STUDIES OF OPERANT AND REFLEXIVE KEY PECKS IN THE PIGEON[1]

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The duration of pigeons' key pecks was studied in three experiments. Experiment I revealed that key pecks early in exposure to continuous reinforcement were of short duration, as were key pecks observed on an omission procedure in which pecks prevented food delivery. Key pecks later in exposure to continuous reinforcement, and those that occurred on positive automaintenance procedures, were of long duration. In Experiment II, pigeons were exposed to fixed-interval and fixed-ratio reinforcement schedules, and durations were recorded separately for each quarter of each interval or ratio. On fixed interval, durations were shorter in the first quarter of each interval than in subsequent quarters; on fixed ratio, durations were longer in the first quarter of the ratio than in subsequent quarters. These data parallel observations of concurrent operant responding and salivation in dogs. In Experiment III, pigeons were exposed to a discrete trial, differential-reinforcement-of-low-rate 6-sec schedule. Durations of responses in the first 2 sec of the trial were substantially shorter than those of responses that occurred later. The data from all three experiments support the view that the pigeon's "key peck" actually consists of two subclasses of peck, one reflexive and one operant.

Key words: peck duration, continuous reinforcement, omission, fixed interval, fixed ratio, differential reinforcement of low rate, pigeon

If the brief illumination of a response key predicts the occurrence of food, pigeons reliably peck the response key at high rates (positive automaintenance: Gamzu and Schwartz, 1973; Gamzu and Williams, 1971, 1973; Schwartz and Williams, 1972). Pecking is maintained even when key pecks prevent the delivery of food (omission: Schwartz and Williams, 1972; Williams and Williams, 1969). The phenomena of positive automaintenance and omission have provided clear evidence that the pigeon's key peck can be generated and maintained by Pavlovian, stimulus-reinforcer relations.

Two recent reviews (Hearst and Jenkins, 1974; Schwartz and Gamzu, 1977) have pointed to evidence of Pavlovian control of key pecking throughout the operant conditioning literature. This evidence raises a number of fundamental problems for traditional theories of conditioning. One of these problems is the putative distinction between reflexive and voluntary behavior. Pavlovian con-

ditioning principles have been taken to apply to the domain of reflexes, like salivation and heart rate. Operant conditioning principles have been taken to apply to voluntary responses, like lever pressing and key pecking. Though this distinction between reflexive and voluntary has never been overly secure (e.g., Kimble, 1961; Turner and Solomon, 1962), these phenomena add further uncertainty.

In an attempt to address the problem posed by automaintenance and omission for distinctions between reflexive and voluntary behavior, Schwartz and Williams (1972) suggested that the pigeon's "key peck", defined in terms of switch closure, might actually be composed of two distinct subclasses, one of which was reflexive, the other voluntary. They explored this possibility by measuring the duration of pigeons' pecks on a variety of procedures (cf. Wolin, 1968). They found that virtually all pecks that occurred on omission procedures were of short duration, i.e., less than 20 msec. On the other hand, whereas some pecks that occurred on operant reinforcement schedules were also of short duration, many were long, i.e., 40 msec or more. It seemed possible that short-duration pecks were reflexive while long-duration pecks were operant. An implication

was that short- but not long-duration pecks would be insensitive to their consequences. To test this implication, Schwartz and Williams (1972) reinforced either only short- or only long-duration pecks. As the pigeons were sensitive to the response-reinforcer dependency only in the latter case, duration appeared to distinguish two different kinds of key peck, one reflexive and one operant.

Though other evidence in support of this peck classification has been obtained (Schwartz and Gamzu, 1977; Schwartz, Hamilton, and Silberberg, 1975), some investigations have either failed to find appropriate duration differences (Warren, cited in Moore, 1973) or have suggested alternative interpretations of the effects reported by Schwartz and Williams (Hearst and Jenkins, 1974). The present series of experiments further explored key-peck durations.

EXPERIMENT I

Schwartz and Williams (1972) found that peck durations on omission procedures were short, and that peck durations on positive automaintenance procedures were both short and long. Indeed, distributions of peck duration on positive automaintenance were indistinguishable from distributions of duration on ratio and interval reinforcement schedules. In contrast, peck durations on continuous reinforcement (CRF) were short, like those on omission. It is not clear why pecks maintained by operant reinforcement (on CRF) should be of the same form as the putative reflexive pecks. Schwartz and Williams suggested that initially trained pecks, no matter what the procedure, would be reflexive. In this, they concurred with Moore's (1973) suggestion that the traditional procedure of shaping by successive approximation is a disguised form of autoshaping. Since the pigeons exposed to CRF in the Schwartz and Williams study were naive, and since their exposure lasted only eight, 50 reinforcement sessions, the observed short durations are consistent with the view that all early key pecks are reflexive and that operant pecks develop with continued exposure to operant contingencies. If this view is correct, one would expect that peck durations would grow longer with continued exposure to CRF. The present experiment explored this possibility by exposing pigeons to

CRF for prolonged periods. In addition, pigeons were exposed to positive automaintenance and omission procedures in an attempt to replicate the earlier findings.

METHOD

Subjects

Twenty-four, experimentally naive White Carneaux pigeons were maintained at 80% of free-feeding weights.

Apparatus

Four identical pigeon chambers (R. Gerbrands Co. Model G 7313) each housed a three-key pigeon panel. The keys were normally closed (R. Gerbrands Co.) and required a force of 0.1N and an excursion of approximately 0.5 mm to operate. They were spaced 7.5 cm apart, center-to-center, and were located directly below the center key, 5.5 cm above the grid floor. A pair of houselights was located in the center of the ceiling of the chamber. Scheduling of experimental events, data collection, and data analysis were accomplished with PDP8/E digital computer (Digital Equipment Corporation). Response durations were recorded, in 5-msec classes, by timing the interval between the break and remake of the normally closed contacts of the response key. All response-dependent events were produced by the remake, and not the break of the key.

