

THE WYCKOFF OBSERVING RESPONSE—A REAPPRAISAL¹

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Pigeons were trained on a Wyckoff observing response procedure in which key responses were reinforced on a mixed schedule consisting of fixed-interval and extinction components. In Experiment 1, stepping on a pedal (a) converted the mixed schedule to a multiple schedule, (b) replaced the mixed-schedule stimulus with an unlit key (or, in different phases, a blackout), or (c) had no consequence. In Experiment 2, pedal standing removed the mixed-schedule stimulus that was physically similar to the multiple-schedule stimuli or one that was less similar. In Experiment 3, Wyckoff's differential and nondifferential discrimination procedure was repeated. The results of Experiments 1 and 2 showed that the Wyckoff pedal response was controlled by neither the removal of the mixed-schedule stimulus nor the production of discriminative stimuli. The results indicated a correlation between key-response rates and pedal-standing time. Experiment 3 showed that high response rates to mixed-schedule stimuli were correlated with little pedal-standing time while high key-response rates to multiple-schedule stimuli were correlated with considerable pedal standing time. The correlation between key-response rates and pedal-standing time was related to the physical arrangement between the key and pedal operanda.

TABLE OF CONTENTS

- Experiment 1: Effects of mixed-schedule stimulus removal on Wyckoff's pedal response.
 Experiment 2: Effects of removing different mixed-schedule stimuli on Wyckoff's pedal response.
 Experiment 3: Wyckoff's differential and nondifferential discrimination experiment—a replication.

Under certain conditions, an organism in a discrimination training situation may respond in either of two ways. It may make a response in the presence of a stimulus correlated with an intermittent schedule of reinforcement and obtain food occasionally and unpredictably.

Alternatively, the organism may first make an observing response, a response that produces discriminative stimuli. A subsequent food response in the presence of a positive discriminative stimulus (S^D) is reinforced while a response in the presence of a negative discriminative stimulus (S^A) is not.

A study by Wyckoff (1951) provided a clear example. Pigeons were trained to peck a white key on a mixed fixed-interval 30-sec extinction (*mix* FI 30-sec EXT) schedule. During any 30-sec component, a pigeon could step on a pedal located on the floor and replace the white keylight with either a red (S^D) or a green (S^A) discriminative stimulus. A pedal response thus converted a mixed schedule to a multiple schedule. Stepping off the pedal reinstated the mixed-schedule stimulus. Wyckoff found that as the color discrimination was acquired, the proportion of time on the pedal increased. When the discriminative stimuli were made nondifferential with respect to reinforcement, observing responses decreased. When the discriminative stimuli were reversed, the amount of observing behavior decreased and then increased as the reverse discrimination was learned. Wyckoff (1951, 1952) attributed the

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increase in observing behavior to the conditioned reinforcing properties of the discriminative stimuli.

However, observing responses not only produce discriminative stimuli but simultaneously remove the mixed-schedule stimulus. Does the removal of the mixed-schedule stimulus itself constitute a possible source of reinforcement? The fact that the mixed-schedule stimulus in observing response experiments has been described as "ambiguous" (Kelleher, Riddle, and Cook, 1962; Segal, 1962), uncertainty inducing (Steiner, 1967), and conflict inducing (Berlyne, 1960) suggests that the stimulus may be more than just a cue for the occurrence of the observing response. An "ambiguous" stimulus may be defined operationally as one that is correlated with two topographically different responses. Several studies suggest that the outright removal of ambiguous stimuli is reinforcing. For example, Hearst and Sidman (1961) showed that rats favored a timeout in place of responding on a lever that produced both shock and reinforcement. Tighe and Leaton (1966) observed a temporary but significant increase in the frequency of lever presses that produced timeouts following a sudden decrease in the difference between a pair of discriminative stimuli. In each case, a response removed an "ambiguous" stimulus and produced a timeout. Timeouts under these conditions may represent escape from an aversive stimulus (*cf.* Leitenberg, 1965). Thus, one way to determine if observing responses are maintained by the removal of the mixed-schedule stimulus would be to substitute a timeout in place of a discriminative stimulus. However, if observing responses are maintained to a large extent by the production of discriminative stimuli and very little by the removal of the mixed-schedule stimulus, the timeout procedure may not be sensitive enough to show this additional source of reinforcement. An alternative procedure would allow observing responses to produce discriminative stimuli but simultaneously remove mixed-schedule stimuli that differ in their degree of "ambiguity". A mixed-schedule stimulus that is more "ambiguous" presumably would maintain a higher level of observing behavior than one that is less "ambiguous". In a study by Steiner (1967), rhesus monkeys and a baboon were trained to make an observing response that replaced a bright or dim keylight (mixed-schedule stim-

uli) with either a red or a green keylight (multiple-schedule stimuli). One of the mixed-schedule stimuli was always correlated with the positive discriminative stimulus, the other with the negative discriminative stimulus. When the difference in brightness between the two mixed-schedule stimuli decreased, observing responses increased. Since the multiple-schedule stimuli remained the same, irrespective of changes in the mixed-schedule stimuli, the increase in observing behavior was due presumably to the increased difficulty in discriminating between the two mixed-schedule stimuli. One variation of the above procedure would be to present mixed-schedule stimuli that differ in their degree of physical similarity to both multiple-schedule stimuli. A mixed-schedule stimulus, which is physically more similar to both the positive and negative discriminative stimuli, should be more "ambiguous" because of stimulus generalization, than one which is unlike either discriminative stimulus, and therefore, should be more likely to be removed.

The present experiments were designed to investigate the possible role of the removal of mixed-schedule stimuli in maintaining the Wyckoff observing response.

EXPERIMENT 1: EFFECTS OF MIXED-SCHEDULE STIMULUS REMOVAL ON WYCKOFF'S PEDAL RESPONSE

Experiment 1 was designed to investigate the empirical prediction that the outright removal of the mixed-schedule stimulus in the Wyckoff observing response experiment is sufficient to establish and maintain observing behavior above an operant level. If the observing response in the Wyckoff (1951) differential reinforcement condition is maintained not only by the production of discriminative stimuli but also by the removal of the mixed-schedule stimulus, observing responses maintained exclusively by the latter should appear above an operant level but below the level established by the Wyckoff condition.

METHOD

Subjects

Three experimentally naive male homing pigeons were maintained at about 80% of their free-feeding weights.

