulus was present throughout most of the negative component. It follows from the resultant imbalance in the amount of exposure to the mixed- and multiple-schedule stimuli during positive and negative components that responses to the mixed-schedule stimulus were reinforced infrequently, if at all. By the same token, the multiple-schedule stimulus most likely to appear following an observing response was S+

rather than S-. The greater frequency of observing responses during the positive component thus increased the probability of reinforcement following an observing response and decreased the probability of reinforcement in the presence of the mixed-schedule stimulus. This interpretation of observing behavior has been suggested previously by other investigators (Gollub, 1970; Dinsmoor *et al.*, 1971).

The present results are consistent with the finding reported by Dinsmoor *et al.* (1971) and Hirota (1972) and extend their analyses to the two-key observing response situation. The observing response requirement for reinforcement in Session 7 effectively curtailed responses to the mixed-schedule stimulus (unlit food key) during Sessions 8 to 13. The introduction of the half-red and half-green mixed-schedule stimulus on alternate test sessions, however, had the effect of initiating responses on the unlit key during later training sessions, as well as immediately increasing the response rate to the mixed-schedule stimulus during test sessions. Clearly, the form of the mixed-schedule stimulus and the response rate that it controls or comes to control is an important determinant of observing response frequency.

In two-key observing response experiments, other parameters such as the size of the fixed-ratio requirement on the observing key, the duration of the response-produced stimulus, and the length of the changeover delay also may be critical. In the present study, these parameters were at or below the minimum values set by Kelleher *et al.* (1962) and Kendall (1965). It is possible that the present results are dependent on a relatively high output in observing behavior and that when this output is reduced by an increase in the FR requirement (Kelleher *et al.*, 1962) or by longer changeover delays (Kendall, 1965), the apparent relationship between observing response rates and probability of reinforcement disappears.

It should be pointed out that the present account of observing behavior, in terms of an increase in the probability of reinforcement during exposure to discriminative stimuli, holds only so long as observing responses that produce S+ are more frequent than those that produce S-. Whereas observing responses that produced S+ decreased across training and testing sessions for four of five birds, the observing response rate did not decline below the

level correlated with S- production. This level ensured exposure to S+ and S- during approximately one-half of the available time. The presence of any observing behavior under these conditions would appear to contradict the present analysis. However, Figure 2 indicates that the combined response rates to the "positive" and "negative" mixed-schedule stimuli were invariably less than the objective average rate to the multiple-schedule stimuli. To the extent that the mixed- and multiple-schedule response rates directly reflect the frequency of reinforcement in their presence, as suggested by the results of the extinction test, the probability of reinforcement was slightly higher following an observing response despite equal exposure to S+ and S-. The higher probability of reinforcement appears to be related to the particular schedule used in this experiment. Fixed-interval schedules are characterized by low response rates early in the interval followed by high terminal rates. A low rate in the presence of the "positive" mixed-schedule stimulus early in the FI component followed by the initiation of observing responses and a high terminal rate in the continued presence of S+ would account for the higher overall response rate following an observing response. During the extinction component, the same number of observing responses presumably would be more evenly distributed. Unfortunately, since only total responses per session were recorded, the suspected effect of the temporal distribution of food- and observing-key responses during the

FI and EXT components could not be assessed in the present experiment.

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