Procedure

The pigeons were trained by hand to eat from the feeder. On the day following feeder training, they were trained, again by hand, to peck the center key for grain. No pigeon emitted more than 20 key pecks on this training day. On the day following key-peck training, the experimental procedures were instituted. The pigeons were exposed, in squads of four, to a continuous reinforcement procedure (CRF). The center key was illuminated with white light, and each key peck operated the feeder for 4 sec, illuminating lights in the feeder and extinguishing the houselights and keylight at the same time. Each of the 24 daily sessions included a total of 50 reinforcements.

At this point, the pigeons were divided into two groups of 12. One group was exposed to a fixed-trial positive automaintenance procedure. In each trial, the center key was illumi-

nated for 6 sec and followed by feeder operation for 4 sec. Each session consisted of 50 trials separated by a variable (geometrically distributed) intertrial interval (ITI) with a mean of 40 sec. Key pecks, though counted, had no scheduled consequence. The second group was exposed to an omission procedure. Trials were the same as in the fixed-trial positive automaintenance procedure. However, a key peck during the trial prevented food delivery at the end of the trial. After 14 sessions of these procedures, the groups were reversed for another 14 sessions. Finally, all 24 pigeons were returned to CRF, for 14 additional sessions. Throughout all procedures, key-peck durations were recorded in 5-msec class intervals.

RESULTS AND DISCUSSION

Figures 1 and 2 present median response durations for each pigeon. Data are averaged across the first and last five sessions of the first exposure to CRF, and across the last five sessions of each subsequent procedure. For 22 of the 24 pigeons, responses early in CRF training had a median duration over the first five sessions of less than 20 msec. By the end of CRF, median duration was greater than 30 msec for 14 of the pigeons. In addition, the median had lengthened by at least 10 msec for 20 of the pigeons. Response durations on positive automaintenance were slightly longer than on CRF. The median duration was greater than 30 msec for 18 of the pigeons. In contrast, on omission, median duration was less than 20 msec for 19 of the pigeons. This duration difference was independent of whether the omission procedure preceded (Figure 1) or followed (Figure 2) the positive automaintenance procedure. Finally, when the pigeons were returned to CRF, median durations were once again long. For 16 pigeons, the median was greater than 30 msec; for 20 pigeons, median duration was at least 10 msec longer than on the omission procedure.

Figures 3 and 4 present relative frequency distributions of duration for four of the pigeons. Data are taken from the same sessions as the medians in Figures 1 and 2. For all four pigeons, there was a clear similarity between omission responding and responding early in CRF. Durations on positive automaintenance matched those from late on CRF.

The present data suggest that the predominance of short-duration pecks on CRF is restricted to early exposure to the schedule. When experienced pigeons are exposed to a CRF procedure, response durations are long. Thus, long-duration responses are not necessarily a function of intermittent reinforcement, as suggested by Hearst and Jenkins (1974).

The data also raise a number of questions:

1. Why are responses early in CRF of short duration? First, it is possible that the response-reinforcer relation is not well learned early in training, so that many pecks are "around the key", but not directly at it. As a result, some key contacts may be glancing and/or weak. This account leads to the expectation of substantial spread in the duration distribution early in CRF—more than would be observed when the pigeons were well trained. As Figures 3 and 4 reveal, the reverse is true. A second possibility is that early key pecks, whether hand shaped or autoshaped, are controlled by Pavlovian, stimulus-reinforcer relations. The fact that early key pecks are both short in duration and relatively narrowly distributed, supports this account. It may be that the development of sensitivity to and control by even an accidental Pavlovian contingency precedes the development of control by an operant contingency.