Apparatus

The standard pigeon panel in a Grason Stadler experimental chamber was replaced by an interior described by Wyckoff (1951). To facilitate access to the feeder, a mirror image of the Wyckoff work panel was used. The 12 by 12 by 12 in. (30 by 30 by 30 cm) compartment contained a key 8.5 in. (22 cm) above the floor and 2.5 in. (6 cm) from the left wall. The feeder was 2 in. (5 cm) above the all-metal floor and 3 in. (8 cm) from the right wall. An aluminum pedal 2 in. (5 cm) wide extended 10 in. (25 cm) along the floor at right angles to the base of the work panel. The pedal protruded 0.25 in. (0.6 cm) above the floor with its right edge directly below the center of the key. A minimum force of 65 g (0.64N) was required to actuate a microswitch located under the pedal. The single transparent key, 0.75 in. (2 cm) in diameter, required a minimum force of 15 g (0.14N) for operation. A click accompanied each effective response.

The response key could be transilluminated with red, green, blue, or white lights as well as black lines 0.3 cm wide on a white surround at 0°, 45°, and 90° from vertical by a Digital Display unit. A speaker located on the upper-right corner of the work panel provided continuous masking noise. A 6-w houselight located on the upper-left corner of the left wall illuminated the chamber except during reinforcement, when it was replaced by a 6-w light behind the work panel and directly above the food tray. The reinforcer consisted of 4-sec access to a grain mixture. Scheduling and recording were controlled by a system of relays, timers, and counters located in an adjoining room.

Procedure

All birds were adapted to the chamber and magazine trained in the presence of a white keylight over a period of 1 hr. This procedure was repeated the next day if a bird was not eating freely within the hour whenever the magazine was raised. On the third day, all birds were trained to peck the white key on a schedule that progressed from reinforcing each response to reinforcing the first response at the end of 30 sec (FI 30-sec). Preliminary sessions terminated after 50 reinforcers.

The experiment consisted of five phases. These phases and the number of sessions in

Table 1
Summary of Experimental Conditions

Phase	Type of Condition	Number of Sessions
I	Line-tilt discrimination training only; pedal standing had no consequence.	9
II	Pedal standing: (a) produced S ^D or S ^A (b) produced an unlit key (c) had no consequence	10
III	Pedal standing: (a) produced S ^D or S ^A (b) produced a blackout (c) had no consequence	16
IV	Same as Phase II	5
V	Pedal standing: (a) produced S ^D or S ^A (b) produced a blackout (c) produced nondifferential stimuli	16

each phase are shown in Table 1. Each session contained 144 periods made up of six cycles of a random sequence of 12 "positive" and 12 "negative" periods.

In Phase I, all birds were trained to discriminate line-tilt stimuli for nine sessions. The schedule in the positive period was FI 30-sec, that in the negative period, extinction, with a 30-sec exposure. The stimulus during the positive period was a vertical line (S^D) and during the negative period, a horizontal line (S^A) for two of the birds. The S^D and S^A pattern was reversed for the remaining bird. Pedal standing had no consequence during this phase because S^D or S^A was present throughout each period. However, the pedal-standing time was recorded to establish a baseline.

Observing response training proceeded over 47 sessions (Phases II, III, IV, and V) with three types of trials presented equally often in any one session. A red, green, or blue keylight indicated which type of trial was in force in the absence of pedal standing. A different combination of colors was used for each bird to denote the three types of trials. These trials differed according to the consequences of standing on the pedal. On one type of trial, stepping on the pedal converted a *mix* FI 30-sec EXT schedule to a multiple (*mult*) FI 30-sec EXT schedule. Pedal standing thus replaced the mixed-schedule stimulus (one of three colors) with either S^D or S^A. This type of trial was comparable to Wyckoff's differential reinforce-

ment condition. On a second type of trial, pedal standing turned off the mixed-schedule stimulus (another color) and produced an unlit key (Phases II and IV) or turned off both the mixed-schedule stimulus and the house-light and produced a blackout (Phases III and V). During Phases III and V when pedal standing produced a blackout, the mixed-schedule stimulus reappeared at the end of 30 sec if a reinforcer was due. The mixed-schedule stimulus remained on regardless of pedal standing until the trial was terminated with a reinforced key peck. The scheduled reappearance of the mixed-schedule stimulus ensured that a bird would not remain in the dark indefinitely and prolong the session. If a reinforcer was not due, a trial ended after 30 sec regardless of pedal standing. On a third type of trial, the mixed-schedule stimulus (a third color) was presented and pedal standing had no consequence (Phases II, III, and IV). This type of trial was changed during Phase V so that pedal standing produced the vertical or horizontal line.

Each of these lines was correlated with both reinforcement and nonreinforcement. This modified trial was comparable to Wyckoff's non-differential reinforcement condition. In each type of trial, a reinforcer was contingent upon a key-peck response at the end of half of the trials, and extinction was in force during the remaining half. The probability of a reinforcer at the end of any trial remained constant whether or not the pedal was depressed.

RESULTS

Key-Response Rate

Figure 1 shows the mean response rate of key pecks for each of the three types of trial in Experiment 1. Key responses during Session 41 were lost due to apparatus failure and are not shown. Key-response rates in Phase I represent rates to S^D and S^A while response rates during positive and negative periods (indicated by $S+$ and $S-$ in Figure 1) in all later phases indicate combined (mixed- and multiple-schedule) key rates. Since key responses normally did

