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Resurgence of responding after the cessation of response-independent reinforcement*

(extinction/operant conditioning/classical conditioning/autoshaping)

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ABSTRACT **In an autoshaping experiment, food-deprived pigeons pecked rapidly at a moving dot that preceded the delivery of food. When the moving dot and food were no longer correlated, the rate of pecking dropped nearly to zero. When, subsequently, no food was given, pecking reappeared at a high rate (nearly 200 pecks per min for each subject), the rate dropping again in subsequent sessions. In two other experiments, designed to clarify relevant variables, the effect was replicated. The data suggest that although response-independent reinforcement produces a decrement in responding, it does not reduce a tendency to respond under other conditions.**

In an experiment on what has come to be called autoshaping (1), conducted in 1946, a pigeon appeared to drive a spot of light across a wall when the excursion of the spot had frequently preceded the delivery of food (2). Recent experiments with rats and pigeons (to be reported elsewhere) only partially replicated the earlier observation and did not confirm that interpretation. The pigeons were probably following the dot rather than driving it. A surprising result in the last experiment in this series is the subject of this paper.

EXPERIMENT I

Method. Two male, adult, Racing Homer pigeons were subjects. Neither had served in laboratory experiments. The chamber was equipped with a feeder and dim houselight. On one wall to one side of, and several inches above the level of, the feeder opening, a 0.9-cm dot of white light was projected from behind the wall on a clear plastic panel 12 cm long and 2 cm high (Fig. 1). The dot moved either to the right or left at various speeds.

After adaptation and hopper training, food was given whenever the spot reached the end of its excursion. A trial consisted of (*i*) the appearance, excursion, and disappearance of the dot, followed at once by (*ii*) 4-sec access to food, followed by (*iii*) a blackout averaging about 1 min 20 sec. There were about 40 trials each day during 1-hr sessions. Events were controlled by electromechanical equipment and a PDP-8 computer.

Results. The subjects began pecking the dot in an unusually short time—subject 1 (272 WP) on the 6th pairing and subject 2 (273 WP) on the 23rd. Rate of responding stabilized after four sessions. During subsequent pairing conditions the rates were approximately 250 and 450 pecks per min for each bird, respectively. The speed and direction of the dot were occasionally changed, but the result was irrelevant to the resurgence phenomenon and hence will not be reported here. Dot and food were paired for 52 sessions, during the last 10 of which the dot moved from left to right, away from the food hopper, at a rate of 3 cm/sec.

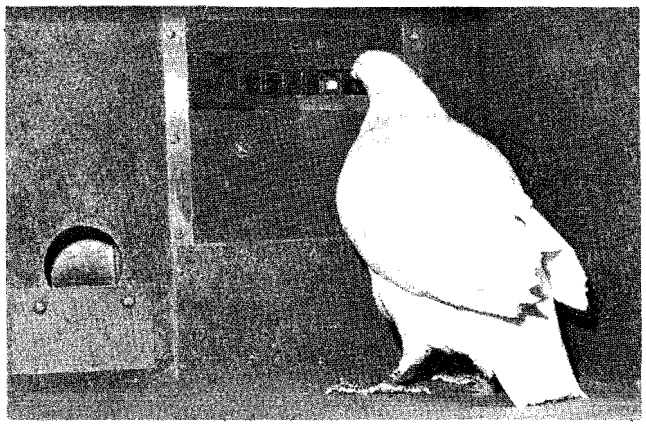

FIG. 1. A pigeon pecks a small (0.9 cm) dot of white light moving away from the feeder recess (lower left) at the rate of 1.7 cm/sec. During the actual experiment, the chamber was almost completely dark.

In order to ensure that pairing was responsible for maintaining the pecking, we presented the dot and food independently of each other, at the same average rate as before (about 40 times per session). Extinction was virtually complete after a few sessions, although between 5 and 15 responses per min still occurred, presumably as the result of occasional adventitious pairings of food and dot.

When, to test this explanation, we presented the dot as usual but gave no food during the session, rapid responding was resumed after about 15 min. Fig. 2 shows cumulative record segments for the two birds from three consecutive daily 1-hr sessions. The segments on the left, for the last extinction session, show little responding. The middle segments are from the first session in which only the dot was presented. Each bird waited about 15 min without responding and then began to peck at a rate typical of that under the paired conditions. The segments on the right are from the next session, in which, again, only the dot was presented. Pecking still occurred at a high rate, though extinction had begun.

Averages for the last five sessions under paired conditions are shown at the left in Fig. 3. Extinction was virtually complete after seven sessions for 272 WP and after two sessions for 273 WP. The birds pecked between 5 and 15 times per min for the remaining six sessions for the first subject and nine for the second. The resurgence in rate after food presentations were discontinued is shown in the graph on the right in Fig. 3. The

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* Based on a paper presented at the 51st Annual Meeting of the Eastern Psychological Association, Hartford, CT, April 1980. Similar work using a stationary stimulus was recently reported at the November 1979 Meeting of the Psychonomic Society by L. L. Lindblom and H. M. Jenkins and is described in Lindblom's master's thesis (McMaster Univ., Hamilton, Ontario, Canada).