2. Why are responses on positive automaintenance of long duration? Since the positive automaintenance procedure is Pavlovian, it would appear that pecks should be of short duration. A possible reason for long-duration pecks is that key pecks initially occur because of the Pavlovian, stimulus-reinforcer relation, but they are followed closely in time by food. Thus, there is an adventitious response-reinforcer contingency in a positive automaintenance procedure that is explicitly eliminated in the omission procedure. This adventitious relation may be responsible for the development of long-duration key pecks. Evidence to support this account was reported by Schwartz and Gamzu (1977). Pigeons exposed to a positive automaintenance procedure made short-duration pecks early in training. After a number of sessions, durations grew longer, like those observed in the present experiment. However, some of the pigeons had been exposed to a prior procedure that prevented the development of an adventitious peck-rein-
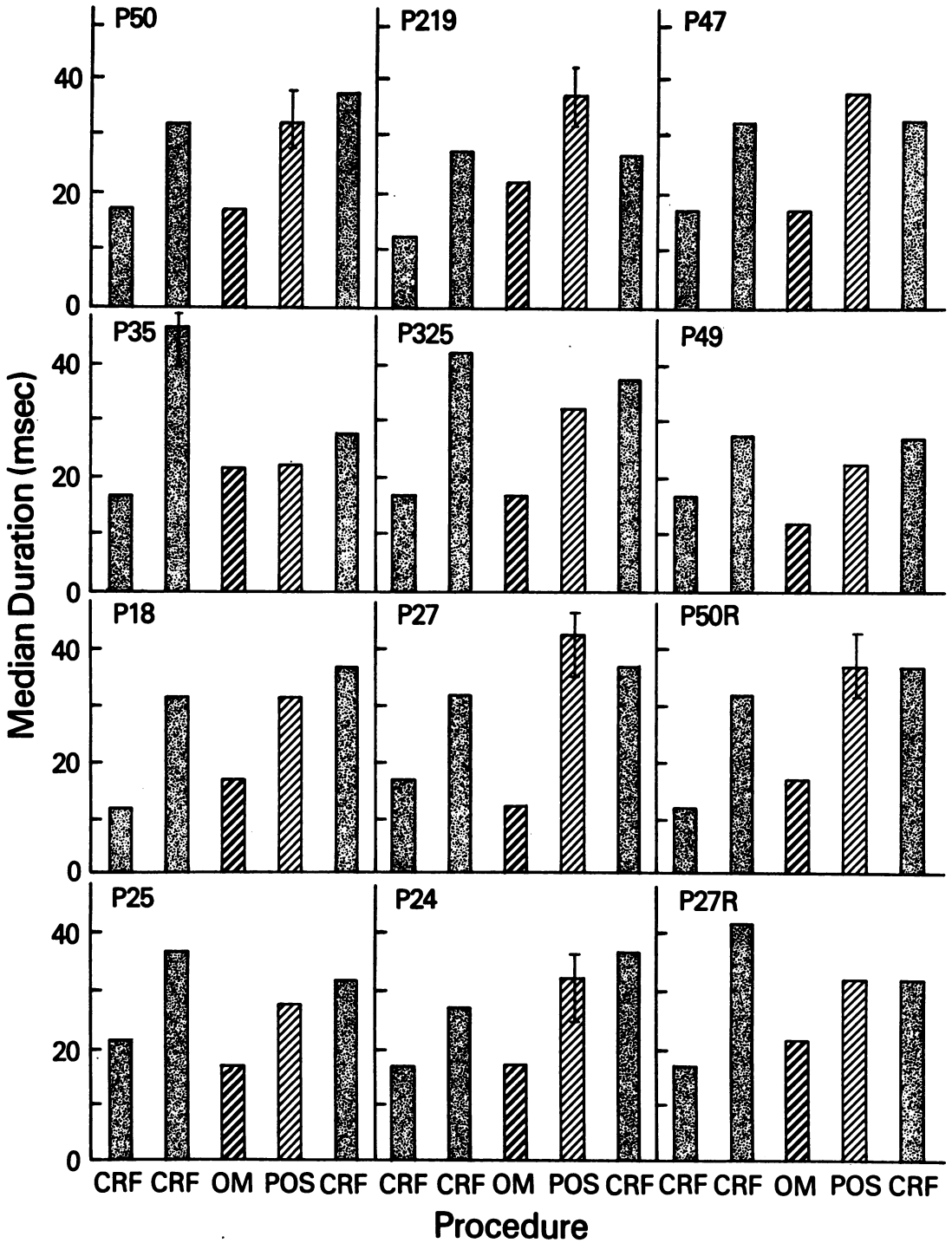
Fig. 1. Median response duration in each procedure of Experiment I for each of 12 pigeons. The procedures are identified on the abscissa (in the order in which they were presented). Data are averaged across the first five sessions of exposure to CRF, the last five sessions of exposure to CRF, and the last five sessions of exposure to the other procedures. Crossed vertical lines indicate the range of daily medians from the sessions from which the overall median was computed. For all bars without indicated ranges, the range was one class interval (5 msec).
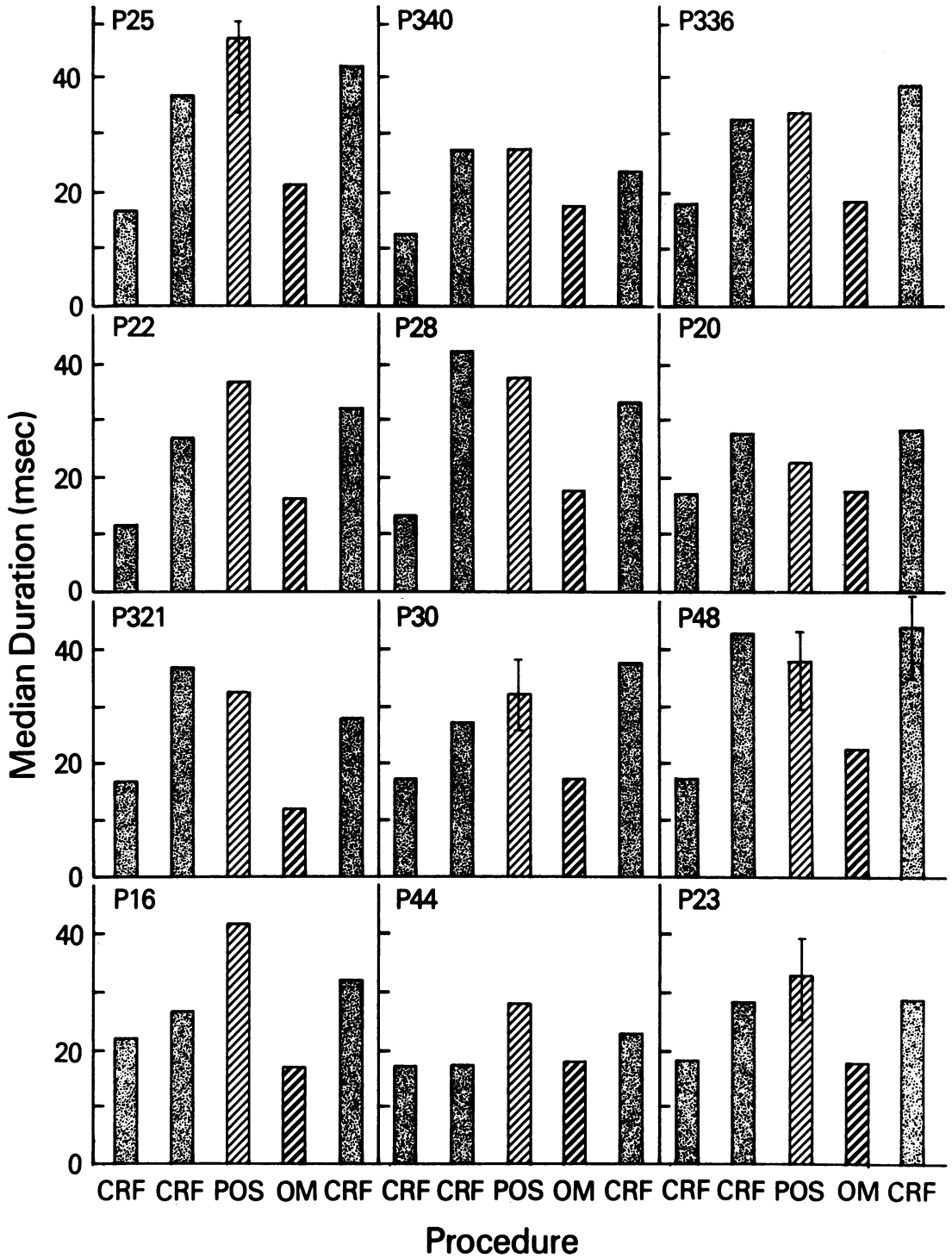
Fig. 2. Median response duration in each procedure of Experiment I for each of 12 pigeons. See legend of Figure 1 for details.
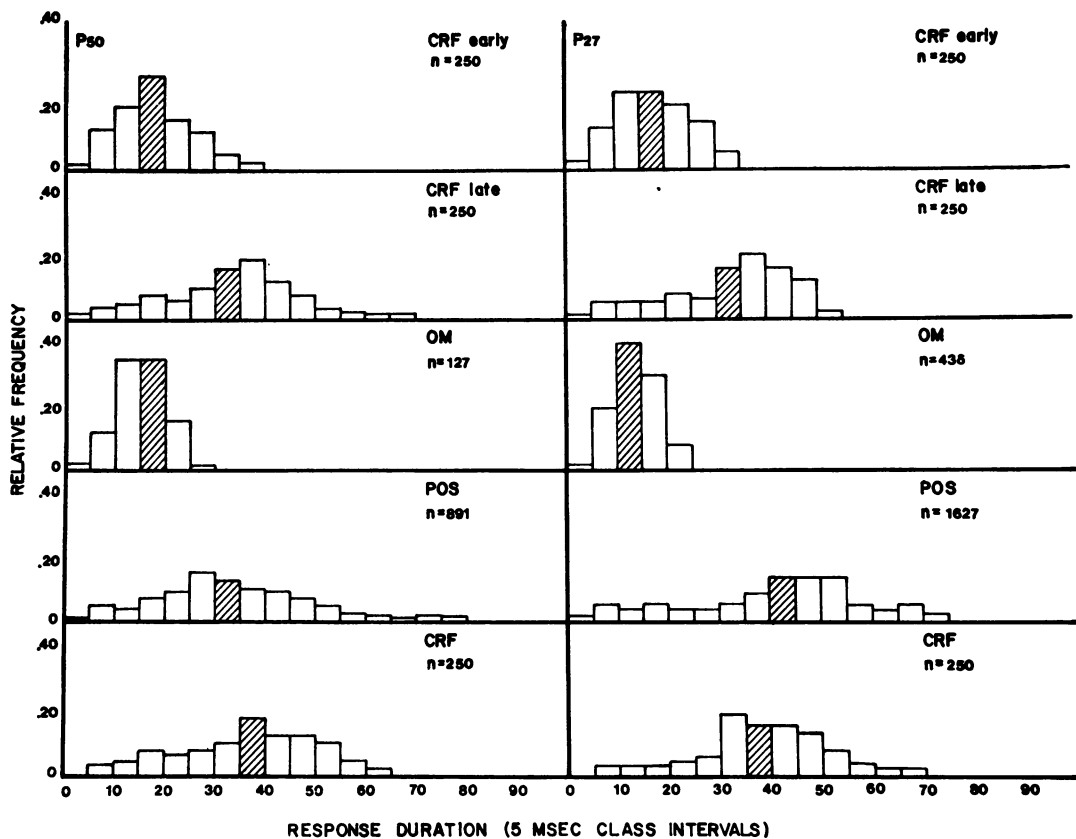
Fig. 3. Relative frequency distributions of duration for two pigeons. Data are presented for the same sessions whose medians are depicted in Figure 1, and hatched bars indicate the medians of the distributions. The number of responses represented in each distribution is also indicated.

