OPERANT CONDITIONING IN THE COMMON CROW (*CORVUS BRACHYRHYNCHOS*)

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CROWS are characterized by their resourcefulness, adaptability to diverse habitats, and extensive behavioral repertoire (Peterson, 1963). They live in well-organized social groups and seem to possess a complex language (Lorenz, 1952; Frings and Frings, 1959; Bannerman, 1963; Chamberlain and Cornwell, 1971). Extraordinary learning capabilities are often attributed to the crow, but evidence of this is primarily anecdotal. Surprisingly few experimental studies have been conducted with crows. In the only contemporary report of this type, two crows (incorrectly identified as *Corvus americanus*) showed a progressive decrease in errors to criterion on multiple reversals of a visual discrimination problem (Stettner et al., 1966). While their performance seemed superior to that of pigeons studied under similar conditions, generalizations are limited by the small number of subjects and the brief duration of the experiment occasioned by the premature death of both birds.

The present experiment was conducted to study the development and maintenance of operant responding in crows, under basic schedules of food reinforcement. Operant conditioning is concerned primarily with responses that have immediate consequences for the subject, such as delivery of food (positive reinforcement), removal of noxious stimuli (negative reinforcement), or the delivery of noxious stimuli (punishment).

Schedules of reinforcement involve various contingencies between behavior and its consequences. Several examples are: Reinforcement for every response (continuous schedule), reinforcement for the first response after 1 minute since the last reinforcement (fixed-interval schedule), reinforcement for the first response after some time period which varies unsystematically (variable-interval schedule).

METHODS

Five adult Common Crows (*Corvus brachyrhynchos*) were maintained at approximately 80 percent of their normal weight. Three of the crows (C1, C30, C45) were shaped to key-peck for food reinforcement (Skinner, 1951). Shaping involves reinforcement of successive approximations of the desired response. 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 other birds (C2, C3) were trained through an auto-shaping procedure (Brown and Jenkins, 1968) in which momentary illumination of the key was followed by food presentation. This resulted in reliable aquisition of key-pecking in pigeons. Gaines Prime (beef variety) was used for reinforcement, and this seemed to be critical. Attempts to train the birds using either mixed grain or dried dog food

TABLE 1

MEAN RESPONSE RATES DURING THE LAST FIVE SESSIONS FOR EACH CROW, UNDER THE FINAL TWO VALUES OF EACH SCHEDULE TO WHICH THE BIRD WAS EXPOSED[1]

Subject	Schedule	Cumulative sessions	Responses per minute	Schedule	Cumulative sessions	Responses per minute	Schedule	Cumulative sessions	Responses per minute
C1	FR-75	69	51.6	VI-30	21	44.1			
	FR-100	82	49.2	VI-60	32	48.4			
C2	VI-60	28	45.1	FR-66	65	36.2	FI-60	35	19.9
	VI-120	39	43.6	FR-100	79	30.0	FR-120	51	16.2
C3	VI-60	29	37.6	VR-75	36	57.4			
	VI-120	46	41.5	VR-100	57	38.4			
C30	VR-50	46	89.4	FI-120	47	9.5			
	VR-75	70	91.2	FI-240	68	3.5			
C45	FR-40	62	51.7	VR-75	36	69.7	FI-60	33	6.8
	FR-50	81	43.7	VR-100	52	62.5	FI-120	52	9.0

[1] The sequence of schedules is indicated from left to right, respectively. Cumulative sessions indicates the number of experimental sessions completed up to that time.

(Ken-L-Ration Biskit) for reinforcement were unsuccessful. Reinforcement times ranged from 3.0 to 5.0 seconds. A standard pigeon test chamber (Lehigh Valley, Model 1519C) was used. The hopper was enlarged and modified so that food could not be obtained when the hopper was down. These modifications were necessitated by the large bill of the crow compared to the pigeon's.

Each crow was studied as schedule requirements were gradually extended. A different key light color was associated with each schedule. The sequence of schedules and mean response rates for each bird are presented in Table 1. Mean response rates were determined by dividing the total number of responses by the total time less the reinforcement time. Each schedule requirement remained in effect until performance stabilized. Stability was judged through inspection of cumulative response records and consistency in response rates between sessions. The duration of experimental sessions ranged from 30 minutes to 2 hours, with session length increasing as the schedule requirement increased.

RESULTS AND DISCUSSION

Figure 1 shows representative cumulative response records for the three crows studied under each schedule. Under fixed ratio (FR) schedules, in the presence of a white key light, the nth key-peck resulted in access to food. Each crow showed consistent pausing after reinforcement and then a steady rate of responding until the next reinforcement was obtained. This is characterized as a break and run pattern and is typical of behavior under FR schedules (Ferster and Skinner, 1957). A consistent direct relationship has been found between postreinforcement pause duration and the ratio response requirement (Felton and Lyon, 1966; Powell, 1968). Quantitative analysis of the present data showed a similar direct relationship for the crow. The mean pause durations in seconds at the last two schedule requirements were

