TIME-BASED RESPONDING IN PIGEONS AND CROWS

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RELATIVELY few laboratory comparisons of learning and performance have been made within the class Aves. Gossette (1968, 1969), who made the most extensive comparisons, showed magpies to be superior to pigeons, doves, quail, chickens, and several other species in habit reversal tasks. In habit reversal animals can respond to either of two stimuli. Responses to one stimulus produce food (S^+) while responses to the second stimulus are not rewarded (S^-), and are considered to be errors. Animals are first trained to a criterion of efficiency, i.e. 90% correct over 20 trials. Then the stimuli are reversed so that S^+ is now S^- and vice versa. Behavior is evaluated in terms of how many trials it takes the animal to recover the same level of efficiency, and this procedure is repeated for many reversals.

The present experiment was conducted to study the performance of pigeons (*Columba livia*) and Common Crows (*Corvus brachyrhynchos*) under time-based schedules of reinforcement. The methods used come under the broad heading of operant conditioning, which primarily concerns responses that have immediate consequences for the organism, e.g. delivery of food (positive reinforcement), removal of aversive stimuli (negative reinforcement), or the delivery of aversive stimuli (punishment).

A schedule of reinforcement specifies a particular contingency between a response and a consequence (reinforcer). The two schedules studied here, fixed interval (FI) and differential reinforcement of low rate (DRL), both impose a time requirement as well as a response requirement. Under FI schedules, the first response that occurs after a specified interval has elapsed is reinforced with food. Under DRL schedules, food reinforcement is contingent upon a response that follows the preceding response by a specified interval. The time between two responses is called an interresponse time (IRT). All IRTs less than the specified interval are not reinforced and also restart the timing contingency.

The rationale for this study was based upon the consistently poor performance of pigeons under DRL schedules as compared to rats and primates (Kramer and Rilling 1970). At DRL values of 30 seconds or more, pigeons rarely obtain more than 5% of the available reinforcers, because they consistently respond prematurely.

Pigeons have become the favorite avian species in studies of learning, mainly because of convenience. They are inexpensive, readily obtainable, easy to handle, and adapt to laboratory conditions without dif-

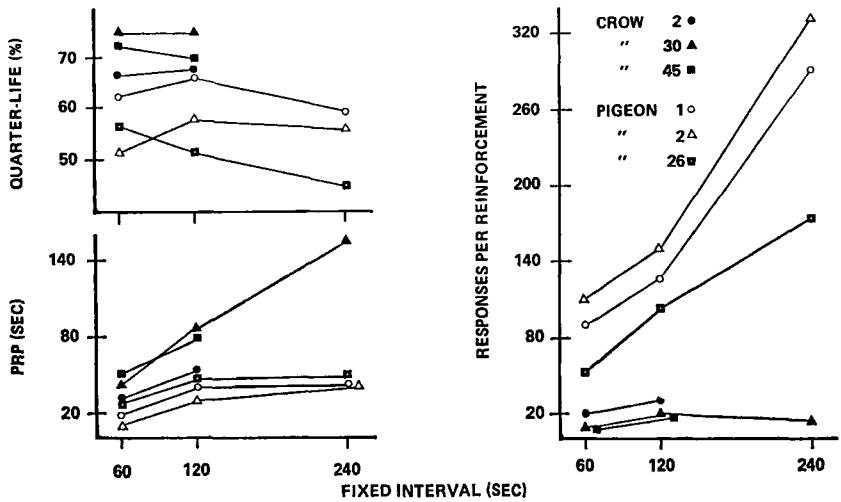

Figure 1. The mean performance for each bird over the final 10 sessions at each schedule value. PRP stands for the postreinforcement pause, i.e. the time from the end of the reinforcement period until the first response.

ficulty. Because of the large body of experimental behavioral data that now exists on the pigeon, it seems important to determine how representative these findings are of other birds, given the diversity of the avian class.

METHODS

The subjects were 4 White Carneaux pigeons, 2 homing pigeons, and 7 Common Crows, all adults. The birds were maintained at approximately 80% of their normal weight during the experiment, and were housed in individual cages where they had free access to grit and water. Four of the pigeons (P16, 20, 26, 33) and three of the crows (C2, 30, 45) had been trained under other schedules of reinforcement prior to the experiment. The previously untrained birds were trained (shaped) to peck an illuminated disc (key-peck) for food through the method of successive approximation. For example as key-pecking was the desired response, the bird was first reinforced (rewarded with food) for facing toward the key, then for standing in front of the key, and finally for pecking the key. The reinforcers were mixed grain (Purina Pigeon Chow) for the pigeons and dog food (Gaines Prime-beef variety) for the crows. A standard pigeon test chamber (Lehigh Valley, Model #1519C) was used in which the response panels were interchanged for the two species. The only difference was an enlarged food hopper to accommodate the crow's larger beak.