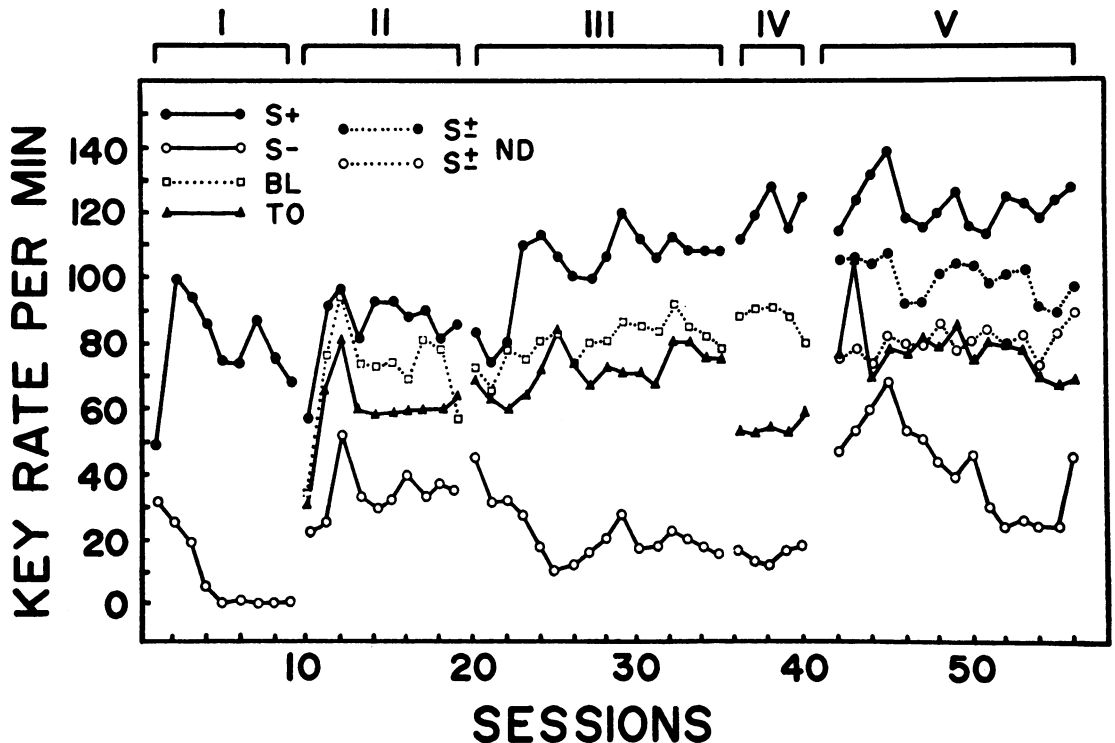


Fig. 1. Mean key-response rates during each phase of Experiment 1. Key-response rates to S^D and S^A are shown in Phase I. Key-response rates in all subsequent phases when pedal standing produced S^D and S^A indicate combined rates to mixed- and multiple-schedule stimuli during positive and negative periods ($S+$ and $S-$). Key-response rates when pedal standing had no consequence are indicated by BL (baseline). Key-response rates when pedal standing produced an unlit key or a blackout are indicated by TO (timeout).

not occur in the dark, key-response rates on trials when a blackout occurred reflect rates to the mixed-schedule stimulus only. Key-response rates on trials when an unlit key occurred indicate combined rates.

The line-tilt discrimination was well established during Phase I. The introduction of the observing response requirement raised the negative period key-response rate. However, the higher rate reflects the combined rate to mixed- and multiple-schedule stimuli and does not imply a decrease in control by S^A . Key-response rates on trials when pedal standing produced an unlit key only or a blackout were comparable to the combined positive and neg-

ative response rates on trials when pedal standing produced S^D and S^A . By contrast, the key-response rates on trials when pedal standing had no effect tended to be consistently higher than the rates under either of the other two conditions. Key-response rates were thus highest during positive periods, lower when the mixed-schedule stimulus did not change, lower yet when an unlit key or blackout occurred, and least during negative periods.

Differential key-response rates on trials when pedal standing produced S^D or S^A were less pronounced in Phase V because of an increased response rate during negative periods. Differential response rates appeared and were main-

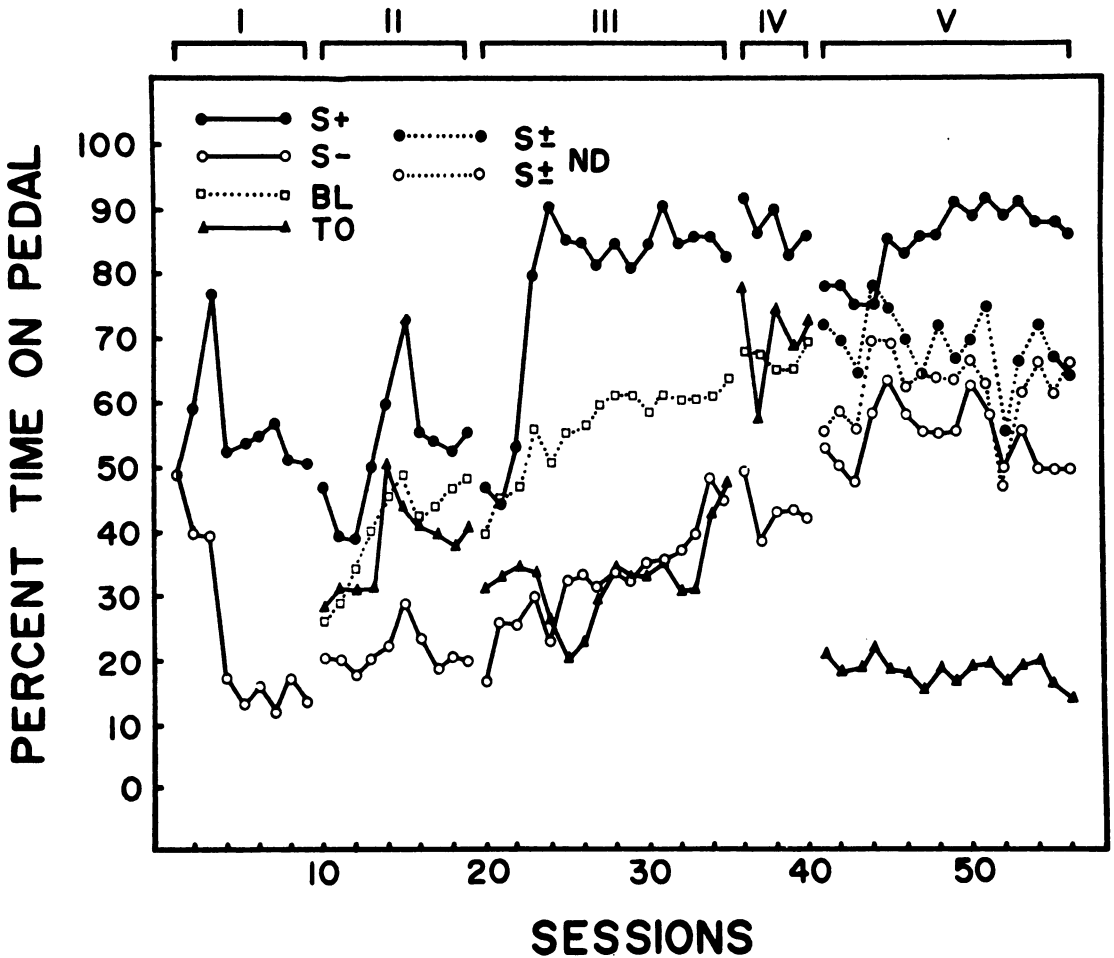


Fig. 2. Mean per cent time on the pedal during each phase of Experiment 1. Pedal-standing time during exposure to S^D and S^A are shown in Phase I. Pedal-standing time in all subsequent phases, when pedal standing produced S^D and S^A during positive and negative periods, is indicated by S^+ and S^- . Per cent time on the pedal when pedal standing had no consequence is shown by BL (baseline). Per cent time on the pedal when an unlit key or a blackout was produced is indicated by TO (timeout).

tained under the nondifferential condition, although considerably attenuated relative to the rates under the differential condition.

