On Reynolds' *Discrimination and emission of temporal intervals by pigeons*

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On each of 200 daily trials, pigeons pecked a red key in order to turn it blue for 30 sec. If they waited a minimum interval of time before pecking in red, the blue key was associated with a variable-interval 1-min schedule for food; otherwise, it was associated with extinction. In a previous experiment using this procedure (Reynolds, 1966), the pigeons could not inhibit red keypecking, and various durations of wait were about equiprobable. However, the longer they waited, the faster they pecked the blue key. In this experiment, the pigeons learned to wait in red, so that longer duration waits were more probable. Again, the longer they waited, the faster they pecked the blue key. But, we found more uniform pecking in blue, suggesting that the control over blue keypecking by the duration of wait in red is different when the birds can and when they cannot inhibit pecking in red.

Reynolds (1966) found that pigeons failed to show graded probabilities in the emission of temporal intervals on a schedule that differentially reinforced spaced responding even though their behavior subsequent to the emission of an interval was controlled by the duration of that interval. He concluded that schedules that differentially reinforce spaced responding (DRL), when they in fact generate higher probabilities for longer interresponse times (IRTs), have served "perhaps [to] direct the birds' attention to time as the dimension of importance" (Reynolds, 1966, p. 68). This view suggests that birds may already discriminate temporal intervals prior to such experiments as a result of genetic and/or experiential factors. The point that experimental naiveté does not imply experiential naiveté has dotted the learning literature for years. Reynolds' findings add further emphasis, especially in operant learning experiments where birds are frequently used in more than one experiment with little systematic knowledge about transfer effects between schedule performances.

The present experiment employed Reynolds' procedure, but excellent timing behavior was generated without the use of an added clock (see Reynolds, 1966). Discriminative control over behavior subsequent to emitted temporal intervals was assessed in the fashion of Reynolds.

METHOD

Subjects

Three experimentally naive, adult White Carneaux pigeons were maintained at 85% of their free-feeding body weights throughout the experiment.

Apparatus

A standard pigeon chamber, as described in Pliskoff, Cicerone, and Nelson (1978), was employed. Only one of the two response keys was functional, and it could be transilluminated by either red or blue light. Electromechanical equipment located in an adjoining room arranged dependencies and recorded response and time data.

Procedure

Sessions were run daily, and each session consisted of 200 trials. A trial was initiated by a dark response key turning red. A single peck on the red key turned it blue for 30 sec (excluding feeder time; see below), following which the key returned to dark. As will be seen, the blue key was associated with a variable-interval (VI) 1-min schedule. When blue gave way to dark, a pigeon had to cease responding for 1 sec in order for the key to return to red and begin another trial. Responses prior to the expiration of 1 sec reset the 1-sec dark interval, and it timed anew.

A waiting requirement was scheduled for the red key. Following onset, the bird had to wait a minimum period of time before pecking the key and thereby turning it blue. If the bird waited at least the minimum time, responding on the blue key was reinforced on a VI 1-min schedule. If the bird pecked the red key before the minimum time expired, pecking on the blue key was extinguished for 30 sec, which was arranged by not permitting the VI tape programmer to run for the 30 sec. The length of a bird's pause following the onset of the red key was the sole determinant of the availability of reinforcement for pecking the blue key. The waiting requirement was set at 12 sec for Bird 12 and at 18 sec for Birds 13 and 14. The feeder cycle was 6 sec for Birds 12 and 14 and 4 sec for Bird 13.

The basic procedure just described was the same as Reynolds' (1966) second procedure, which he found to yield the same results as a procedure in which the pigeon was required to initiate the red-key waiting interval with a peck and then peck a second time to terminate the interval and produce the blue key.

The important way in which the present experiment differed from that of Reynolds (1966) was the manner in which the waiting interval was instituted. It seems clear from his report that the 18-sec waiting interval for the red key was instituted at the start.

In the present experiment, the required waiting period was slowly increased in 1-sec increments over 3 months from a duration less than 1 sec for all birds to the final durations. Also, in the present experiment, whenever a bird waited long enough in red, the peck that turned the key to blue also illuminated the houselight while the key was blue. Too quick a response on the red key resulted in a blue key without the houselight. (Note

that the houselight could not serve as a discriminative stimulus for pecking the red key, since it was never on in red.) The houselight was eliminated through fading soon after the final procedure was attained, that is, the full-duration waiting requirements in red. Fading occurred over a 3-week period and was followed by 266 sessions on the final procedure.

