

362
87
82-025

FIXED INTERVAL PERFORMANCE IN TURTLE DOVES: A COMPARISON WITH PIGEONS AND RATS

HELGA LEJEUNE and MARC RICHELLE

Laboratory of Experimental Psychology, University of Liège, 32 boulevard de la Constitution, 4020 Liège, Belgium

(Received 6 April 1981)

(Accepted 13 November 1981)

ABSTRACT

Turtle doves, pigeons and rats were trained on fixed-interval (FI) 2, 4, 6, 8- and 10-min schedules. Response rates were, at each FI value, higher in both bird species. They decreased as FI value increased in rats and pigeons. Rats' curvature indices were in all cases superior to those of birds, and the turtle doves differed significantly from pigeons at 2, 4 and 6 min. Curvature indices decreased in rats and increased in birds (except for 2 turtle doves) as the FI value increased. These results question the traditionally assumed cross-species generality of performance in FI schedules.

Key words: inter-species comparison; turtle dove; pigeon; rat; fixed-interval schedule.

Little attention has been given, until recently, to species differences in the patterning of operant behaviour by schedules of reinforcement, once believed to exert such a strong control over an organism's response as to cancel out species-specific constraints (Skinner, 1956). However, closer inspection of classical data, together with recent comparative studies have revealed quantitative or qualitative differences between members of different species. In this respect, contingencies typically generating temporal regulation of behaviour, such as fixed-interval (FI) or Differential Reinforcement of Low Rates (DRL) are especially interesting, since cross-species comparisons might help us in understanding the timing mechanism(s) involved and, eventually, in relating them to biological periodicities observed under other conditions.

Given the sensitivity of schedule-controlled behaviour to a number of variables, conclusive evidence cannot be drawn from results obtained in various species in separate experiments, usually run under somewhat different conditions in spite of the use of the same schedule and the same temporal parameters. In a few recent studies, members of two different species have been run under rigorously identical conditions. For instance, Lowe and Harzem (1977) have compared the performances of rats and pigeons under FI and fixed-time (FT) contingencies; Richardson and Loughhead (1974) have compared the performances of the same species under DRL schedules, and Powell (1974) has compared the performances of pigeons and crows under DRL schedules. The differences observed have been assigned either to differences between the response used and their peculiar status in the species' repertoire, or to the position of the species being considered on the phyletic scale. In order to delineate the origin of species differences in temporally regulated behaviour, it would seem advisable to compare species closely related to each other zoologically, using an operant response of identical topography. Major differences in performance observed in such cases would question the evolutionary hypothesis, relating the quality of adjustment to time to the species' position on the phyletic scale (see Richelle and Lejeune, 1980, for details).

The present study compares the behaviour of turtle doves and pigeons under FI schedule, with key pecking as the operant. This comparison was extended to rats, a classical point of reference in operant studies. Turtle doves (*Streptopelia risoria*) are close to homing pigeons (*Columba livia*) zoologically, both being members of the Columbidae family. They have been very rarely used as experimental subjects in conditioning studies, though they are easy and cheap to keep, and can be very easily trained to peck a key. Bayes (1972, 1975), on the basis of his own successful attempts, asserts that they recommend themselves as a convenient alternative to pigeons in the operant laboratory.

METHOD

Subjects

The subjects were four adult male rats (Wistar strain), four homing pigeons and four domestic turtle doves (*Streptopelia risoria*). They were kept in individual cages in the animal room and were maintained at 90% of ad lib body weight throughout the experiment.

Apparatus

Two different kinds of conditioning chambers were used, each being appropriate to a given species. The rat cage (25 × 20 × 20 cm) was equipped with a lever protruding from the wall 3 cm above the floor, and with a pellet dispenser. A force of 25 g was enough to close the lever microswitch. The birds cages (40 × 40 × 40 cm)

were equipped with a Plexiglas response key (2 cm in diameter) and a grain dispenser located on the same wall. Both the key and the dispenser were illuminated from behind the wall by a 60 W bulb. The key was located 20 cm from the floor in the pigeon cage, and 12 cm from the floor in the turtle dove cage. On the pigeon as well as the turtle dove key, a force of 20 g was enough to close a microswitch. The control (integrated circuits) and recording equipment was located in another room.