Observing Responses

Observing behavior is expressed as mean per cent of time on the pedal for each type of trial and is shown across phases in Figure 2. The amount of time on the pedal differed strikingly according to exposure to S^D and S^A during Phase I when pedal standing had no consequence. The introduction of the observing response requirement for exposure to S^D and S^A did not alter the difference in pedal-standing time. This difference in pedal time was maintained throughout the experiment.

Observing behavior differed as a function of whether pedal standing produced an unlit key or a blackout. When pedal standing produced a blackout, the amount of time on the pedal fell to the level associated with S^A production (Phase III) or fell even lower (Phase V).

Differentiation of observing behavior during positive and negative periods was less pronounced in Phase V. The decrease in differentiation was due to increased pedal standing during negative periods. Differences in pedal standing under the two nondifferential stimulus conditions disappeared by the end of Phase V, but the overall amount did not decrease.

Relationship between Key-Response Rate and Observing Behavior

An examination of Figures 1 and 2 shows a clear relationship between key-response rate and observing behavior when pedal standing produced discriminative stimuli. High key-response rates during positive periods were accompanied by a considerable amount of pedal standing, and low key-response rates during negative periods were correlated with less time on the pedal. When pedal standing produced an unlit key, both key-response rates and pedal-standing time were comparable to the combined performance during positive and negative periods. The relationship between key-response rate and pedal-standing time was less clear under the conditions when pedal standing produced a blackout. When pedal standing produced a blackout, pedal-standing time decreased to a level associated with the negative period while key-response rate remained at an intermediate level.

DISCUSSION

The results of Experiment 1 clearly show that removal of the mixed-schedule stimulus did not maintain observing behavior above an operant level. Furthermore, a distinct preference for the mixed-schedule stimulus over the blackout alternative is evident from the decreased pedal-standing time when blackouts were produced during the final phase of the experiment. The apparent "avoidance" of a blackout does not appear to be attributable to the stimulus change component of a blackout since observing responses that produced an unlit key (stimulus change but no blackout) were not depressed. The blackout itself appears to be aversive. The results thus support other evidence that timeout from a schedule of positive reinforcement is generally aversive (Leitenberg, 1965).

The positive relationship between key-response rates and time on the pedal is clearly evident during Phase I, when pedal standing had no effect. This relationship remained consistent and ordered under all three types of trials when the observing response requirement was in force. The one exception to the positive correlation between key-response rates and pedal-standing time that occurred on trials when pedal standing produced a blackout appears to be an artifact. The relatively high key-response rates on blackout trials actually reflected the response rate in the presence of the mixed-schedule stimulus only and not the overall rate during a trial, since responses did not occur during a blackout.

Several features of the present results are not consistent with Wyckoff's (1951, 1952) conditioned reinforcement explanation of observing behavior. The differentiation of pedal-standing time into S^D and S^A components during Phase I when pedal standing had no effect suggests that pedal standing in later phases occurred, not because discriminative stimuli were produced, but because pedal standing was correlated with responding or not responding on the key.

Wyckoff (1951) combined positive and negative periods to obtain per cent time on the pedal. In the present experiment, observing responses that produced discriminative stimuli (combined positive and negative periods) did not differ in amount from those that had no consequence. The implication is quite clear.

The observed level of pedal-standing time is not maintained by the production of discriminative stimuli.

Wyckoff (1951) found that pedal-standing time decreased when the nondifferential condition was introduced. In the present experiment, nondifferential reinforcement attenuated the difference in pedal-standing time between positive and negative periods but failed to reduce the overall pedal-standing time. The maintained discrimination in key-response rate in the presence of nondifferentially reinforced line-tilt stimuli (an effect not obtained by Wyckoff) appears to be responsible for the persistence in observing behavior under the nondifferential condition. The differential and nondifferential stimulus conditions differed only with respect to the mixed-schedule stimulus (two different colors). Since the mixed-schedule stimuli were present only about one third of the time during a trial (see Figure 2), the differential reinforcement line-tilt stimuli would control differential responding during exposure to the same stimuli under the nondifferential condition.

EXPERIMENT 2: EFFECTS OF REMOVING DIFFERENT MIXED-SCHEDULE STIMULI ON WYCKOFF'S PEDAL RESPONSE

Experiment 1 showed that the outright removal of the mixed-schedule stimulus did not maintain observing behavior above the level established when such behavior had no consequence. In fact, when blackouts replaced the mixed-schedule stimulus, observing responses fell considerably below the operant level. The results suggest that if the mixed-schedule stimulus is aversive at all, it is at least less aversive than a timeout. Experiment 2 examined the alternative method of determining whether or not the removal of the mixed-schedule stimulus is reinforcing. The empirical prediction to be tested was that a mixed-schedule stimulus that is physically midway between the positive and negative discriminative stimuli would control a higher level of observing behavior than one that is orthogonal to the discriminative stimulus. If mixed-schedule stimuli are ambiguous because they evoke incompatible responses, then such stimuli should be more ambiguous if they resemble the stimuli that

directly control the incompatible responses. Since the removal of either mixed-schedule stimulus by the observing response would be followed by exposure to discriminative stimuli, the prediction could be tested without withdrawing the schedule of positive reinforcement, a condition that appears to have impaired observing behavior in Experiment 1.

Experiment 1 also showed that the production of discriminative stimuli (combined positive and negative periods) did not elevate observing behavior above the operant level. To explore further this anomalous effect, the initial discrimination phase was extended to determine the course and reliability of the $S^D - S^A$ difference in observing behavior obtained in Experiment 1.

METHOD

Subjects and Apparatus

Four experimentally naive male homing pigeons were maintained at about 80% of their free-feeding weights.

The apparatus was the same as in Experiment 1, except for the addition of a Digital Display stimulus consisting of a 0.125 in. by 0.125 in. (0.32 cm by 0.32 cm) black square in the center of a white surround.

Procedure

Magazine and keypeck training was the same as in Experiment 1. Line-tilt discrimination training was the same as in Experiment 1 except that training was extended from nine to 12 sessions. For two of the birds, S^D was a vertical line and S^A was a horizontal line. The pattern was reversed for the remaining two birds. Discrimination training was followed by 14 sessions of observing response training in which a pedal response converted a *mix* FI 30-sec EXT schedule to a *mult* FI 30-sec EXT schedule. In each session, two types of trials occurred equally often in a random sequence. The mixed-schedule stimulus on one type of trial was a small black square on a white surround. On the second type of trial, a diagonal line either 45° to the left or 45° to the right of vertical appeared. A pedal response removed the mixed-schedule stimulus and produced either the vertical or horizontal line as in Experiment 1. Key responses to mixed- and multiple-schedule stimuli were recorded separately.