forcer relation. These pigeons, when exposed to many subsequent sessions of positive auto-maintenance, never made long-duration responses.

In summary, the present data are consistent with both the data and the interpretation of Schwartz and Williams (1972).

EXPERIMENT II

In 1965, Williams reported a series of experiments with dogs in which panel pushing was maintained by either fixed-ratio or fixed-interval schedules of food reinforcement, and salivation was measured concurrently. With ratio schedules, the onset of salivation in any interreinforcement interval lagged substantially behind the onset of operant responding. In contrast, when the dogs were responding on interval schedules, salivation and operant responding tended to co-originate, or, in some

instances, salivation tended to precede operant responding. The present view of short- and long-duration key pecks would treat the short-duration peck as functionally equivalent to salivation in the dog. If this is the case, then based on Williams' findings, one would expect that:

1. When key pecking is maintained on ratio schedules, response durations early in the ratio should be longer than response durations later in the ratio. This duration difference would reflect the absence of reflexive pecks early in the ratio.

2. When key pecking is maintained on interval schedules, response durations early in the interval should be shorter (if different at all) than response durations later in the interval. This duration difference would reflect the fact that reflexive pecks precede or co-originate with operant pecks on interval schedules.

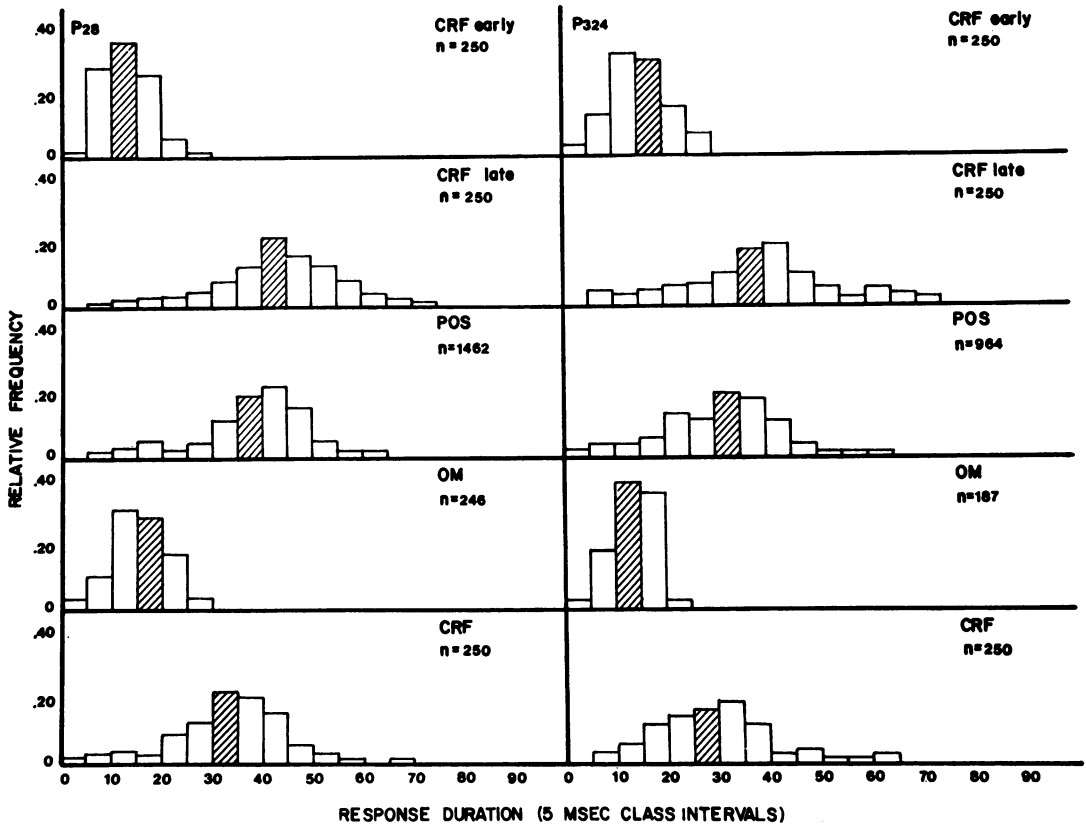Experiment II tested these possibilities by

