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**DIFFERENTIAL REINFORCEMENT OF PERCHING DURATION
IN THE PIGEON: A COMPARISON WITH
DIFFERENTIAL-REINFORCEMENT-OF-LOW-RATE KEY-PECKING**

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ABSTRACT

Pigeons were required to jump on a perch and sit on it for a specified duration before stepping off, in order to gain access to food. This duration was progressively increased by 1-sec steps. Median response duration approximated the required response duration up to values of 40 or even 50 sec and efficiency remained high. Response duration distributions had sharp peaks and comparable dispersions throughout the critical values range. These results contrast with the performance of the same birds in a conventional differential-reinforcement-of-low-rate schedule involving a key-peck response. This indicates that pigeons are able to regulate in time their own motor behaviour over much longer time intervals in the case of a perching response than in the case of key-pecking.

Key words: differential reinforcement of response duration; differential reinforcement of low rate; pigeon.

Pigeons have been found to perform poorly under schedules of differential reinforcement of low rates (DRL) when the critical delay exceeds 15 sec or so (Staddon, 1965). In terms of efficiency ratio, RF/R (reinforced responses divided by total responses) or of mean or median interresponse time (IRT), their performance compares with that of mice (Maurissen, 1970), but is typically inferior to that of rats (Ferraro, Schoenfeld and Snapper, 1965) cats (Macar, 1969, 1971), monkeys (Weiss, Laties, Siegel and Goldstein, 1966) or, among avians, crows (Powell, 1972, 1974). This limited capacity for temporal regulation of behaviour does not seem to reflect, however, a general deficiency in time estimation. Pigeons have been successfully

trained to discriminate the duration of external events, in particular visual stimuli, as long as 40 sec (Stubbs, 1968). The discrepancy between the performances observed in these two kinds of situation might be due to the difficulty encountered by pigeons in regulating their own motor responses according to temporal constraints, as opposed to the supposedly easier task of attending to some external stimulus and then making a judgement about its duration.

Another possible explanation, however, would relate the performance of pigeons in a key-peck DRL schedule with grain reinforcement to the characteristics of the pecking response in the species-specific repertoire. Indeed, in the pigeon, pecks for food are emitted at high rates. Furthermore, the high degree of similarity between the key-peck and the consumatory response evoked by the reinforcement has already been pointed out (Jenkins and Moore, 1973). Converting pecking into an operant response would not free it from its characteristics as a typical behaviour unit in food searching and eating activities. Properties of key pecking would reflect the frequency, duration and strength of natural pecks (Staddon, 1972; Schwartz, 1977; Topping, Pickering and Jackson, 1971), food presentation being a more potent factor than schedule contingencies.

Pigeons trained to press a treadle under DRL schedules performed more efficiently – that is, a higher proportion of responses were reinforced – than when key-pecking was used (Hemmes, 1975). The gain was mainly due, however, to an increase in dispersion of their IRTs' distributions, with many IRTs greatly exceeding the critical value. This is poor evidence of temporal control (Richardson and Clark, 1976). But lever pressing with the foot is a difficult movement for birds. It might be advisable to look for a more convenient alternative to key-pecking.

In the present experiment, perching was used as the operant (Bastian and Hothersall (1970) already described a perch-hop fixed ratio (FR) performance in passerine birds). Perching is, like key-pecking, both a simple and a natural behaviour. Pigeons were trained to jump on a perch and sit on it for a minimal period of time (critical duration) in order to obtain a reinforcement. These contingencies might be more properly defined as a schedule of differential reinforcement of response duration (DRRD) rather than DRL. The same individuals were trained under a classical DRL schedule using a key-pecking response, allowing comparison between performances obtained under the two conditions.

METHOD

Subjects

Four naive homing pigeons, about six months old at the beginning of the experiment, were maintained at 90% of their free feeding weight. They were housed in individual cages in the animal room.

Apparatus

The conditioning chamber used in the study of the perching response was a cubicle ($50 \times 50 \times 50$ cm) equipped with a metal perch protruding 16 cm from the rear wall and located 13 cm above the floor. A weight of 180 g (considerably less than a pigeon's weight) sufficed to depress the perch and close a circuit through a microswitch located behind the cage wall. A Gerbrands grain dispenser was accessible on a side wall for 5 sec whenever a reinforcement was due. The experiment was controlled by integrated circuits. The pigeon's performance was also recorded on a 6-channel pen-recorder and by means of electronic counters, giving the distribution of response durations in 12 time fractions, each of which corresponded to one-sixth of the critical duration. Control and recording equipment was located in an adjacent room.