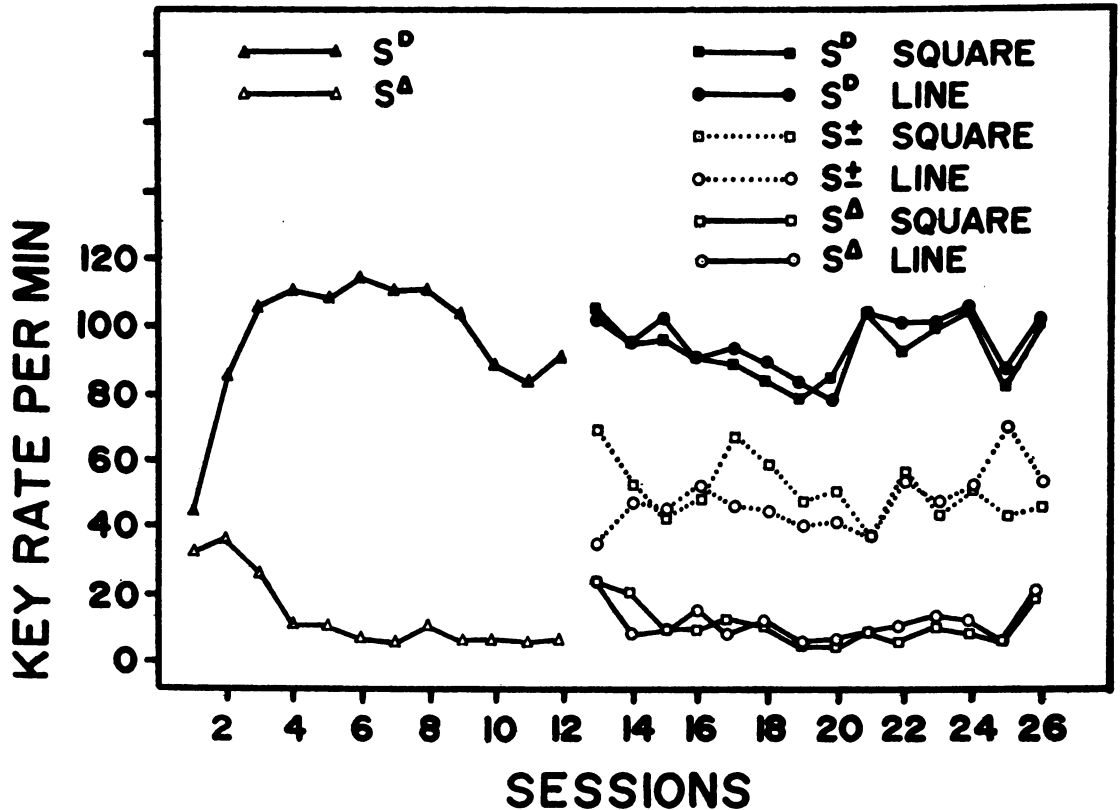


Fig. 3. Mean key-response rates during discrimination training (Sessions 1 to 12) and observing response training (Sessions 13 to 26) in Experiment 2. Filled and open triangles indicate key-response rates to S^D and S^A . Filled squares and circles (solid lines) indicate key-response rates to S^D when the mixed-schedule stimulus was a small black square (SQUARE) and a diagonal line (LINE). Open squares and circles (solid lines) represent corresponding key-response rates to S^A . Dotted lines indicate key-response rates to mixed-schedule stimuli (S^\pm SQUARE and S^\pm LINE) during combined positive and negative periods.

RESULTS

Key-Response Rate

Figure 3 shows the key-response rates for Experiment 2. The line-tilt discrimination was well established in the first phase and did not differ from the pattern observed in Experiment 1. The pattern was comparatively more stable than in Experiment 1 when the observing response requirement was introduced. Key-response rates to S^D and S^A did not differ under the two mixed-schedule stimulus conditions. Figure 3 also shows that key-response rates to the mixed-schedule stimuli did not differ from each other and were intermediate between S^D and S^A key-response rates.

Observing Responses

The per cent time on the pedal for Experiment 2 is shown in Figure 4. The initial level

of observing behavior was considerably lower (18 to 21%) than the level observed in Experiment 1 (about 49%). The differentiation of pedal-standing time into S^D and S^A components that did emerge was slower in developing than the key-response rate discrimination. As in Experiment 1, the introduction of the observing response requirement had no effect on the S^D and S^A differentiation, which closely matched the terminal levels of the first phase of the experiment. The amount of observing behavior did not differ under the two mixed-schedule stimulus conditions.

DISCUSSION

The results of Experiment 2 confirmed earlier indications that pedal-standing behavior was controlled by neither the removal of mixed-schedule stimuli nor the production of discriminative stimuli. To the extent that