Fig. 4. Relative frequency distributions of duration for two pigeons. See legend of Figure 3 for details.

exposing pigeons to interval and ratio schedules and collecting response durations separately for each quarter of each ratio or each interval.

METHOD

Subjects

Eight pigeons from Experiment I, chosen at random, were maintained at 80% of free-feeding weights.

Apparatus

The apparatus was the same as in Experiment I.

Procedure

The pigeons were divided into two groups and exposed to fixed-ratio or fixed-interval schedules in daily sessions providing 50 reinforcements. Four pigeons were exposed to a fixed-ratio 40 (FR 40) schedule. Every fortieth response produced 4-sec access to food. The FR 40 was approached gradually over three sessions, with rate of approach determined

separately for each pigeon. The other four pigeons were exposed to a fixed-interval 1-min (FI 1-min) schedule. Reinforcement delivery depended on a single response at least 1 min after the preceding reinforcement. The pigeons experienced one session of FI 15-sec and one session of FI 30-sec before exposure to the FI 1-min schedule. After 28 daily sessions, the groups were reversed, and after an additional 28 sessions they were returned to their original schedule for 28 sessions. Then, the pigeons originally exposed to FR 40 were switched to FI 2-min, and those originally exposed to FI 1-min were switched to FR 80. After 28 sessions, the groups were again reversed for 28 final sessions.

Response durations (in 5-msec classes) were recorded separately for each quarter of the FI and FR schedules. Thus, on FI schedules, distributions of duration were obtained for each 15-sec period (or 30 sec on FI 2-min), and on FR schedules, distributions of duration were obtained for each 10 responses (or 20 responses on FR 80). The last FI response,

which occurred after the interval had elapsed, was not included in the analysis.

RESULTS AND DISCUSSION

Figure 5 presents median durations separately for each quarter of each FI or FR. The data are cumulated across the last five sessions of each procedure. On FI, the median duration for the first quarter was generally shorter than the median for subsequent quarters. A difference of at least 5 msec was observed in every case but one (P 18's second exposure to FI). Differences of 10 msec or more were observed in 10 of 20 FI exposures. Median duration in quarters of the FI after the first tended to be uniform. If there was any trend over the course of the entire interval, it was for durations to grow longer. There was no difference in durations between FI 1-min and FI 2-min.

On FR, the pattern differed. With some exceptions, median duration was longer in the first quarter of the FR than in subsequent quarters. In six of 20 cases, the difference in

duration was 5 msec; in seven cases, the difference was 10 msec or more. As in the case of the FI, duration over the remainder of the ratio was uniform, and no difference was observed between FR 40 and FR 80. With regard to variability, in only eight of 160 possible cases (one for each bar) was the range of medians from the sessions from which overall medians were composed larger than one class interval (5 msec).

Thus, the observed pattern of durations was consistent with expectations based on Williams' (1965) findings: pecks early in the FI were shorter than pecks later in the FI, and pecks early in the FR were longer than pecks later in the FR. The observed differences were small. However, when the pattern of durations on FI is compared to the pattern of durations on FR, the effect seems large and reliable. Comparison of first-quarter median duration between Procedures 2 and 3 and between Procedures 4 and 5 yields 16 comparisons. In 12 of these cases, differences in duration in the expected direction (FR longer than FI)
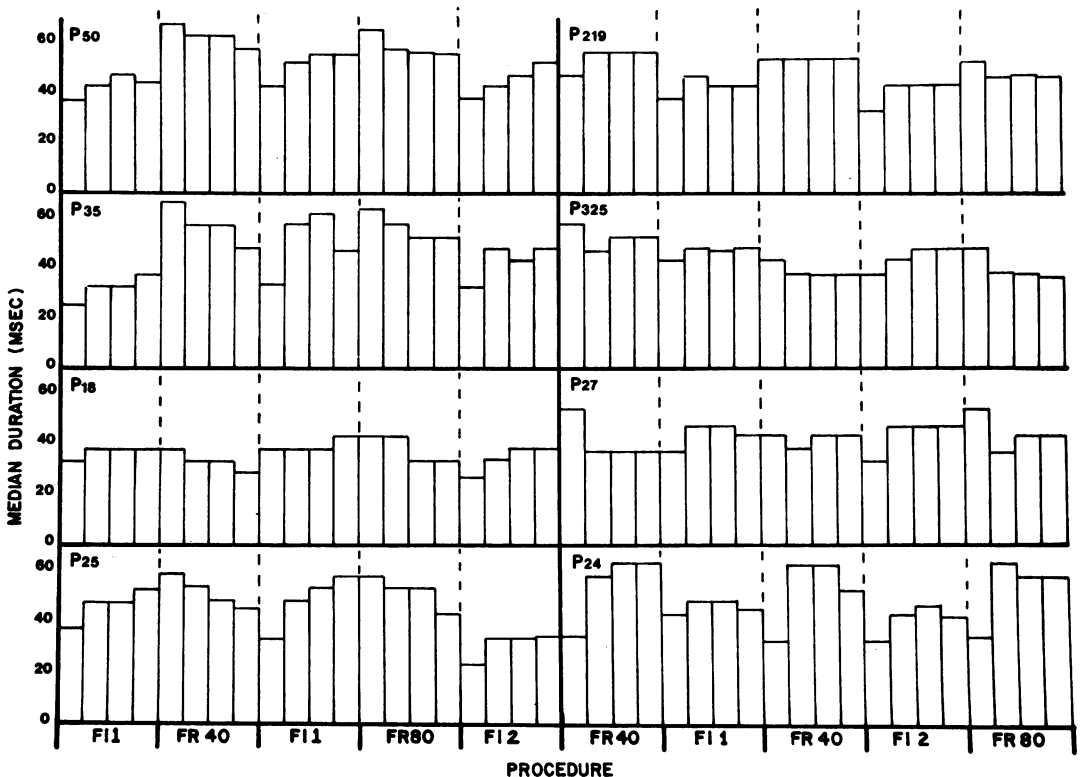

