Habit reversal in the crow, *Corvus Americanus*

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Two crows were run on multiple reversals of a simultaneous visual discrimination problem. The crows showed a marked progressive decrease in errors to criterion over the series of reversals. Their performance appeared to be superior to that of more primitive but more widely studied avians such as the pigeon. The crows' performance also differed from that found in the rat in that the latter's performance in reversal situations has generally been characterized by an initial increase in errors per reversal followed by a progressive decrease.

Despite the fact that the crow is considered to exemplify one of the most advanced levels of avian brain development (Cobb, 1960), there have been very few experimental studies of its learning capacity. Such studies may have special comparative significance in the light of the fact that the pigeon, the avian subject generally used in learning studies, is considered among the lowest group of birds on the basis of comparative brain development (Cobb, 1960). Thus, a proper assessment of the learning capacity of class *aves* cannot be made until a more advanced representative of the class has been studied extensively.

Previous work on the crow (Coburn, 1914; Coburn & Yerkes, 1915) indicated that they learn visual discriminations readily and also that they can learn to respond to the relationship of "the first open door on the right" or "the first open door on the left," in a ten-door multiple-choice apparatus. These investigators did encounter some difficulties in training, however, as they reported being unable to induce the crows to make more than 20 responses per day, and frequently had to modify their procedures in progress in order to avoid "discouraging" the animals. The technique and the results of a study of repeated visual habit reversal in the crow are described below. The reversal task was chosen because it has been shown to be a useful tool for assessing comparative learning ability (Bitterman, 1965).

Method

The Ss were two male crows (*Corvus Americanus*), one to two years of age. They were maintained on a limited ration of 4 oz. of canned dog food per day throughout the course of pre-adaptation as well as the experiment proper.

After a period of six weeks in the laboratory, during which the crows were adapted to eating in E's presence, their daily ration was placed in a large four-wheeled unpainted plywood box, 25 x 29 x 19 in. high, fitted at one end with a guillotine entrance door made of vertically oriented wire bars set 1/2 in. apart. This box was pushed up against the cage door, and after the crows entered the box without hesitation for seven consecutive days, dog food was placed in a small wire basket mounted on the outside wall of the box. Access to the food was provided by a 1 x 2-1/2 in. opening fitted with a solenoid-operated guillotine door, and the crows were adapted to the procedure of eating whenever the solenoid was operated.

The experiment proper began when the crow, after entering the box, was wheeled into the experimental room and the wire bar door placed up against two Lehigh Valley transparent pecking keys set 2 in. apart. Directly behind each pecking key was mounted a Grason-Stadler stimulus projector with a viewing surface 1-1/2 in. square. The stimuli projected were sets of three white stripes on a black field; one set was oriented horizontally, the other vertically.

The apparatus was designed so as to perform the following operations automatically: (1) present horizontal and vertical sets simultaneously at each stimulus presentation, in random arrangement spatially; (2) program all stimulus onsets with a random arrangement of intertrial intervals of 30, 45, 60, and 90 sec.; (3) terminate the presentation of stimuli whenever a key was pecked; (4) reinforce each correct peck by allowing access to the dog-food basket for 3 sec.; (5) perform "delayed correction" (see below); and (6) record on an Esterline-Angus event recorder the onset, duration, and termination of stimuli, as well as the occurrence, position, and correctness of each response.

During training, each S received 80 trials per day five days per week. On acquisition, one S was reinforced for pecking at the vertical stripes, the other for pecking at horizontal. When criterion of three successive training sessions at 90% correct or better was reached, the next session was a reversal of the acquisition condition. Subsequently, the criterion for successful habit reversal was 16 or more correct responses in the last 20 of each session. When criterion was met, another reversal was programmed on the *following* day, which meant that generally some small degree of "overlearning" was involved on each reversal.

In order to eliminate the possibility of a "spatial fixation," wherein the animal could be rewarded 50% of the time by responding to either the right or left stimulus regardless of visual differentiation, a delayed correction procedure was established, wherein the stimuli would be presented in the same spatial position until a correct response "stepped" the stimuli to the next unit in the sequence of random positions. Thus, continued responding to the same side would result in 0% rather than 50% reinforcement.

Training was continued until one S had reached criterion on 12 reversals, the other on 15. At this point, the birds began to leave their daily ration uneaten,

and training was suspended on the surmise that they were ill. They both died within 10 days of a respiratory infection.

Results

As can be seen in Fig. 1, number of errors to criterion for each reversal for each S, both birds showed evidence of improvement over the course of the series of reversals. Moreover, the magnitude of the improvement was considerable, involving a change from 180 errors on the first reversal to less than 20 errors per reversal at the peak of performance. One can only conjecture as to whether or not the birds were performing at asymptotic level when the series had to be terminated, but there certainly was a leveling off on the latter reversals, with S 1 never besting his performance of the ninth reversal and S 2 reaching a similar peak on the tenth.

The crow's performance was also characterized by a high terminal level of correct performance on each reversal. The crows generally responded at a level of 90 to 100% correct on the last 20 trials before reversal, performing above our criterion. Thus, once the perseverative response to the previously positive stimulus was extinguished, the new correct response became established very quickly. It was the perseverative response tendency which decreased with successive reversals.

Discussion

On the basis of the closest comparisons that can be made with available data, performance of the crow appears to be superior to that of the pigeon, which only has shown improvement on successive visual reversals under conditions designed to facilitate discrimination to a greater degree than those employed in the present study with crows. Bullock & Bitterman (1962) found evidence of improvement only when a specialized "guidance" training procedure was used which signalled the correct response by presenting it in isolation after a preset number of perseverative errors. Stearns & Bitterman (1965) found improvement when there was direct association of the actual feeding response with the discriminative cue, whereas the curves they show for the more standard single feeding location situation as used with crows shows no superiority of the last reversal as compared to the first one.

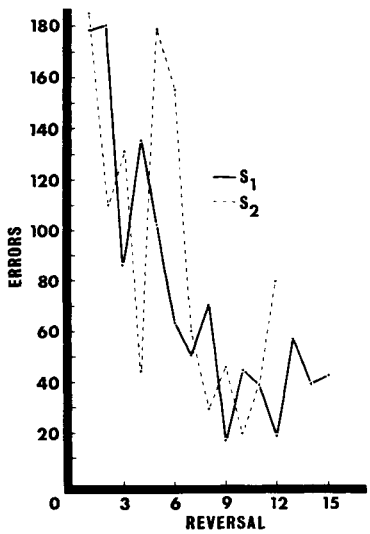

Fig. 1. Number of errors to criterion for each reversal for each S.

Although the crow's performance might be considered as similar to the rat in that they both show progressive improvement in habit reversal, the trend of the crow's performance differs in at least one important respect from that of the rat. The latter shows an initial increase in the number of errors per reversal on early reversals followed by subsequent improvement to a point where they are making fewer errors than they were initially (Bitterman, Wodinsky, & Candland, 1958), as opposed to the drop in errors right from the outset shown by the crow. There is no a priori means of deciding which pattern is "superior." Perhaps at this point, the crow's performance should best be characterized as "non-mammalian" rather than sub-mammalian, a characterization consistent with the suggestion made as to the evolutionary status of birds by Romer (1962). The crow has proven to be amenable to experimentation using current techniques and certainly would repay further study designed to evaluate its performance in a variety of learning situations.

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