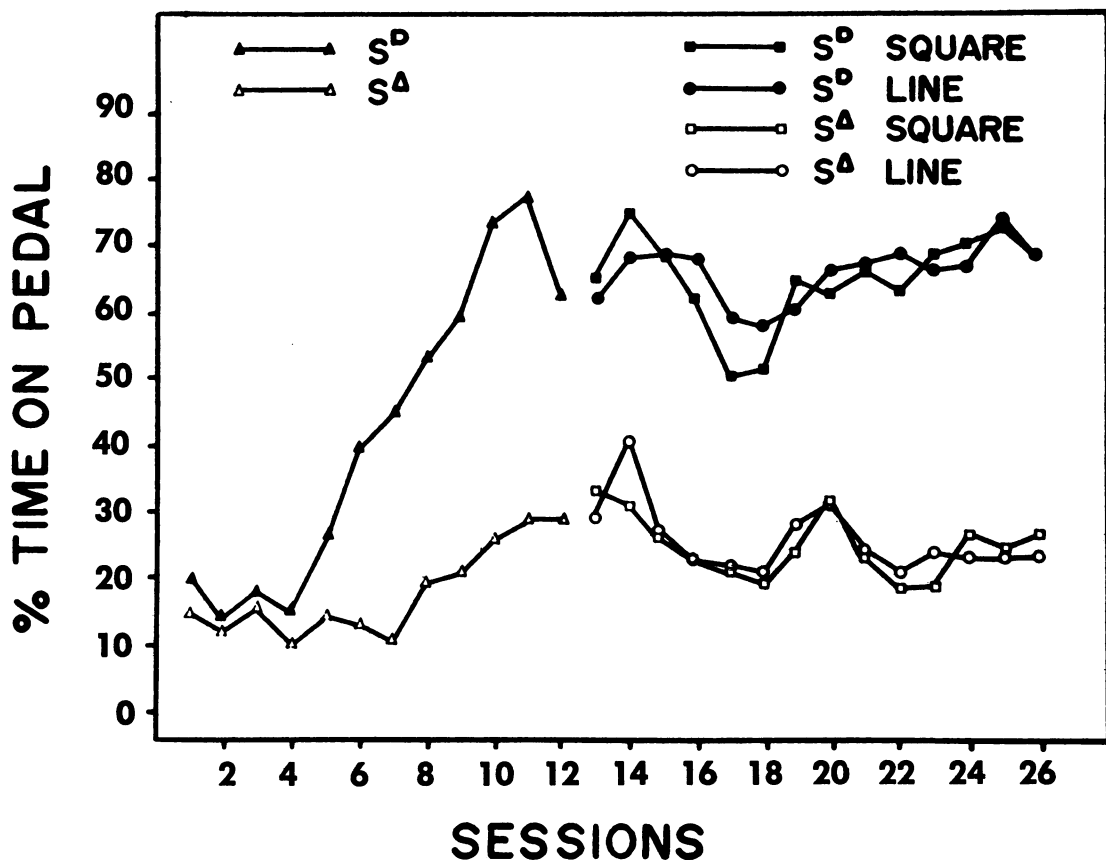


Fig. 4. Mean per cent time on the pedal during discrimination training (Sessions 1 to 12) and observing response training (Sessions 13 to 26) in Experiment 2. Filled and open triangles indicate mean per cent time on the pedal during exposure to S^D and S^A . Filled squares and circles indicate per cent time on the pedal when S^D replaced a small black square (SQUARE) or a diagonal line (LINE). Open squares and circles indicate corresponding time on the pedal when S^A replaced the square and the line.

pedal-standing time is controlled by factors other than the production of discriminative stimuli, Wyckoff's (1951) results appear to be an artifact of his pedal-standing measure. A suggestion in Experiment 1 of a correlation between key-response rates and observing behavior was supported. Furthermore, emergence of a difference in S^D and S^A pedal-standing time after the establishment of a key response discrimination during Sessions 1 to 12 suggested a dependence of pedal pressing on key responses.

EXPERIMENT 3: WYCKOFF'S DIFFERENTIAL AND NONDIFFERENTIAL DISCRIMINATION EXPERIMENT—A REPLICATION

Experiment 2 provided additional evidence that pedal-standing behavior was independent

of both the removal of the mixed-schedule stimulus and the production of discriminative stimuli. Experiment 3 explored further the relationship between key-response rates and amount of pedal-standing time under conditions that more closely approximated Wyckoff's procedure. Experiments 1 and 2 departed from Wyckoff's procedure in several ways. First, Experiments 1 and 2 used nine and 12 sessions, respectively, to establish a baseline, while Wyckoff provided only 45 min of preliminary training. The extended training showed the development of a correlation between key-response rates and time on the pedal, a development that could not be demonstrated using Wyckoff's procedure. However, the extended preliminary discrimination training could have seriously impaired subsequent control of pedal standing by discriminative

stimuli. Second, the multiple trial procedure used in Experiment 1, and to a lesser extent in Experiment 2, could have favored decreased control of pedal standing by the discriminative stimuli. Finally, sessions in Experiments 1 and 2 were conducted daily, as compared to every other day in the Wyckoff study. While the possible effect of this variable could not be predicted, neither could it be discounted.

Three methods of recording, not employed by Wyckoff, were used in the present experiment to establish a clearer basis for evaluating the relationship between key-response rates and pedal-standing time. Observing responses were recorded separately during S^D and S^A as in Experiments 1 and 2. Key responses to mixed- and multiple-schedule stimuli were also recorded separately, as in Experiment 2. Key responses to mixed-schedule stimuli were further separated in the present experiment into positive and negative periods.

METHOD

Subjects and Apparatus

Five experimentally naive male homing pigeons were maintained at about 80% of their free-feeding weights. The apparatus was the same as in Experiment 2. Additional counters recorded key responses to mixed-schedule stimuli during positive and negative periods.

Procedure

Wyckoff's (1951) procedure was followed as closely as possible. After magazine and key-peck training over three days, as in the previous experiments, the birds received a preliminary conditioning session of 45 min. In this session, the birds were trained to peck a white, red, or green keylight. During the first 15 min, the key was white continuously. For the remaining 30 min, the key was red or green for 30-sec intervals. A response at the end of a 30-sec interval was reinforced half of the time under each color. Observing responses had no consequence at this time.

All birds then received six sessions of observing response training (Wyckoff's differential discrimination training) in which pedal standing converted a *mix* FI 30-sec EXT schedule to a *mult* FI 30-sec EXT schedule. Fixed-interval components alternated randomly with 30-sec EXT components according to a sequence derived from Wyckoff (1951). Pedal

standing replaced the white key with either a red (S^D) or a green (S^A) key for the duration of the component as long as the pedal was depressed. The first response at the end of the FI component was reinforced whether or not the pedal was depressed. The end of the EXT component was followed immediately by the next component without an intervening blackout. Each component appeared 75 times in a session. The experiment was terminated with six sessions of nondifferential discrimination training in which reinforcement occurred equally often in the presence of the red and green keylights. Each bird was run on alternate days. On intervening days the birds were weighed and fed.

RESULTS

Only two of the five birds acquired the color discrimination. Figure 5 (upper panels) presents the key-response rate over differential (Sessions 1 to 6) and nondifferential (Sessions 7 to 12) discrimination training sessions for these two birds. Differential responding was clearly established to S^D and S^A in the first session. Differential responding to the mixed-schedule stimuli associated with S^D and S^A was also evident but considerably weaker. Differential responding deteriorated for both birds under nondifferential discrimination training. Bird 9 showed a gradual loss in $S^D - S^A$ differentiation as well as an overall decline in response rate. Bird 11 showed an immediate loss in differentiation with no consistent decline in overall responding. The relatively weak differentiation of mixed-schedule response rates established during differential training disappeared under nondifferential training. For both birds, an overall increase in response rates to the mixed-schedule stimuli under nondifferential training appeared when response rates to S^D and S^A were decreasing.

Figure 5 (lower panels) shows the per cent time on the pedal for the two birds that acquired the color discrimination. Both birds showed differential pedal standing to S^D and S^A , as in Experiments 1 and 2. This differentiation appeared without the extensive pre-training associated with previous experiments. Nondifferential training eliminated differential pedal standing, slowly in Bird 9 and rapidly in Bird 11. The decrease in overall pedal-standing time for each bird was similar to the pattern observed in key-response rates.