Fixed interval schedules.—Three crows (C2, 30, 45) and three pigeons (P16, 20, 33) were tested under FI schedules ranging from 60 to 240 seconds. Training sessions continued until stable performance developed. The criterion for stability limited variation in response rate to $\pm 10\%$ of the mean rate over 10 consecutive sessions. Performance was compared according to the following measures: (1) Responses per

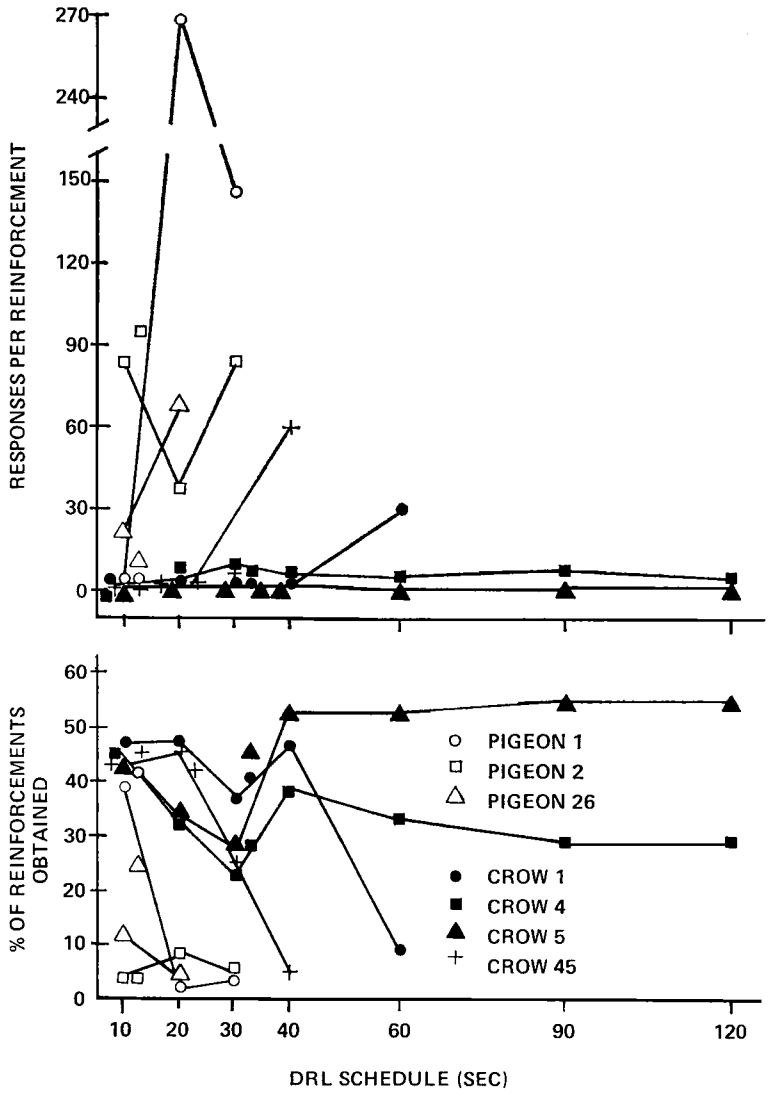

Figure 2. The percent of reinforcements obtained and the number of responses per reinforcement for each bird. Each data point represents the mean performance over the final five sessions at each DRL value. Those data points displaced to the right of the values on the abscissa represent the redetermined performance at that schedule value.

