RESPONDING UNDER POSITIVE AND NEGATIVE RESPONSE CONTINGENCIES IN PIGEONS AND CROWS

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Four crows were trained to key peck for food. Then, they were exposed to a positive response contingency that required them to peck the key when it was illuminated briefly (the trial) in order to receive food. This procedure resulted in consistent within-trial pecking. When the contingency changed so that food was presented at the end of a trial when no response occurred, but the trial terminated immediately and food was omitted when a response occurred (negative response contingency), responding decreased markedly. Eight pigeons were studied under the same change in contingencies. These birds varied in their response histories from naive to having several years' experience. The previously naive pigeons also showed rapid declines in responding under the negative contingency; the responding of the birds with extended training histories declined much more slowly. Eventually, however, six of the eight pigeons showed little or no responding under the negative contingency, while they responded consistently when re-exposed to the positive contingency. These findings question the power and the generality of the negative automaintenance phenomenon.

Key words: negative automaintenance, food-omission contingency, stimulus-correlated food schedule, history of reinforcement, key peck, crows, pigeons

A rather perplexing phenomenon, referred to as negative automaintenance, was first reported by Williams and Williams in 1969. These authors employed a procedure under which a response-key is illuminated briefly and food is presented simultaneously with the offset of the light. Responses on the illuminated key result in the omission of food on that trial. Williams and Williams found that this procedure resulted in frequent and prolonged pecking in pigeons, so that they received few of the scheduled reinforcers. Responding was engendered in naive birds, as well as being maintained in previously trained animals. Other reports have appeared to replicate the original finding (Herrnstein and Loveland, 1972; Schwartz and Williams, 1972). However, most of the recent experiments, which have sought to extend the analysis of this phenomenon, have found a substantial decline in responding under the negative contingency, in comparison to either response-contingent or noncontingent reinforcement (Barrera, 1974; Gamzu and Schwam, 1974; Hursh, Navarick,

and Fantino, 1974; Stiers and Silberberg, 1974; Wessels, 1974).

The present experiment was undertaken to assess the power and generality of the negative automaintenance phenomenon through the study of pigeons and crows under nearly identical conditions. The crow was selected for study for several reasons. First of all, crows can reliably be trained to key peck for food (Powell, 1973) and they show response patterns similar to pigeons under intermittent schedules of reinforcement (Powell, 1972). Second, crows respond much more successfully under simple differential-reinforcement-of-low-rate (DRL) schedules than do pigeons (Powell, 1974). The results of this study indicated that the species differences observed arose from differential sensitivity to stimuli generated by the animal's own behavior. Third, crows show little or no responding under positive autoshaping and automaintenance procedures (Powell, 1975). Finally, crows are thought by some ornithologists to represent the most advanced stage of avian evolution (Thomson, 1964). Thus, while some of the findings cited above suggest that crows would respond very little under negative automaintenance, a contrary finding would be par-

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ticularly impressive. It would extend the generality of a behavioral phenomenon based on results from two species that are phylogenetically remote, one of which seems to have greater capability for response inhibition (Powell, 1974).

METHOD

Subjects

Four adult Common Crows (*Corvus brachyrhynchos*) and eight domesticated pigeons (*Columba livia*) were used. Five of the pigeons were homers and three were White Carneaux. The crows were obtained from the Fur-N-Feather game farm in Neshkoro, Wisconsin. They had been taken from their nests before fledging and were experimentally naive. The pigeons were obtained from the Palmetto Pigeon Plant in Sumter, South Carolina. Three were experimentally naive (P 23, 24, 25), two (P 3, 19) had approximately two months training each under a continuous reinforcement schedule (CRF), and three (P 20, 21, 42) had extensive histories of training under all of the basic reinforcement schedules. All subjects were maintained at approximately 85% of their free-feeding weights during the experiment, and were housed in individual cages with water and grit freely available. This level of deprivation is well within the range that will produce consistent responding in pigeons (Ferster and Skinner, 1957), and crows (Powell, 1973).

Apparatus

A three-key operant conditioning chamber for large birds (Lehigh Valley Electronics Model 132-06) was used for the crows, but only the center key was functional; the other two keys were covered. Prime dog food was the reinforcer. A two-key operant-conditioning chamber (Lehigh Valley Electronics Model 1519C) was used for the pigeons, but only the right key was functional, the left key being covered. Standard 28-V dc houselights were used in each chamber, but the housing for the bulb was positioned so that the light was directed toward the ceiling. Mixed grain was the reinforcer for the pigeons.

Procedure

Preliminary training. The previously naive birds were placed in the experimental cham-

ber and the lighted food tray was presented periodically for 5-sec intervals. All of the crows and pigeons reliably approached and ate from the food tray within one 60-min session. They were then trained to peck the lighted key through the method of successive approximation, which was accomplished within two 1-hr sessions for each bird.