A control experiment involving a key-pecking response took place in a conventional conditioning chamber ($40 \times 40 \times 40$ cm). The illuminated key (2 cm in diameter) was located 20 cm above the floor, 14 cm above the magazine aperture. Food presentation lasted 4 sec, that is, 1 sec less than in the perching duration condition. This difference made the real access to food approximately equal since, in the latter case, the bird had to walk to the food dispenser from the place where it stepped down from the perch, whereas it stood directly in front of the food aperture when it pecked on the key.

Procedure

All subjects were first run in the perching duration schedule and then in the DRL key-pecking condition.

Differential reinforcement of perching duration. After habituation to the experimental enclosure, the birds were trained to produce the perching response and then exposed to a continuous reinforcement schedule (limited to 25 reinforcements), without any temporal requirement, for a further three sessions. Then, the minimal duration of the perching response was specified: the food dispenser was operated only if the bird stepped down off the perch after the critical duration had elapsed. The minimal duration (initially 1 sec) was increased by 1-sec steps every 4th session up to the point where efficiency dropped to less than 10%. However, the subjects were maintained for 15 sessions instead of 3 at the 30-sec, 40-sec and (for bird P5 only) 50-sec requirements. Sessions lasted until 25 reinforcements had been obtained and they took place twice a day (except for the very last sessions, where efficiency dropped severely) at approximately the same hour, six days a week.

Differential reinforcement of low rates of key-pecking responses. After the perching study was completed, birds were transferred to a conventional DRL schedule, using the key-peck as a response, to make sure that their performance in the perching duration schedule did not simply reflect an unusually good timing capacity. After shaping of the response, the critical delay was increased, as in the first part of the experiment, by 1-sec steps every 4th session. Sessions were limited to

25 reinforcements or 1 hr duration (because of the poor performance of the birds). This control experiment was terminated after the critical delay of 20 sec was reached, since the efficiency ratio was less than 5%. In other respects, the procedure was the same as in the perching duration experiment.

The efficiency ratio (number of reinforced responses/total number of responses) and the median response duration for successive values of the critical duration were computed from the recorded data. Relative frequency distributions of response durations in successive time fractions (six below and six above the critical value) were derived from the absolute frequencies. Data from the key-pecking were treated in the same manner, interresponse time being substituted for response duration.

RESULTS

One of the four subjects did not show any evidence of adjustment to the temporal contingencies and its results have been discarded from the following analysis.

Perching duration

In the other three subjects, the duration of perching was clearly controlled by the schedule requirements, the median response duration approaching the critical value up to 46, 43 and 54 sec for birds P2, P4 and P5, respectively. This is illustrated in Figure 1 in which the median response durations have been plotted as a function of the critical values for each individual bird. A few points have been selected for the sake of clear presentation. Data for 30, 40 and 50 sec were averaged from the last five sessions of 15 sessions run on each of these values of the critical duration. Other points are based on 3 sessions.

Temporal control was further evidenced by the distributions of response durations along the time continuum. For all values of the critical duration, the relative frequency distributions were characterized by central tendency indices close to the critical value, with comparable dispersion throughout the critical values range. This is further evidenced when considering the ratio between median perching duration and semi-interquartile range of perching duration. At 30, 40 and 50 sec, this ratio was 0.151, 0.151 and 0.154, respectively, for bird P5. At 30 and 40 sec, bird P4 had ratios of 0.158 and 0.129, and bird P2 ratios of 0.142 and 0.131 respectively (other points were not considered because of the small number of sessions at each step). Samples of response duration distributions are shown in Figure 2. Points were obtained from 3 or 5 sessions (at 30, 40 and 50 sec) as in Figure 1. It is clear from the shape of these distributions that the reinforced responses were not accidental by-products of long perching, but the result of precise timing of behaviour. The high efficiency of behaviour is also clearly apparent from Figure 2. The ratio of the number of reinforced responses to the total number of responses (or efficiency ratio) remains above 0.20 up to 40 sec in P4 and up to 50 sec in P5. Bird P2's performance was extremely stable, with an efficiency ratio remaining at or