Procedure

All subjects were initially trained to produce the required response, lever-press for rats, key-peck for birds. They were maintained on a continuous reinforcement schedule for 1 session, and then exposed to FI contingencies, with the interval increasing by steps of 10 s from one session to the next up to 2 min. They were then trained for 40 sessions under FI 2 min, 30 sessions under FI 4 min, 30 sessions under FI 6 min, 40 sessions under FI 8 min, and 30 sessions at 10 min. The duration of the sessions was limited to 15 reinforced intervals up to FI 6 min and to 12 intervals at FI 8 and 10 min. The reinforcer consisted of one 45-mg pellet for rats, and 3-sec access to grain for birds.

Subjects were run in the experimental cages at approximately the same hour each day, 6 days per week. Responses and reinforcements were recorded by means of cumulative recorders. In addition, total number of responses emitted in each fourth of the interval were recorded on digital counters. Response rate and the curvature index (Fry, Kelleher and Cook, 1960), were computed from the recorded data. With the fixed interval subdivided into 4 fractions, the curvature index (I) may be computed as follows,

$$I = \frac{3R_4 - 2(R_1 + R_2 + R_3)}{4R_4}$$

with R_4 = total responses, R_1 = responses in the first fraction of the interval, R_2 = responses in the first two fractions of the interval, R_3 = responses in the first three fractions of the interval. As a general formula for dividing the fixed interval into n fractions, the equation is written as follows:

$$\frac{(n-1)R_n - 2\sum_{i=1}^{n-1} R_i}{nR_n}$$

RESULTS

The average overall response rate was computed for each individual subject and for each group, for the last ten sessions at each value of the interval from 2 to 10 min. Data are plotted in Figure 1. The group mean values displayed an inverse

relationship between the response rate and the length of the interval. Rats illustrate this relationship very clearly, individual results being within a very narrow range around the group mean value. Exceptions to the inverse relationship, as observed for turtle doves at FI 4 min and pigeons at FI 10 min probably reflect the much wider scatter and variability of individual performances in both bird species. For all values of the interval, turtle doves and pigeons exhibited higher response rates than did the rats. In no case was there any overlap between the mean response rates of the rats and the turtle doves, and rarely between the mean rates of the rats and the pigeons (visual observation indicated that the low recorded response rate of pigeon P2 (under FI 2 min was essentially due to off-key pecking). Except at the FI 2 min value, group mean response rates of turtle doves exceed that of pigeon 5. These differences are, however, not statistically significant (Mann-Whitney U Test). Differences between the rats and the bird species are significant (at $P < 0.02$ or $P < 0.05$; Mann-Whitney U Test, two-tailed), except at the FI 2 min value between rats and pigeons.

Sample cumulative records from one subject in each species are shown in Figure 2. It is apparent that differences in response rates were at least partly due to differences in temporal patterning of the behaviour. This is further evidenced by the distribution of responses in successive fractions of the interval shown in Figure 3. The classically described pause-response pattern is more clearly evident in rats than in pigeons, and is virtually absent in turtle doves.

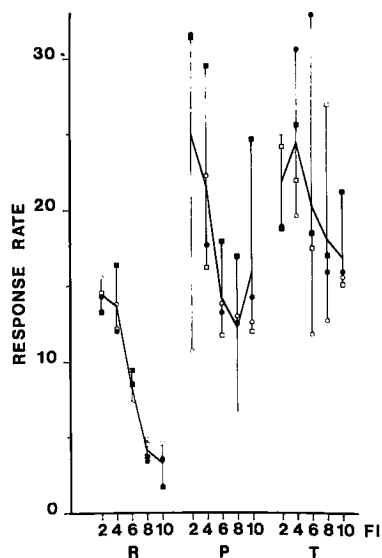


Figure 1. Response rate (responses per minute) as a function of FI interval for rats (R), pigeons (P) and turtle doves (T). Thick lines: averaged results of the 4 subjects in each group computed from the last ten sessions at each value of FI interval. Individual results are plotted as symbols on thin vertical lines, showing the range of observed rates. For each species, subject 1 = ●, 2 = ○, 3 = ■, 4 = □.