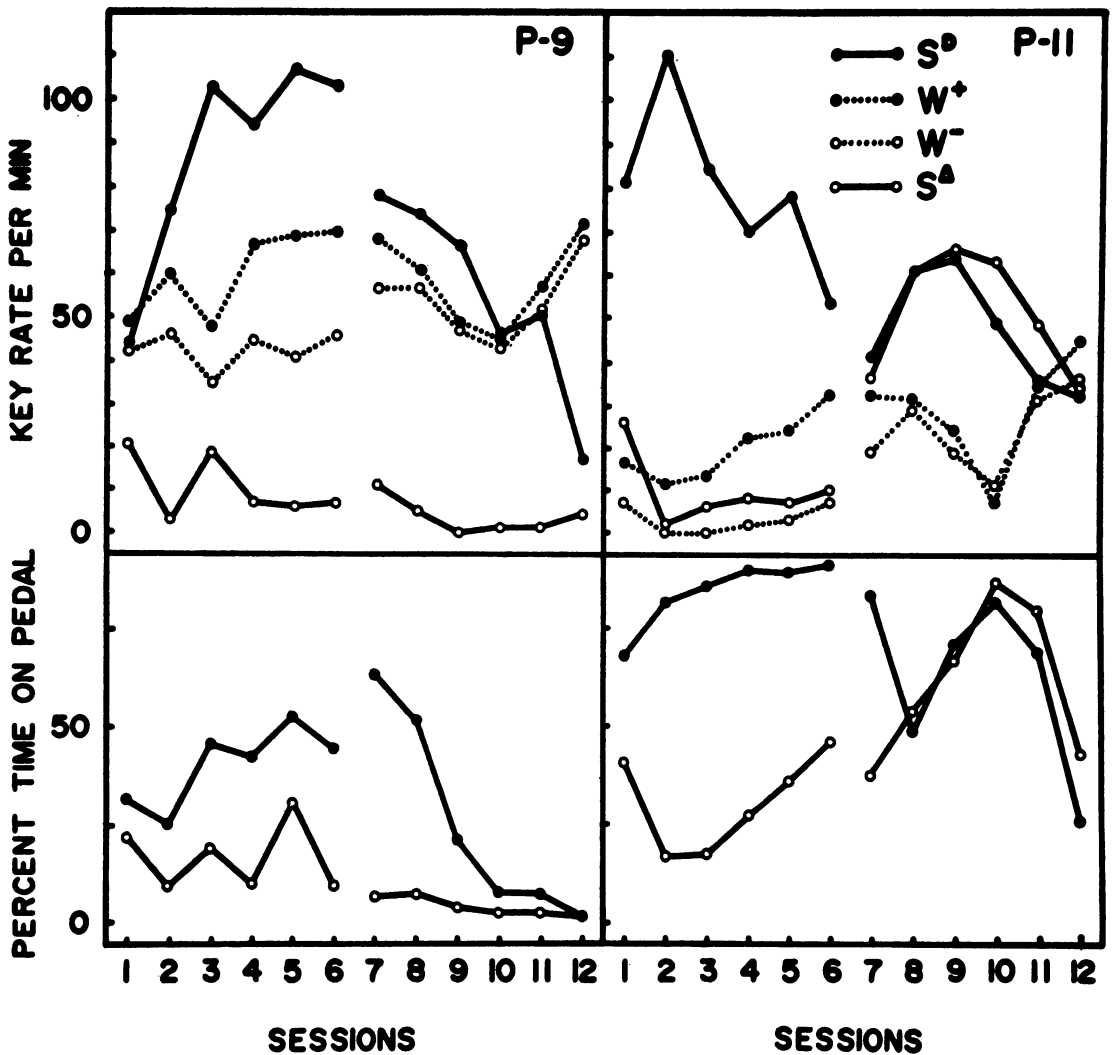


Fig. 5 Mean key-response rates (upper panels) and mean per cent time on the pedal (lower panels) during differential (Sessions 1 to 6) and nondifferential (Sessions 7 to 12) training in Experiment 3 for the two birds that acquired the color discrimination. Filled and open circles (solid lines) indicate key-response rates and per cent time on the pedal during S^D and S^A. Dotted lines in Sessions 1 to 6 indicate key-response rates to the mixed-schedule stimulus (white keylight) during positive (W⁺) and negative (W⁻) periods. Dotted lines in Sessions 7 to 12 indicate key-response rates to the mixed-schedule stimulus during nondifferential training.

Figure 6 presents the performance of the three birds that did not acquire the color discrimination. The upper panels indicate the key-response rates to both mixed- and multiple-schedule stimuli across differential and nondifferential training. Response rates to mixed-schedule stimuli were generally higher than the rates to S^D and S^A for the three birds across all sessions. Response rates to mixed-schedule stimuli tended to increase across nondifferential training sessions. Key-response

rates to S^D and S^A dropped to near zero after Session 1 and did not recover for Birds 8 and 10. The performance of Bird 12 suggests the formation of a color discrimination during Sessions 5 and 6 and even during Sessions 7, 8, and 9 under nondifferential training. The lower panels of Figure 6 show the percentage of pedal standing time for Birds 8, 10, and 12 across differential and nondifferential training sessions. Virtually no time was spent on the pedal by any of the three birds. Some caution

is required in assessing the acquisition of a color discrimination by Bird 12 in the upper panel in light of the small amount of pedal standing. The key-response rates to S^D in Sessions 6 and 7 by Bird 12 were based on 15 responses in 0.32 min and 17 responses in 0.24 min, respectively.

DISCUSSION

The results of Experiment 3 suggest that the operant level of pedal standing at the beginning of training plays a crucial role in the development and maintenance of a key-response discrimination. When the amount of pedal-standing time was low (below 25% for Birds 8, 10, and 12), exposure to the color stimuli was minimal. Consequently, reinforcement was more likely to occur during a key peck to the mixed-schedule stimulus. Once the mixed-schedule stimulus controlled a relatively high response rate, stepping on the pedal was unlikely because the stimulus controlling a high response rate would be replaced by a stimulus controlling a low response rate. Since exposure to S^D and S^A would be infrequent under these conditions, the color discrimination would not be learned. When the operant level of pedal standing was initially high (above 25% for Birds 9 and 11), key responses would be reinforced more frequently in the presence of S^D and S^A and less frequently during exposure to the mixed-schedule

stimuli as compared to Birds 8, 10, and 12. Consequently, the color discrimination would be learned.