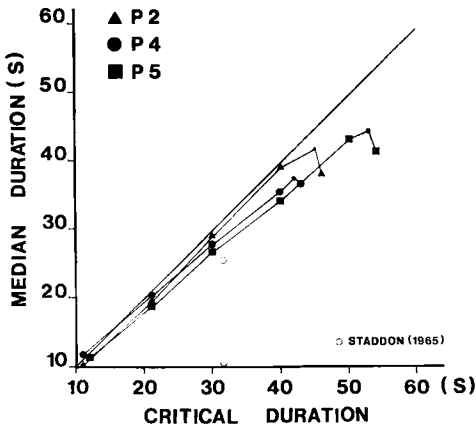


Fig. 1. Median duration of the perching response as a function of the critical duration for each individual bird. Points for 30, 40 and 50 sec on the abscissa were averaged from the last five sessions (out of a total of 15 sessions). Points for other values were averaged from 3 sessions. Results from individual birds under key-peck DRL, from Staddon (1965), have been plotted for comparison.

above 0.40 for all critical values up to 45 sec. These results contrast with the performance classically described for pigeons spacing their key-pecks under DRL contingencies. In order to rule out the possibility that the subjects were, by chance, exceptionally gifted with respect to timing capacity, they were submitted to a control experiment using key-pecking.

Key-pecking DRL

The results are summarized in Figures 3 and 4, which parallel Figures 1 and 2, respectively, except that the scales of the abscissa and ordinate in Figure 3 are different, and that every data point is obtained from 3 sessions. Our birds did not perform better than those of previous experiments using key-pecking in DRL contingencies. The median IRT does not coincide with the critical value even at 5 sec, and it deviates further and further from the critical value as the latter increases to 10, 15 and 20 sec. Bird P2, which showed median perching duration very close to the critical duration up to 40 sec showed no evidence of temporal control of key-pecking. The efficiency ratio dropped from initial values between 0.10 and 0.20 at 5 sec to values below 0.05 at 20 sec. By the criterion used to stop the perching experiment, the DRL study should have been interrupted after the 15-sec critical delay.

Interresponse time distributions (Figure 4) provided further evidence of the poor temporal control of key-pecking, that fades out at critical delays of 15 sec.

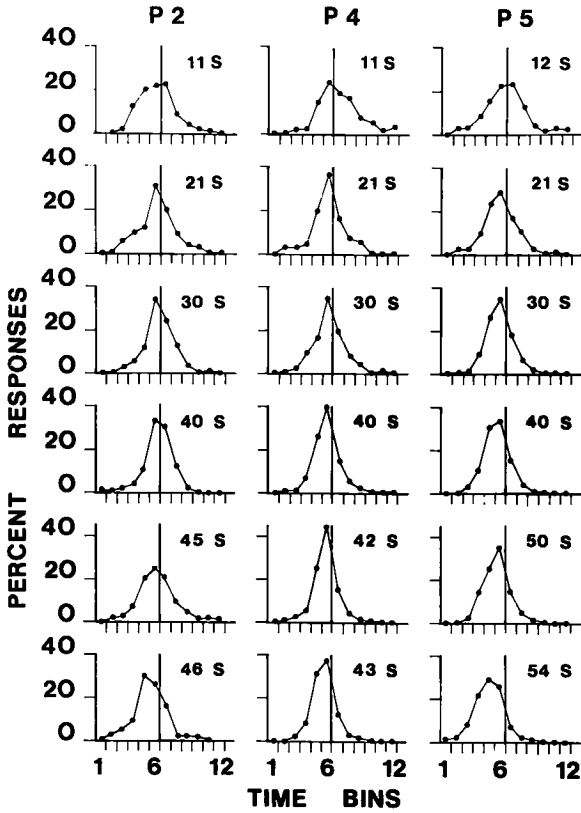


Fig. 2. Relative frequency distributions of response duration for 3 individual birds (columns), at increasing values of critical duration (top to bottom). Response durations in the first 6 time bins (left of vertical line) were not reinforced. Those in the 7th bin and above (right of vertical line) were reinforced. Each time bin corresponds to one-sixth of the critical duration. Data points obtained as in Figure 1.

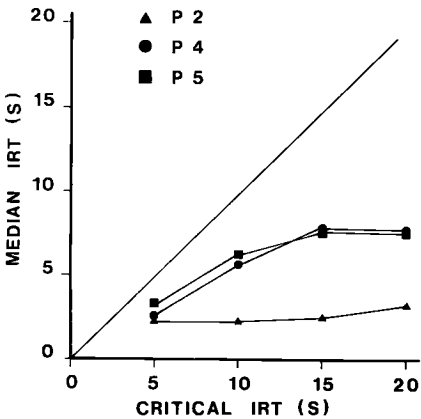


Fig. 3. Median IRTs as a function of the critical delay for each individual bird under DRL contingencies (key-pecking). Data were averaged from 3 sessions at each value of the critical delay.