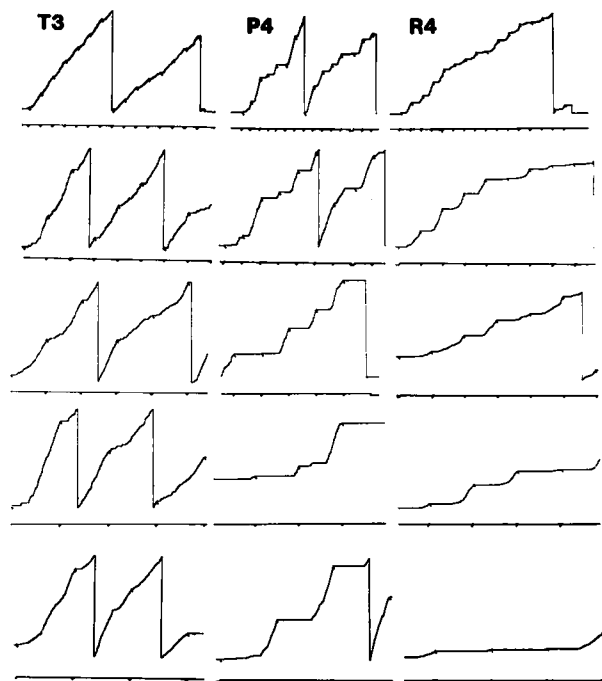


Figure 2. Samples of cumulative records from one turtle dove (T3), one pigeon (P4), and one rat (R4) at the last session at each value of the Fixed Interval (from top to bottom, 2, 4, 6, 8 and 10 min). Each record is for 30 min approximately. The cumulative pen reset automatically after 360 responses. Deflections of the fixed pen indicate the end of each interval.

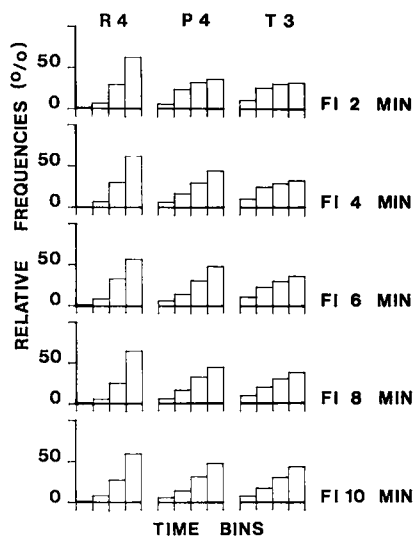


Figure 3. Relative frequency distributions of responses in the four successive quarters of the interval. Data shown were averaged from the last ten sessions for each value of the interval for rat 4 (R4), pigeon 4 (P4) and turtle dove 3 (T3) – the same individual subjects whose cumulative records are shown in Figure 2.

Computation of the curvature index provides a more precise measure of temporal regulation. Using a subdivision of the interval into four fractions, the index can take a maximal value of 0.75. The results are summarized in Figure 4 where the mean curvature index is shown for each species at each value of the interval (filled symbols). Standard deviations have been computed at each value of the interval from the last 10 daily group means for each species. As can be seen, turtle doves showed much lower indices than pigeons which themselves showed much lower indices than rats. While rats showed a decrease in curvature index as the interval increased, the reverse effect was observed in birds, at least when averaged group results are considered. A measure of inter-session variability has been computed by taking the ratio between the standard deviations and the means plotted in Figure 4. The values of this coefficient of variation are given in Figure 5. Birds show a much greater variability than rats. For two values of the interval, i.e., 4 and 6 min, the coefficient of variation is exceptionally high in turtle doves. Fig. 6 presents individual values of the curvature index as a function of the length of the interval. The range is clearly wider for turtle doves under FI 8 min and FI 10 min. This reflects the fact that two birds (T1 ● and T3 ■) began to show some temporal patterning, at least occasionally. It can be seen that three rats out of four (R1 ●, R2 ○, R3 ■) illustrate the decreasing trend evidenced in group mean performances (Figure 4). For pigeons, the increasing trend is illustrated in three birds (P1 ●, P2 ○, P4 □), whereas in turtle doves, two birds showed this trend (T1 ● and T3 ■) and two showed the opposite trend (T2 ○ and T4 □). Except for turtle doves under FI 8 and 10 min, there was no obvious difference between ranges of inter-individual performances between rats and birds, in contrast to the one evidenced for response