Fig. 5. Median response duration for each quarter of the FI and FR schedules employed in Experiment II. Data are averaged across the last five sessions of each procedure, and the procedures are identified on the abscissa.
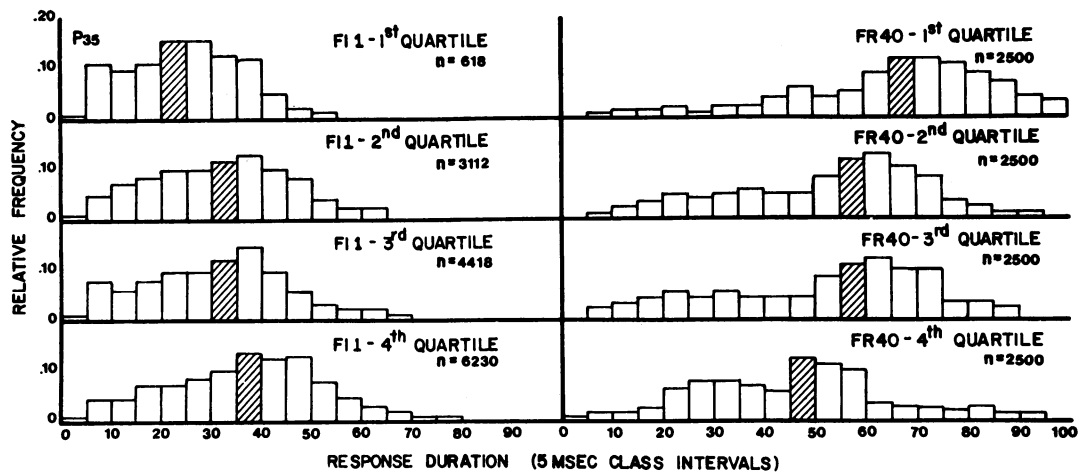
Fig. 6. Relative frequency distributions of duration for one pigeon on FI 1-min and FR 40 schedules. Data are averaged across the last five sessions of each of the first two procedures to which the pigeon was exposed, and distributions are presented separately for each quarter of the interval or ratio. Hatched bars indicate medians of the distributions; the number of responses represented by each distribution is also indicated.

were obtained. The size of those differences was 10 msec (twice), 15 msec (three times), 20 msec (twice), 25 msec (twice), 30 msec (twice), and 35 msec (once).

Relative frequency distributions of duration for two pigeons are presented in Figures 6 and 7. The data are averaged across the last five sessions of the first exposure to the FI and FR schedules. For both pigeons, the shape of the duration distribution from one quarter to the next did not change appreciably. The distribution was simply shifted to the left (in the case of FI) or to the right (in the case of FR) during the first quarter. Comparison of dura-

tions between FI and FR revealed a substantial difference for P35, but no appreciable difference for P27. For other subjects, FR durations tended to be longer than FI, but the effects were small and inconsistent.

The observed differences in duration might stem from differences in response rate under the FR and FI schedules. Mean rates of responding in each quarter of the FI 1-min and FR 40 schedules (from first exposure to each) are presented in Table 1. Fixed-ratio response rates were computed by recording the time between the first and tenth, eleventh and twentieth, twenty-first and thirtieth, and
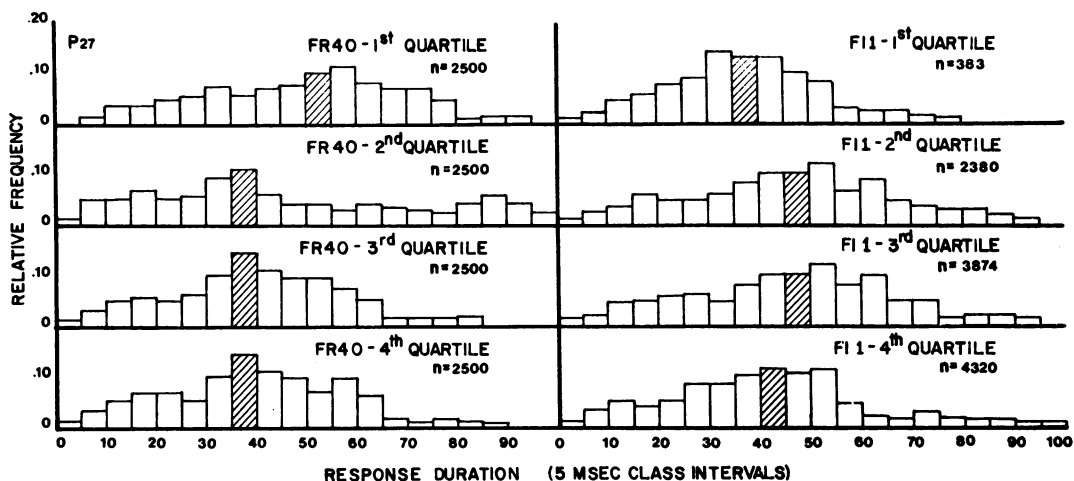

Fig. 7. Relative frequency distributions of duration for one pigeon on FR 40 and FI 1-min. See legend of Figure 6 for details.