The data consisted of waiting-time durations in 2-sec class intervals for Bird 12 and in 3-sec class intervals for Birds 13 and 14. Also, each waiting-duration time class was associated with a different counter for VI responding on the blue key. Thus, it was possible to compute a VI response rate for the blue key for each time class associated with the red key.

RESULTS

The data for each bird were combined over the last seven sessions (1,400 trials) of the experiment. The data for the red key consisted of count frequencies with which a bird's waiting durations fell in each of the six time classes up to the required waiting duration plus a frequency with which the required duration was exceeded (dump class). Conditional probabilities were computed from those frequencies in the same manner used to compute IRTs per opportunity. The result is a probability that a bird will respond on the red key after a given duration of wait given that the bird waited at least that long. For each bird, waiting time per opportunity (WT/Op) was computed for each of the six time classes; for the dump class, the statistic necessarily equals unity. As noted above, VI response rates for the blue key were computed separately for each time class associated with the red key. Thus, for each bird, there were seven such VI rates, the seventh associated with the red-key dump class. Each of the seven VI response rates for a bird was divided by the largest response rate of the seven, thereby creating a scale for response rate from zero to unity, the same as for WT/Op. (The above calculations are the same as performed by Reynolds, 1966.) The findings are shown in Figure 1.

Figure 1 should be compared with the one published by Reynolds (1966, p. 67), paying attention only to his curves represented by unfilled circles. His IRT per opportunity curves are essentially flat, although two birds show a peak in the first time class. Our WT/Op curves show good temporal discrimination in the presence of the red key, which was to be expected given a training procedure that featured a gradual approach to the final waiting times. A sometimes used measure of "efficiency" is the percentage of trials on which a bird waits the minimum time; in our experiment, those values were just at 20% for Birds 12 and 14 and just over 50% for Bird 13.

The relative VI 1-min response rate curves are also different in the two studies. While Reynolds' (1966) birds showed an essentially linear increase in relative response rate, our birds showed a concave downward increase. The curve for Bird 12 would have resembled those for the other birds more closely had the point for the first time class been lower.
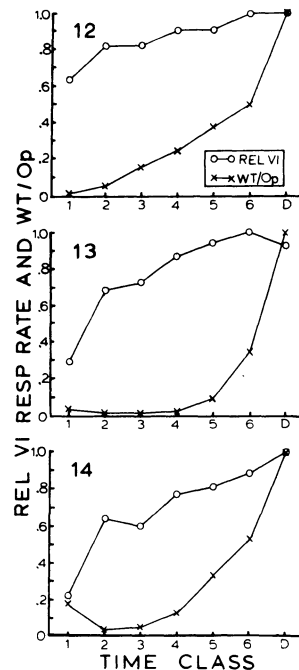

Figure 1. Relative VI response rate and waiting time per opportunity (WT/Op) as a function of time class (see text for further details). D represents the dump class.

DISCUSSION

The concave downward increase in the relative response rate curves obtained in the present experiment suggests altered discriminative control by the temporal intervals emitted on the red key, compared with the results obtained by Reynolds (1966). In other words, our birds, in Reynolds' terms, attended to time as the relevant dimension when the key was red, but they demonstrated either (1) diminished control over VI responding by emitted temporal intervals in red, or (2) maintained control but a greater tendency to "judge" too brief an interval as "long enough." A most conspicuous illustration is the fourth class interval for Bird 13, which included all waiting times in red between 9 and 12 sec: The conditional probability of a waiting time in that class was only .03, but the response rate in blue following such a wait in red was .87 of the maximum VI response rate.

The results of the present study supplement those reported by Reynolds (1966). By comparison with Reynolds' findings, ours suggest that important changes take place in the discriminative control over VI responding when temporal differentiation develops on the red key. That conclusion must be guarded because there were differences between the two studies. It seems clear, however, that the changes are worthy of study, since we know so little about the stimulus properties of schedule performances.

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