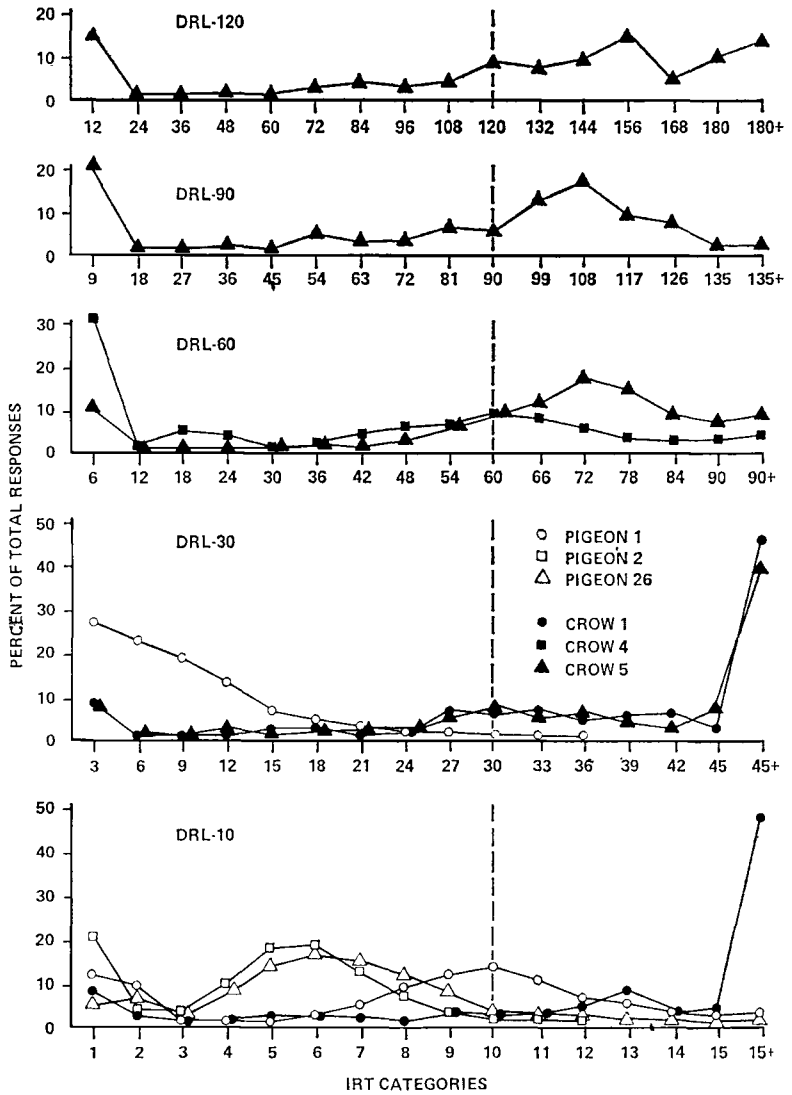

Figure 3. The relative frequency distribution of IRTs at selected schedule requirements. The numbers on the abscissa represent the upper limit for each category. The data were averaged over three consecutive sessions, during the last five sessions at that schedule value. The dashed vertical line indicates the minimum IRT required to obtain reinforcement.

reinforcement, (2) postreinforcement pause, the time from the end of the reinforcement period until the first response, (3) quarter-life, the percentage of time taken, in the interval between reinforcements, for the first 25% of the total number of responses to occur, i.e. if 100 responses occur in the time between two reinforcements, the quarter-life is the percentage of the interval that the first 25 responses take to occur. Accordingly a quarter-life of 70% indicates that only 25% of the responses occurred during the first 70% of the interval.

DRL schedules.—Four crows (C1, 4, 5, 45) and three pigeons (P1, 2, 26) were exposed to DRL schedules extending from 10 to 120 seconds. The schedule was changed when performance was stable over 5 consecutive sessions, provided that a minimum of 10 sessions had been completed under that schedule. The criterion for stability limited variation in the daily reinforcement rate to $\pm 15\%$ of the mean rate over five consecutive sessions. Performance was compared according to the following three measures: (1) Responses per reinforcement, (2) percent of reinforcements obtained of the total number possible, (3) relative frequency distribution of interresponse times.

Results

Fixed interval schedules.—The crows performed more efficiently than pigeons according to each dependent measure, as shown in Figure 1. The number of responses per reinforcement increased for each species as the schedule requirement increased, but the increase for the crows was slight. The crows paused longer after reinforcement and had higher quarter-life scores, indicating more effective temporal discrimination. None of the dependent measures showed any overlap between species.

DRL schedules.—The crows were much more successful than the pigeons under this schedule. Figure 2 shows that the crows had higher reinforcement rates and made fewer responses per reinforcement. The differences between species generally increased as the schedule requirement increased. Each pigeon obtained less than 10% of the reinforcers possible at DRL-20 seconds and DRL-30 seconds, while two crows continued to respond effectively up to DRL-120 seconds.

The crows had much fewer short IRTs than the pigeons, having instead a high percentage of responses that far exceeded the minimal DRL requirement. The results presented in Figure 3 suggest that the crows actually had more accurate temporal discriminations at the higher DRL requirements, as the IRT distributions tended to peak just beyond the minimum time required for reinforcement.

Discussion

The present results show a major difference in performance between pigeons and crows under temporally-based schedules of reinforcement. It has recently been shown that the response patterns of crows are similar to those of pigeons under schedules of reinforcement that do not involve temporal discrimination (Powell 1972). The superior per-

formance of the crows under the conditions studied here may arise from a more highly developed capacity for temporal discrimination. Another factor could be greater inhibitory control over pecking for the crow than for the pigeon. The successful performance by two crows (C4, C5) under DRL-120 seconds has not been demonstrated for any other species.

These findings agree with Gossette's results (1968, 1969) that show corvids to be superior to a number of other avian species in habit reversal tasks. Thus the limited evidence that does exist suggests corvids are superior to other birds in their capacities for behavioral adjustment. Similarly it has been reported that corvids display the most advanced level of avian brain development (Cobb 1960). These findings seem important because an organism's capacity for behavioral adjustment may be a significant factor in the process of natural selection.

SUMMARY

The operant behavior of pigeons and crows is compared under FI and DRL schedules of reinforcement. This comparison shows more efficient behavior for crows under FI schedules, where they emitted substantially fewer responses per reinforcement. Under DRL schedules, the crows were also much more successful, obtaining many more reinforcements than the pigeons at all schedule values.

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