Table 1

Average response rate in each quarter of the FI 1-min and FR 40 schedules for each pigeon. Data are averaged across the last five sessions of each procedure. Response rates in the first quarter of the FR schedule are computed from the occurrence of the first response. Response rates in the first quarter of the FI schedule are computed both from the termination of the previous reinforcement, and from the occurrence of the first response (in parentheses). This latter measure was obtained by subtracting the total postreinforcement pause time in a session from 750 sec (15 sec times 50 intervals).

Pigeon	FI 1-min				FR 40			
	1st Q	*2nd Q*	*3rd Q*	*4th Q*	*1st Q*	*2nd Q*	*3rd Q*	*4th Q*
50	2.4(14.4)	18.2	39.4	56.4	50.2	50.4	51.2	54.2
35	10.0(38.7)	50.2	71.3	99.5	74.5	80.2	79.8	81.4
18	6.1(20.3)	24.8	49.2	62.3	66.7	65.2	65.8	67.0
25	5.8(31.1)	30.1	40.4	58.0	48.4	49.6	49.7	50.4
219	9.4(18.6)	42.2	49.6	62.2	42.3	46.4	46.0	47.2
325	3.2(11.0)	14.6	41.3	78.1	82.2	88.4	84.2	88.0
27	6.2(31.9)	38.4	62.5	69.7	61.3	68.8	69.2	68.6
24	7.1(17.4)	28.1	55.4	77.0	74.5	74.2	75.0	76.1

thirty-first and fortieth responses of each ratio. Thus, postreinforcement pauses were not included in the computation. The FI response rates were computed for each 15 sec of the interval, thus including postreinforcement pauses. To facilitate comparison of FR and FI response rates, the total session FI pause time was subtracted from the total session time spent in the first quarter of the FI (750 sec: 15 sec x 50 intervals). Response rates thus derived are presented in parentheses in Table 1. Response rate was substantially lower early in the FI than early in the FR. However, while FR rate remained stable throughout the ratio, FI rate increased until, by the last quarter (expect Pigeons 18 and 325), response rates on FI were equal to or higher than those on FR. If response duration were an artifact of response rate, one would expect to observe increases in duration from quarter to quarter of the FI. As Figure 5 indicates, these increases were not observed. In the case of FR, given constant response rate, one would expect to find no difference in duration from quarter-to-quarter of the ratio, an expectation contradicted by the data. Thus, while it is possible that differences in response rate contribute to differences in duration, they cannot play the major causal role.

The present data are consistent with Williams' (1965) report of the relation between salivation and panel pushing on ratio and interval schedules in dogs. If short-duration responses are analogous to salivation, and long-duration responses are analogous to an arbitrary operant like panel pushing, the present findings indicate that reflexive pecks are more likely to occur early in interval schedules than early in ratio schedules.

EXPERIMENT III

The previous experiment indicated that some responding on interval and ratio schedules may not be under the control of the operant contingency. Instead, short-duration pecks may be influenced by the temporal regularity of food delivery. These data raise an immediate question about the contribution of these nonoperant pecks to the phenomena of schedule control. Would performances maintained by schedules of reinforcement look different if the nonoperant pecks were factored out? This question was investigated by exposing pigeons to a differential-reinforcement-of-low-rate (DRL) schedule. This schedule provides reinforcement only for responses separated by a specified minimum amount of time. There is evidence that pigeons are a good deal less efficient on DRL schedules than are other species (Kramer and Rilling, 1971), despite their capacity to discriminate intervals of time (e.g., Stubbs, 1968). Schwartz and Williams (1971) found no evidence of mastery of a DRL 6-sec schedule after 69 sessions. Hemmes (1975) showed that the pigeon's inefficiency can be eliminated by establishing treadle hopping, rather than key pecking, as the required operant. The present experiment explored whether peck durations on discrete-trial DRL schedules might indicate the presence of nonoperant responses. Short-latency DRL key

pecks, like omission pecks, might be non-operant, *i.e.,* of short duration, while long latency DRL pecks might be operant, *i.e.,* of long duration.

METHOD

Subjects

Four pigeons from Experiment I, chosen at random, were maintained at 80% of free-feeding weights.

Apparatus

The apparatus was the same as in Experiment I.

Procedure

The subjects were exposed to a discrete-trial DRL 6-sec schedule. After a variable intertrial interval (ITI) with a mean of 30 sec, the center key was illuminated with white light. A peck on the key within the first 6 sec terminated the trial without reinforcement. A peck on the key 6 to 12 sec after the trial began, terminated the trial with 4-sec access to grain. After 12 sec without a response, the trial terminated without reinforcement. Thus, the DRL schedule included a 6-sec limited hold. There were 90 trials in each daily session, and the procedure was continued for 132 sessions.

RESULTS AND DISCUSSION

Figure 8 presents latency distributions over the last 10 sessions for each pigeon. Not only did the pigeons obtain a substantial proportion of the possible reinforcements, but there was clear evidence of temporal control even in trials in which key pecks were premature. However, in addition to making responses that were clearly under temporal control, each pigeon made a substantial number of very short-latency responses. Responses with latencies of 2.0 sec or less accounted for 27% of the total for P340, 12.5% for P28, 14% for P30, and 12% for P44. These short-latency responses should not be confused with the short inter-response-time (IRT) responses frequently observed with *free-operant* DRL procedures (*e.g.,* Blough, 1963; see Kramer and Rilling, 1971 for a review). These responses may be the result of response "bursts"; in the discrete-trial procedure, only a single response can occur on any trial. The observed short-latency responses are nearly identical in latency to
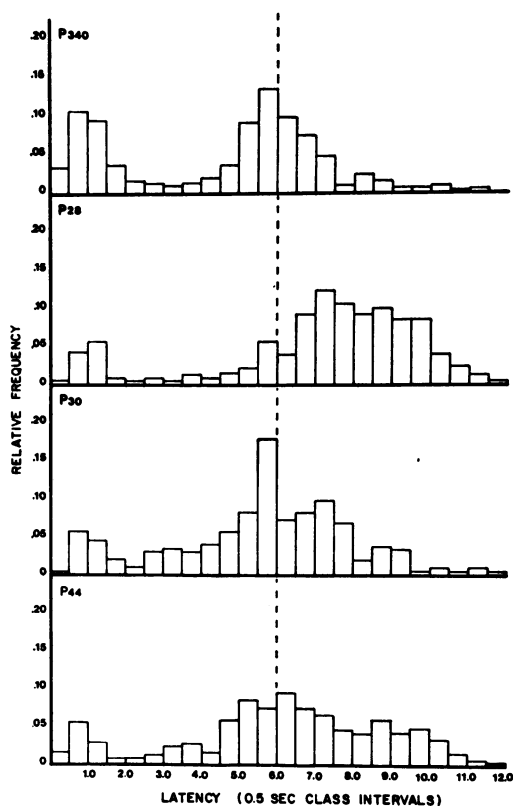