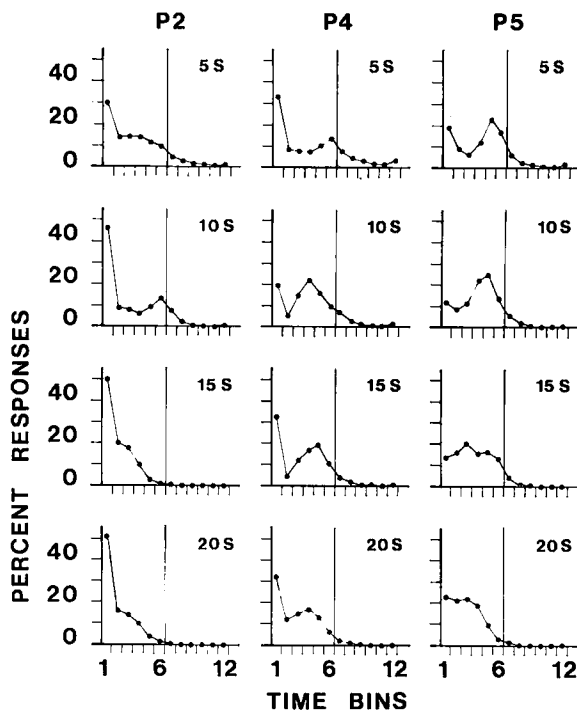


Fig. 4. Relative frequency distributions of IRTs for 3 individual birds (columns) at increasing values of critical DRL delay (top to bottom). Vertical lines separate unreinforced (left) from reinforced (right) IRTs. Data points obtained as in Figure 3.

DISCUSSION

Key-pecking is amenable to operant control, with respect to both duration and interpeck interval. Key-peck duration is sensitive to reinforcement to within a few tens of milliseconds (Schwartz and Williams, 1972; Whipple and Fantino, 1980; Zeiler, Davis and De Casper, 1980; Zirix and Silberberg, 1978). Interpeck interval is also effective as an operant, but our results and other reports show a discrepancy between emitted IRTs and DRL schedule requirement when the latter exceeds 15 or 20 sec (see Kramer and Rilling, 1970, or Richelle and Lejeune, 1980, for reviews). Efficient performances at higher DRL values (of about 30 sec) have also been reported (Hemmes, Eckerman and Rubinsky, 1979; Staddon, 1965); however, these are exceptions, or may be related to the particular experimental history of the subjects (Hemmes et al., 1979). The results of the present experiment demonstrate that perching duration, another motor behaviour, can be regulated in time far beyond the limits described above (the contrast with key-peck duration reinforcement is the more striking). Perching would be amenable to the temporal control

described here presumably because it is not linked with food-seeking or eating activities which impose on pecking a natural 'rhythm' counteracting the spacing requirement of a DRL. The quality of timing observed with a perching response is also considerably better than with treadle pressing (Hemmes, 1975): the relative frequency distributions of perching duration testify to a very precise temporal control, while IRTs in treadle pressing studies exhibit large dispersions (see distributions shown by Richardson and Clark, 1976, and Mantanus, Julien and Pitz, 1977). One might speculate that the status of perching behaviour in the natural repertoire, where it is linked with rest and sleep, would favour the kind of inhibitory control involved in response duration schedules. However, before accounting for the observed performance exclusively in terms of the nature of the response, one should point to some procedural differences between the differential reinforcement of response (perching) duration and conventional DRL (pecking) schedules and put the possible influence of these factors to experimental test. In the perching duration situation, the subject initiates a trial by jumping on to the perch, while each key-peck in a classical DRL terminates the previous trial and initiates the next one, leaving no 'free' interval between successive periods of time estimation. Timing is a continuous process in the latter case, while it is a discrete exercise in the first. The two situations would be closer to each other if two keys, A and B, were used, with a peck on A initiating the trial (as jumping on the perch does) and a peck on B terminating it (as stepping off does). Adding a key-pecking requirement to the perching response would take us one step further toward similarity: in both cases, a peck on A would initiate a trial and a peck on B terminate it. In between, the 'perching bird' would have to sit on its perch, while the behaviour of the 'key-pecking bird' would not be subject to such restrictions. Perching would become a constraint on collateral behaviour. On the basis of our results, it would paradoxically be predicted that perching would have an improving rather than degrading effect on timing as usually observed or inferred when restriction is imposed on collateral activities (see, for example, Laties, Weiss and Weiss, 1969).

The abrupt deterioration of performance with critical durations between 40 and 55 sec (depending on the individual) deserves further attention. This phenomenon should be explored with reference to the properties of spontaneous perching behaviour, still to be described.

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