Positive response contingency. All subjects were studied first under a positive response contingency, in which the key was transilluminated with white light for 6 sec, unless a peck occurred. If a peck occurred, the keylight was turned off and the reinforcer was presented immediately. The reinforcer was not presented at the end of a trial in which no response occurred. The key was dark between trials and the intertrial interval (ITI) was variable, averaging 30 sec. Intertrial pecks had no scheduled consequences. Reinforcement times were 2.0 sec for the crows and 2.5 sec for the pigeons. Experimental sessions lasted 45 min per day. All birds except Pigeon 42 were trained for eight sessions under the positive response contingency and were then switched to a negative response contingency. Pigeon 42 received 23 sessions training before the change in contingencies, because this bird continued to emit large numbers of intertrial responses. This suggested that its behavior was still primarily controlled by its previous history of intermittent reinforcement.

Negative response contingency. This procedure was the same as the positive response contingency described above, except that food was presented at the end of trials in which no response occurred, whereas pecks during a trial immediately turned off the keylight and food was not presented. All birds were studied under this procedure for a minimum of three sessions, and until the animal achieved a criterion of obtaining 50% or more of the reinforcers possible during two consecutive sessions. Training was terminated for Pigeon 20 after 31 sessions when it failed to achieve this criterion. In addition, a program error in the eleventh session for Pigeon 42 markedly improved performance. The program error consisted of the keylight remaining on throughout the session, while reinforcers were presented on the same schedule as previously, providing that no response occurred during the 6 sec before reinforcement delivery. Because of the effect that this procedure had upon the behav-

ior of Pigeon 42, it was subsequently invoked for three sessions with Pigeon 20. This matter is discussed further in the Results section.

Reversal of contingencies. All birds that met the criterion under the negative response contingency (all except Pigeon 20) were subsequently studied as the response contingency alternated between positive and negative over blocks of sessions. Each contingency remained in effect for a minimum of three sessions. While a change in contingencies was usually not made until a bird obtained 50% or more of the reinforcers in each of two consecutive sessions, the existing contingency was sometimes continued beyond this point. Since the purpose of this procedure was to ascertain whether sensitivity to changes in response contingencies would increase with repeated exposure to these changes, it seemed desirable that a fixed temporal pattern in contingency changes be avoided (*e.g.*, changes contingencies every fourth session).

RESULTS

The primary dependent measure is the percentage of reinforcers obtained, which reflects the number of trials with a response under the positive contingency, and the number of trials without a response under the negative contingency. Data on intertrial responding are not presented because such responding was negligible in most cases, and was unsystematic for the few birds where it occurred. The results are first grouped according to length of reinforcement history, as this factor appeared to have a significant effect on performance during the bird's initial exposure to the negative response contingency.

Each of the crows responded consistently under the positive response contingency, and each bird quickly learned not to respond when switched to the negative contingency, as shown in Figure 1. All birds met the criterion of obtaining 50% or more of the reinforcers possible during two consecutive sessions within the minimum time requirement (three sessions). When changed to the negative contingency for the second time (Neg. II), two crows (13 and 18) performed much more successfully during the first session than they had during their first exposure to this contingency. While the other two crows did not show substantial changes in this respect, both had performed

Fig. 1. The per cent of reinforcers obtained for each crow under positive (Pos.) and negative (Neg.) response contingencies. The data for all sessions are presented, except, that Pos. I represents the final three of eight sessions under this contingency.

Fig. 2. The per cent of reinforcers obtained under positive and negative response contingencies for the three pigeons that had no training before this experiment. The data for all sessions are presented, except that Pos. 1 represents the final three of eight sessions under this contingency.

very successfully during their first exposure to the negative contingency.

The three pigeons with no training before this experiment (Pigeons 23, 24, 25) also showed quite rapid and successful adjustment when placed under the negative contingency. Figure 2 shows that Pigeons 24 and 25 met the criterion in the minimum number of sessions, and Pigeon 23 required only five sessions to do so. Two birds (Pigeons 23 and 25) showed increasingly successful performance during subsequent exposures to the negative response contingency, but Pigeon 24 performed less successfully than it had initially.

The crows appeared to display greater initial sensitivity to the negative response contingency than the pigeons, and a Kruskal-Wallis analysis of variance that compared the mean percentage of reinforcers obtained during the first three sessions under the negative contingency revealed that the difference between groups was statistically significant ($H = 3.128$, $df = 1$, $p < 0.05$, one-tailed).

The two pigeons with extensive CRF training also displayed fairly rapid and successful adjustment to the negative response contingency. Figure 3 shows that the birds met the criterion in four (Pigeon 3) and five sessions (Pigeon 19), respectively. Both birds also showed some improvement during the first session under the negative response contingency, when the first and second exposure to this condition are compared.