Fig. 8. Latency distributions across the last 10 sessions of exposure to the DRL schedule. All latencies to the right of the dashed, vertical line were reinforced.

responses observed on omission procedures. Williams and Williams (1969) reported that most responses on omission procedures occurred within the first 2 sec of the 6-sec trial. If short-latency DRL responses are controlled, as are omission responses, by the stimulus-reinforcer relation, they should be of short duration (see data from omission procedures in Figures 1 to 4). The relevant data are presented in Figure 9. Median durations across the last 10 sessions of the experiment are presented separately for responses with latencies between 0 and 2 sec, between 2.5 and 6 sec, and between 6.5 and 12 sec. The median duration of short-latency responses was less than 20 msec for all four pigeons, while the median duration of longer latency responses was between 30 and 45 msec. There was no difference in duration between intermediate and long-latency responses.

Relative frequency distributions of duration for one pigeon are presented in Figure 10. Short-latency responses were not only shorter
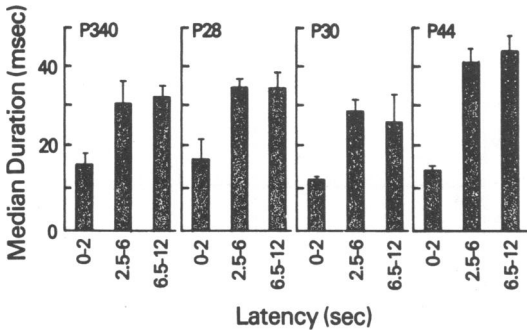
Fig. 9. Median durations of responses with latencies shorter than 2.0 sec, of 2.5 to 6.0 sec, and of 6.5 to 12 sec, averaged across the last 10 sessions of exposure to the DRL. Crossed vertical lines indicate the range of daily medians from the sessions from which the overall median was computed.

in duration than long-latency responses, but were also much more narrowly distributed. Comparison of Figure 10 with Figures 3 and 4 reveals a clear similarity between short-latency DRL durations and omission durations, and between long-latency DRL durations and positive automaintenance and CRF durations.

In contrast to some earlier work with discrete-trial DRL schedules (Schwartz and Williams, 1971) the present pigeons mastered the DRL. The major difference between the pres-
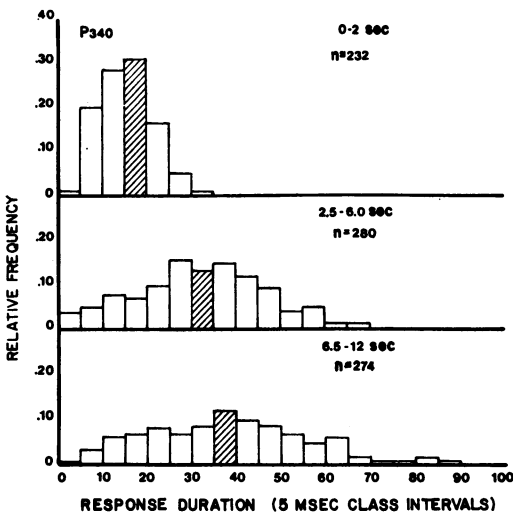

Fig. 10. Relative frequency distributions of duration for 0- to 2-sec latency, 2.5- to 6.0-sec latency, and 6.5- to 12-sec latency responses for a single pigeon. Data are averaged across the last 10 sessions of the experiment. Hatched bars indicate medians of the distributions; number of responses represented by each distribution is also indicated.

ent experiment and (Schwartz and Williams, 1971) is that in their study, pigeons were exposed to a total of 69, 50-trial sessions, or 3450 trials; in the present study, the pigeons received 132, 90-trial sessions, or 11,880 trials. In fact, there was little sign of DRL efficiency in the present experiment by the fortieth session. Other studies of discrete-trial DRL performance in pigeons have also obtained efficient performance after prolonged exposure to DRL (Catania, 1970).

GENERAL DISCUSSION

The present series of experiments provides data consistent with the data and conclusions offered by Schwartz and Williams (1972). The major results of these experiments are:

(1) There are at least two classes of key peck, distinguishable on the basis of duration. One class, of short duration, seems reflexive, and insensitive to its consequences; the other class, of long duration, seems operant, and controlled by its consequences.

(2) All key pecks early in training are short duration. Continued exposure to an operant contingency results in development of long-duration responses. Exposure to procedures, like omission, which prevent the development of a positive response-reinforcer correlation, prevents development of long-duration pecks (Schwartz and Williams, 1972), and eliminates them if they have already developed.

(3) The temporal distribution of short-duration pecks within a fixed-interval or fixed-ratio schedule is similar to the temporal distribution of salivation in dogs exposed to similar schedules.

(4) Short-latency responses on discrete-trial DRL schedules are of short duration; responses that are under the control of the temporal contingency are of long duration.

These data cannot be readily explained in terms of variables such as intermittency of reinforcement, rate of pecking, or conflicting tendencies to peck and not to peck, which result in weak or glancing key contacts. Together with other data on peck duration (Schwartz and Gamzu, 1977; Schwartz, Hamilton, and Silberberg, 1975; Schwartz and Williams, 1972) the data provide persuasive evidence that some of the pigeon's key pecks are reflexive, i.e., under Pavlovian control, and that others are operant.

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