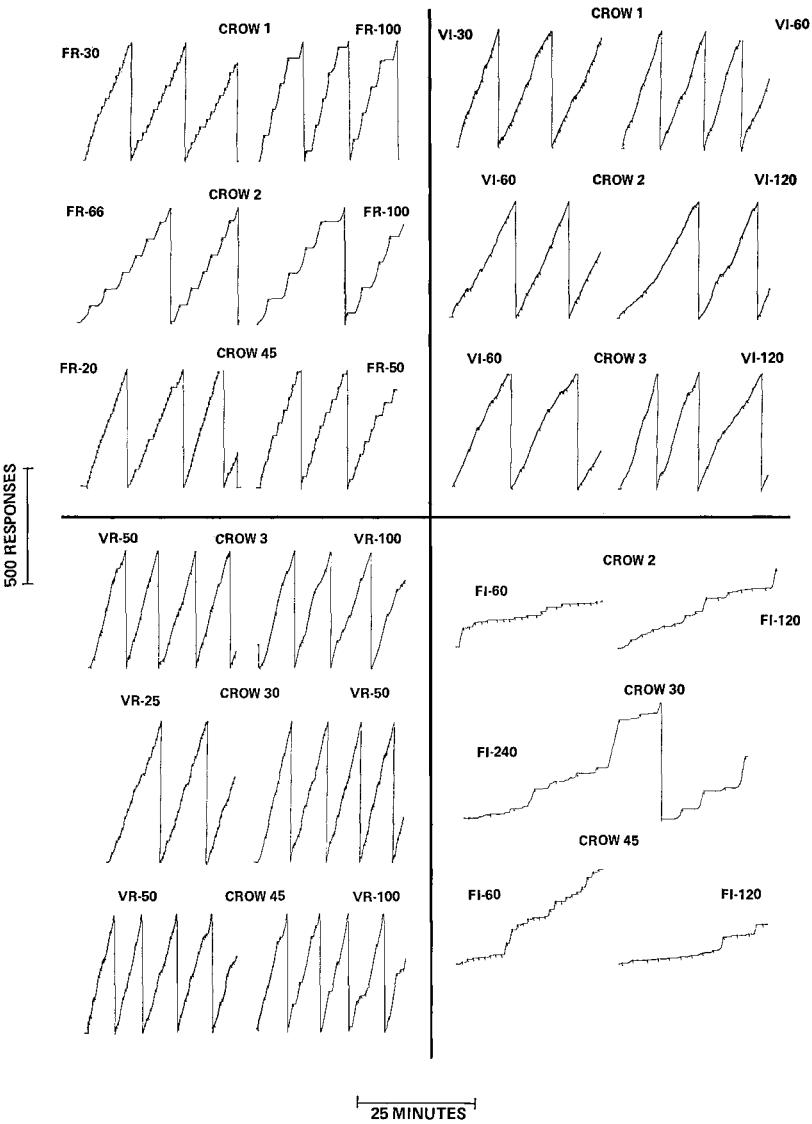

Figure 1. Cumulative response records showing representative performance for each crow studied under the four schedules of reinforcement. Slash marks indicate the presentation of food reinforcement.

as follows: Crow 1, FR-75 (37.9), FR-100 (50.8); crow 2, FR-66 (37.6), FR-100 (78.7); crow 45, FR-40 (25.6), FR-50 (33.6).

The variable interval (VI) schedules were associated with a red key light. Under these schedules, the first key-peck after a specified interval of time elapsed produces food reinforcement. The duration of each successive interval varies, with the overall schedule requirement identified by the mean of the intervals, i.e. 30 seconds, 60 seconds. The cumulative response records in Figure 1 show very consistent responding under the VI schedules. Discernible pauses rarely occurred. Mean response rates under the VI and FR schedules did differ substantially, and local response rates were much higher under the FR schedules as shown by the slope of the response records.

The variable ratio (VR) schedules were signalled by a green key light. Under these schedules, the nth key-peck, on the average, was reinforced with food. The results in Table 1 show that the VR schedules generally produced the highest rates of response of the schedules studied here. The cumulative response records in Figure 1 show fairly consistent responding with high local rates. Pausing, particularly after reinforcement, was not uncommon. Inspection of response records suggests that postreinforcement pauses increased in frequency and duration with increases in the schedule requirement. Thus in several respects responding under the VR schedules was more analogous to FR than VI behavior in the crow.

The fixed interval (FI) schedules were signalled by a red key light, as were the VI schedules. Only crow 2 was studied under both VI and FI schedules, the first key-peck after a fixed period of time resulted in food reinforcement. Response rates under the FI schedules were the lowest by far of any schedule studied. The cumulative response records in Figure 1 show that FI behavior was characterized by a break and run pattern of response. The crow typically paused for long periods following reinforcement, and then responded steadily until the next reinforcement was obtained. Gradually accelerated responding occurred much less frequently than the break and run pattern.

The most important result of this experiment was the reliable control of responding in the crow through standard operant conditioning procedures. Responding was effectively maintained under each of the basic schedules of reinforcement and terminal patterns of response were very similar to other species that have been studied under these schedules.

Except for minor apparatus modifications, we used the same experimental procedures for crows as are generally employed with pigeons.

The systematic relationships that have been observed between behavior and the schedule of reinforcement are extended by the present results. These data clearly show that the Common Crow can be usefully employed

as an experimental subject. Perhaps of greatest importance in this respect, various characteristics of the species such as language, social relationships, capacity for learning, and sensory capabilities became accessible to study through objective experimental procedures.

SUMMARY

Five Common Crows were trained to key-peck for food reinforcement. Three crows each were then studied under four intermittent schedules of reinforcement: Fixed ratio, variable interval, variable ratio, and fixed interval. Consistent responding was maintained in all birds as schedule requirements were gradually extended to substantial values. Similar response patterns developed for each of the three crows under the same schedule of reinforcement. The behavior of the crows was comparable to that of pigeons (Ferster and Skinner, 1957), rats (Appel, 1964; Miller and Ackley, 1970), and monkeys (Hake et al., 1967; Hodos and Trumbule, 1967).

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