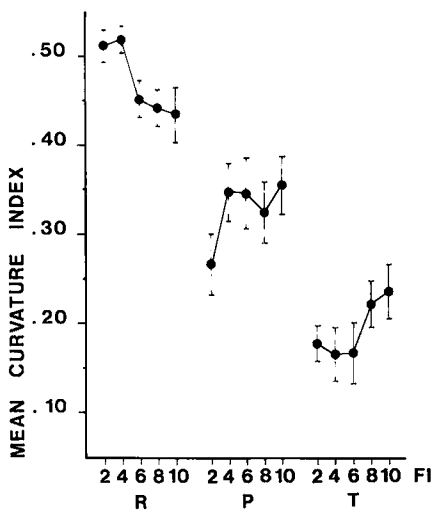


Figure 4. Mean curvature index for each value of the interval for rats (R), pigeons (P) and turtle doves (T). Standard deviations were computed for each value of the interval from the 10 daily group means.

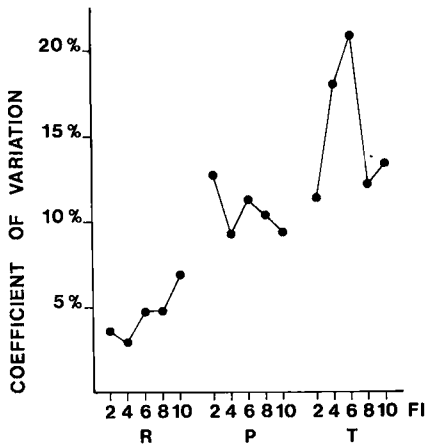


Figure 5. Ratio between standard deviations and group mean values shown in Figure 4. This coefficient of variation gives an estimation of group intersession variability for each species.

rate (see Figure 1). Statistical significance of the differences observed in Figure 6 was tested by means of the Mann-Whitney U test (two-tailed). All differences between species taken two by two were significant (at $P < 0.02$ or $P < 0.05$), except between pigeons and turtle doves at 8 and 10 min.

Response patterning did not show a clear difference between pigeons and rats. Break-and-run type behaviour was observed occasionally in rats, and scallops were often present in pigeons. Turtle doves often responded continuously throughout the

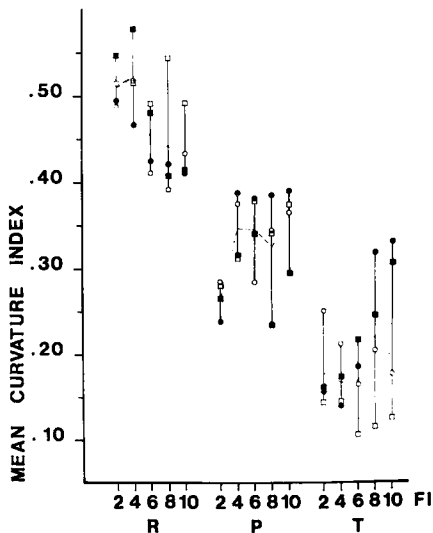


Figure 6. Individual indices of curvature plotted as symbols (see Figure 1) on vertical lines showing, for each FI value, the range of observed performances for each species. Points were computed from the last 10 sessions at each FI value. Group mean values are joined by the thin broken line.

interval, as can be seen in Figure 2. Some of them emitted responses in bursts, giving the cumulative record a stair-like appearance rarely found in pigeons and rats. When pauses were present in turtle doves, response patterning seemed comparable to that of pigeons. However, the data recording in four fractions of the interval did not allow a detailed comparison. An intriguing behaviour was repeatedly observed in doves, and more specifically in two individuals (T2 ○ and T4 □): they continued to peck the key during the reinforcement, the operation of the grain dispenser being immediately followed by a burst of responses that lasted sometimes for the whole duration of access to food. It should be remembered that no change in key or magazine illumination occurred when the reinforcement was delivered. Furthermore, there was no clear relationship between FI duration and response patterning, as had previously been described for instance by Schneider (1969) in pigeons and Hanson, Campbell and Witoslawski (1959) in rats. This may be related to the comparatively smaller number of sessions of our subjects at each FI value (30 or 40 sessions in this experiment, compared to more than 70 sessions in Schneider's and Hanson et al.'s experiments).