The above interpretation suggests that the proportion of time on the pedal is not a measure of the strength of observing behavior and is, instead, a measure of where the bird is standing when a key response is made. The particular location of the pedal in relation to the key was selected by Wyckoff (1951) so that "the base level of pedal pressing would be high enough to ensure discrimination formation but low enough so that increases in pedal pressing would occur". The present results indicate that for some of the birds, the base level was not high enough. This problem was also encountered by Zeigler and Wyckoff (1961) in a simultaneous discrimination experiment using two keys and two pedals in a single experimental chamber. Four of eight birds failed to solve a series of six problems even though the birds were given as many as 15 to 25 sessions on a single problem. In each case, the failure to learn a discrimination was attributed to a low level of pedal-standing time.

The acquisition of differential pedal standing appears to depend on the development of a key-response discrimination. The two birds that acquired the color discrimination also showed a difference in pedal-standing time, a difference that was absent in the other three birds. When a pedal response produced a

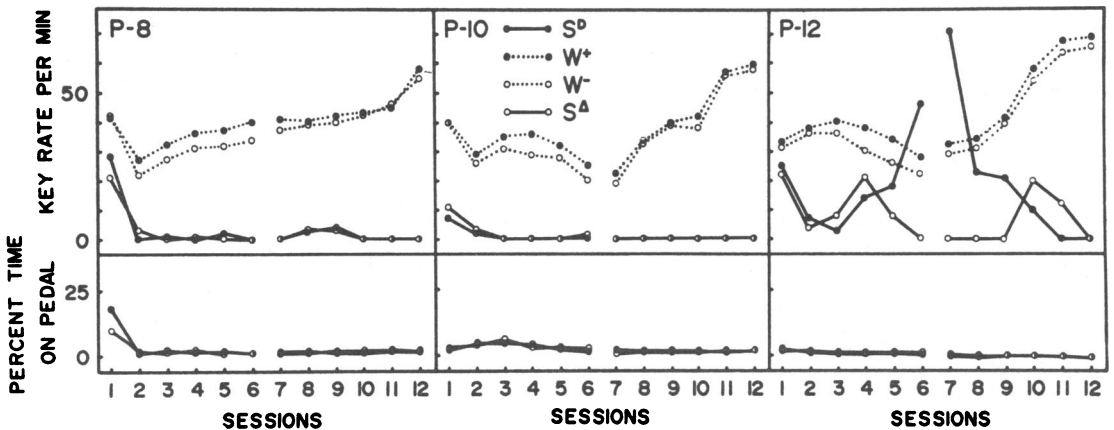


Fig. 6. Mean key-response rates (upper panels) and mean per cent time on the pedal (lower panels) during differential (Sessions 1 to 6) and nondifferential (Sessions 7 to 12) training in Experiment 3 for the three birds that did not acquire the color discrimination. Filled and open circles (solid lines) indicate key-response rates and per cent time on the pedal during S^D and S^A . Dotted lines in Sessions 1 to 6 indicate key-response rates to the mixed-schedule stimulus (white keylight) during positive (W^+) and negative (W^-) periods. Dotted lines in Sessions 7 to 12 indicate key-response rates to the mixed-schedule stimulus during nondifferential training.

stimulus controlling a high response rate (S^D), the pedal was depressed throughout most of the period. When a pedal response produced S^A , movement away from the key tended to occur. Because the pedal was located beneath the key, movement away from the key generally involved movement off the pedal.

When the color stimuli were made nondifferential with respect to reinforcement, differential pedal standing was attenuated. According to the present interpretation, the introduction of the nondifferential condition does not reduce the total average amount of pedal standing directly, but merely eliminates differential pedal standing. The decrease in the total amount of pedal standing would, instead, be related to an increase in key-response rate to the mixed-schedule stimuli. However, since the increase in key-response rate to the mixed-schedule stimuli would depend on the production of nondifferential reinforcement stimuli, there is an indirect relationship between the decrease in pedal standing and the introduction of the nondifferential condition. The failure of differential pedal standing to appear for the three birds that did not acquire the color discrimination is quite compatible with the interpretation that such differences depend on the acquisition of the key-response discrimination.

GENERAL DISCUSSION

Experiments 1 and 2 were designed to test the empirical prediction that the removal of the mixed-schedule stimulus in the Wyckoff observing response experiments was reinforcing. The results showed that neither the removal of the mixed-schedule stimuli nor the production of discriminative stimuli controlled the level of pedal standing. The results indicated that the total amount of pedal-standing time consisted of a large amount attributable to a high key-response rate and a small amount attributable to a low key-response rate. The results of Experiment 3 suggested that nondifferential training attenuates total pedal-standing time by reducing the overall key-response rate to pedal-produced stimuli and by increasing the overall key-response rate to mixed-schedule stimuli.

The present experiments suggest that the correlation between key-response rates and pedal-standing time occurs as a result of the

physical relationship between the key and the pedal. This interpretation of the relationship between key-response rates and pedal-standing time under differential and nondifferential training conditions presents a rather complex picture of the Wyckoff observing response effect. More direct evidence in support of the present interpretation would, of course, require the manipulation of the location of the pedal with respect to the key.

The results of the present experiments indicate two basic difficulties with Wyckoff's observing response measure. First, the initial level of pedal standing is not under experimental control in the Wyckoff experiments. Consequently, the birds may or may not acquire the discrimination. Second, Wyckoff's assumption that key responses and pedal-standing time are relatively independent of each other is not supported by the present results. Clearly, an alternative procedure is necessary to determine whether or not the removal of the mixed-schedule stimulus in observing response experiments is reinforcing. An alternative procedure, which minimizes the first problem, involves the use of a second key in place of the pedal. Kelleher (1958) and Kelleher, Riddle, and Cook (1962) showed that responses on one key, which produced discriminative stimuli on a separate food key, were maintained at a high level. Key responses that produced nondifferential stimuli, however, extinguished. These effects have been confirmed by numerous investigators (Kendall, 1965; Hendry and Dillow, 1966; Bower, McLean, and Meacham, 1966). The relatively high operant level required by Wyckoff's pedal response to establish a discrimination is avoided by using a two-key procedure. Furthermore, this procedure clearly demonstrates the differential-nondifferential observing response effect that appears to be an artifact in the Wyckoff experiments. The two-key procedure, however, does not resolve the second problem. Since a response on each key cannot occur simultaneously, the observing response and the food-reinforced response are not mutually independent. Kelleher *et al.*, (1962) and Kendall (1966) showed that observing responses occur more frequently immediately after reinforcement and are less likely to occur when reinforcement is imminent. The competing response interpretation favored by these investigators is clearly a function of the

two-key procedure, since the present experiments show that pedal-standing time is positively correlated with the response rate on the food key.

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