If the five pigeons considered so far are taken as a group and compared to the crows on the basis described above, a Kruskal-Wallis test indicates that the crows performed more

successfully during the first three sessions under the negative response contingency ($H = 6.00$, $df = 1$, $p < 0.01$, one-tailed).

The three pigeons with extensive histories of intermittent reinforcement performed much less successfully under the negative contingency than any of the other birds in this experiment. As shown in Figure 4, Pigeon 21 eventually met the criterion under the negative contingency. However, when this bird was exposed again to the negative contingency, it quickly ceased responding, and thus obtained a large percentage of the available reinforcers.

Pigeon 42 also displayed ineffective performance during the first 10 sessions under the negative contingency, generally receiving less than 10% of the reinforcers possible. During the eleventh session a program error occurred, as mentioned earlier, in which the keylight remained on throughout the sessions, while reinforcement for not responding occurred on the same schedule that it had previously. Under this condition, the bird responded rapidly and consistently for approximately the first half of the session, thus receiving few reinforcers. As responding extinguished, reinforcers were obtained with increasing frequency over the latter half of the session. During subsequent sessions under the negative contingency, with the correct program in effect, Pigeon 42 continued to receive substantial numbers of reinforcers, and was able to meet the criterion in four more sessions. This bird also showed a rapid decline in responding, and thus effective performance when it was re-exposed to the negative contingency.

Fig. 3. The per cent of reinforcers obtained under positive and negative response contingencies for the two pigeons that had only CRF training before this experiment. The data for all sessions are presented, except that Pos. 1 represents the final three of eight sessions under this contingency.

Pigeon 20 responded persistently under the negative contingency and never received more than 10% of the reinforcers possible, except during sessions in which the program error was deliberately employed. It was reasoned

that this procedure might produce the same type of permanent change in behavior that it had with Pigeon 42. While this procedure did produce similar effects during two of three sessions in which it was employed, the effects did

Fig. 4. The per cent of reinforcers obtained under positive and negative response contingencies for the three pigeons with extensive histories of intermittent reinforcement. The data for the sessions marked with an asterisk indicate the presence of a special procedure (see text for description). The data for all sessions are presented, except that Pos. 1 represents the final three of eight sessions for Pigeons 20 and 21, and the final three of 23 sessions for Pigeon 42.

not generalize when the normal procedure was re-instated.

It is apparent that these three pigeons differed from the other pigeons as well as the crows, in their sensitivity to the negative response contingency. This suggests that an animal's reinforcement history, and particularly its experience with response-reinforcer contingencies, may have a significant influence upon its successful adjustment to a negative response contingency.

DISCUSSION

The present findings demonstrate that under the conditions studied here, both crows and pigeons are quite sensitive to a negative contingency between a response and a positive reinforcer. Thus, the findings are in essential agreement with most of the recent reports on negative automaintenance (Barrera, 1974; Gamzu and Schwam, 1974; Hursh, *et al.*, 1974; Stiers and Silberberg, 1974; Wessels, 1974). While all of these experiments show that the frequency of responding decreases under a negative contingency in comparison to either response-contingent or noncontingent reinforcement, the amount of reduction was rather slight in one case (Stiers and Silberberg, 1974), but quite substantial in all others. The present results seem to be at the extreme in terms of the rapidity and extent of response decrement under the negative automaintenance procedure (*i.e.*, greatest sensitivity to the existing contingencies), particularly for the crows. Each of the four crows received 90% or more of the reinforcers during the third session under the negative response contingency.

One possible basis for the difference between the present findings and those of Williams and Williams (1969), is that the present birds received more extended training under the positive response contingency, which corresponded to their FR 1 timeout procedure. Thus, the present animals had more opportunity to learn about the nature of the contingency between pecking and reinforcement.

Another salient finding was that pigeons with long histories of intermittent reinforcement had the greatest difficulty adjusting to the negative response contingency. The persistence of responding in these birds is not surprising when one considers that they had rou-

tinely emitted large numbers of key pecks, in prior experiments, of which only a few were reinforced. Therefore, successful adjustment to the negative response contingency would seem to pose a more difficult problem in discrimination for these birds. It seems particularly noteworthy that pigeons that required extended exposure to the negative contingency before learning not to peck nevertheless adjusted their behavior as successfully as the other pigeons when they were re-exposed to this contingency.

It has been suggested that differences between crows and pigeons in these experiments may arise because of the differences in patterns of feeding behavior displayed by these species in their natural habitats (Powell, 1974). The apparent intractability of pecking by pigeons in the presence of stimulus-reinforcer pairings seems to have been overstated in early reports (Herrnstein and Loveland, 1972; Williams and Williams, 1969). This is exemplified in the statement by Herrnstein and Loveland that, "hungry pigeons peck a key more readily to avoid food than to avoid shock" (p. 382). Examination of their data shows, however, that pigeons pecked on only about 10% of the trials when a negative contingency existed between responding and food.

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