DISCUSSION

Comparative studies are faced with the problem of equivalence of the experimental situations (see Richelle and Lejeune, 1980, Chap. 4, for details). In the present experiment, the experimental designs were as similar as possible, but the results gathered so far are only a first step towards the analysis of the independent variables involved. Our results, besides outlining differences between rats and both bird species, point to an unexpected discrepancy between pigeons and turtle doves. These birds did not exhibit the typical post-reinforcement pause, except for occasional pausing in 3 out of 4 subjects (turtle dove 4 □ never displayed pausing) when the interval increased.

The cross-species generality of the typical pattern(s) generated by the FI contingencies, though scarcely documented, has rarely been questioned. Previous results, in fact, seemed to support this view (Schneider, 1969; Dews, 1970), except for second-order details such as dominance of scallop or break-and-run patterns (see Dews, 1978) or occasional reports on poorly performing species such as bees (Grossman, 1973) or fish (Eskin and Bitterman, 1960).

Recently, Lowe and Harzem (1977) have raised some doubt about the generality of FI patterns on the basis of their comparative study of rats and pigeons. The differences observed in our experiment are all the more striking as turtle doves are close to pigeons on the phyletic scale and as a response of similar topography was used. Of course, this similarity might be only apparent, and may hide subtle differences that would be detectable only through refined analysis. Also, pecking behaviour of similar topography might show different temporal distributions in the natural

repertoire of the two species, and this might account for the differences observed in the operant situation. At this stage, the possibility of species-specific characteristics with regard to time estimation or temporal control should of course not be ruled out, intriguing as it might seem in such closely related species.

Finally, though we agree with Bayes (1972, 1975) that turtle doves are very convenient experimental subjects, their behaviour cannot be regarded as equivalent to that of pigeons, at least in studies using FI contingencies.

REFERENCES

- Bayes, R. Utilizacion de tortolas en el laboratorio operante. *Revista Latinoamericana de Psicologia*, 1972, 4, 227-234.
- Bayes, R. Utilizacion de tortolas en experimentos a largo plazo. *Revista Mexicana de Analisis de la Conducta*, 1975, 1, 69-73.
- Dews, P.B. The theory of Fixed Interval responding. In W.N. Schoenfeld (Ed.), *The Theory of Reinforcement Schedules*. New York: Appleton Century Crofts, 1970.
- Dews, P.B. Studies on responding under fixed-interval schedules of reinforcement: II The scalloped pattern of the cumulative record. *Journal of the Experimental Analysis of Behavior*, 1978, 29, 67-75.
- Eskin, R.M. and Bitterman, M.E. Fixed interval and fixed ratio performance in the fish as function of prefeeding. *American Journal of Psychology*, 1960, 73, 417-423.
- Fry, W., Kelleher, R.T. and Cook, L. A mathematical index of performance on fixed interval schedule of reinforcement. *Journal of the Experimental Analysis of Behavior*, 1960, 3, 193-199.
- Grossman, K.E. Continuous, fixed-ratio and fixed-interval reinforcement in honey bees. *Journal of the Experimental Analysis of Behavior*, 1973, 20, 105-109.
- Hanson, H.M., Campbell, E.H. and Witoslawski, J.J. FI length and performance on a FI-FR chain schedule of reinforcement. *Journal of the Experimental Analysis of Behavior*, 1962, 5, 331-333.
- Lowe, C.F. and Harzem, P. Species differences in temporal control of behavior. *Journal of the Experimental Analysis of Behavior*, 1977, 28, 189-201.
- Powell, R.W. Comparison of differential reinforcement of low rates (DRL) performance in pigeons (*Columba livia*) and crows (*Corvus brachyrhynchos*). *Journal of Comparative and Physiological Psychology*, 1974, 86, 736-746.
- Richardson, W.K. and Loughhead, T.E. Behavior under large values of the differential reinforcement of low rates schedule. *Journal of the Experimental Analysis of Behavior*, 1974, 22, 121-129.
- Richelle, M. and Lejeune, H., *Time in Animal Behaviour*, Oxford, Pergamon Press, 1980.
- Schneider, B.A. A two-state analysis of fixed-interval responding in the pigeon. *Journal of the Experimental Analysis of Behavior*, 1969, 12, 677-687.
- Skinner, B.F. A case history in scientific method. *American Psychologist*, 1956, 11, 221-233.

Reprints may be obtained from: H. Lejeune, Experimental Psychology Laboratory, University of Liège, 32 boulevard de la Constitution, 4020 Liège, Belgium.