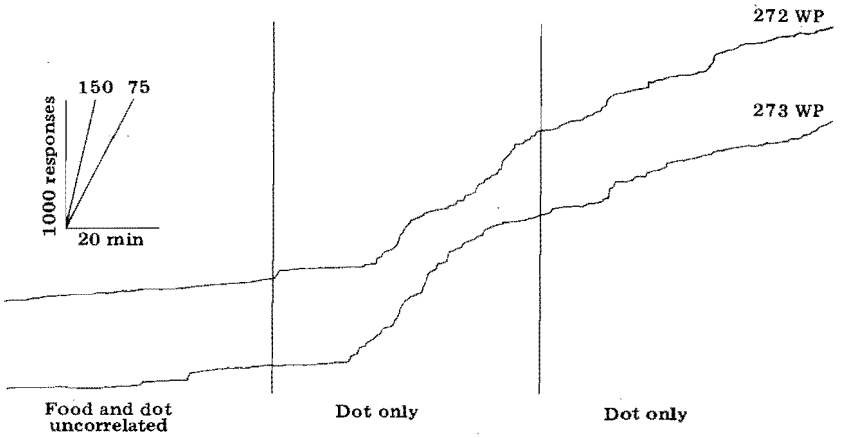

FIG. 2. Cumulative record segments for the two subjects in experiment I. The segments on the left are from the last 1-hr session in which the food and dot presentations were uncorrelated and show virtually no responding. Segments in the center are from the next session, in which only dot presentations occurred. The subjects paused for between 10 and 15 min and then began to peck at high rates. Segments on the right are from the next session, in which a second extinction has begun.

session averages were 158 responses per min and 188 responses per min, respectively. Extinction then followed during the dot-only condition. Thus, a high rate of responding was restored by the cessation of free food.

EXPERIMENT II

Given the histories of the birds in experiment I, the resurgence of pecking could have been due to several possible sequences of conditions: (*i*) response-independent reinforcement, followed by cessation of response-independent reinforcement and presentation of a salient stimulus, (*ii*) uncorrelated presentations of the stimulus and reinforcer, followed by the cessation of reinforcement and continuing presentations of the stimulus, or (*iii*) stimulus–reinforcer pairings, followed by uncorrelated presentations of the stimulus and reinforcer, followed by the cessation of reinforcement and continuing presentations of the stimulus (as in the first experiment).

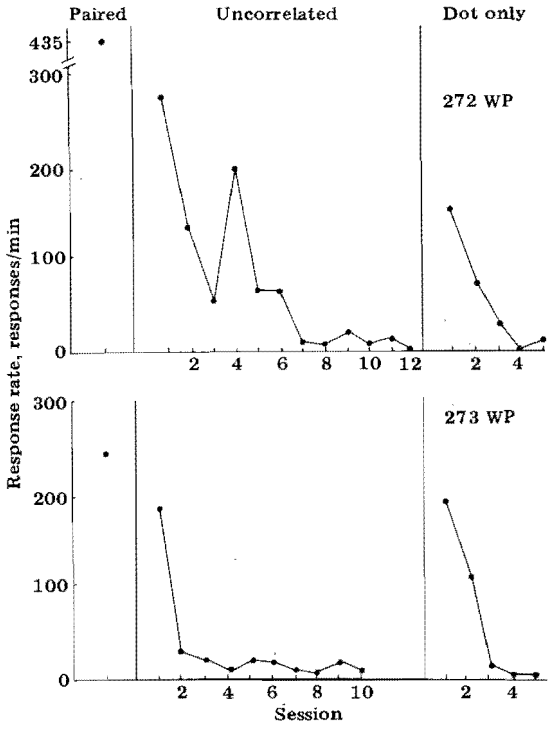

FIG. 3. Average rates of responding for the three conditions of experiment I. The average rate of responding over the last five sessions in which the dot and food were paired is shown in the left-most portion of each graph. There was a decrement in responding when the dot and food were presented independently. The right portions of the graphs show a subsequent resurgence in responding when response-independent food was discontinued, followed by a second extinction.

In a further experiment, using three naive Silver King pigeons with no previous history in the chamber, only a dim houselight was illuminated for 17 consecutive daily 1-hr sessions. Then the moving dot was presented for three sessions (moving from left to right at a rate of 1.7 cm/sec). The pigeons did not peck the spot.

The birds were then hopper trained, and food was presented in a response-independent manner for 15 sessions (4-sec hopper operations about 40 times per hr). Then, once again, the moving dot was presented for three sessions (at the same speed and direction as above) with no presentation of food. If the resurgence effect were a "frustration" phenomenon (3) or a species-specific reinforcer-withdrawal effect such as polydipsia (4), we should expect pecking at this point. None occurred.

In a third condition the dot and food were presented independently for 15 sessions, followed, once again, by three sessions in which only dot presentations occurred. No pecking occurred during this test.

Finally, all three of the elements in experiment I were restored. The moving dot was paired with food (the dot moved from left to right, away from the food hopper at a rate of 1.7 cm/sec) until each subject had spent from 20 to 25 sessions pecking the dot (half the number of sessions of experiment I). Then we extinguished pecking by presenting the food and dot independently of each other, and, after pecking was extinguished, we discontinued presentations of free food.

The results are shown in Fig. 4. Resurgence is indicated for subject 1 (278 WP) and possibly for subject 2 (279 WP) but not for subject 3 (280 WP). Either the large effect we observed in experiment I was anomalous, perhaps restricted to the breed we had used (Racing Homer) or, and this seems more likely, prior exposure to the dot alone minimized the effect in experiment II. This may explain why no pecking occurred during the second and third conditions of the experiment. In other words, we have not eliminated the possibility that resurgence is a frustration or adjunctive phenomenon.

EXPERIMENT III

To check the possibility that the large effect in experiment I was not replicable with pigeons other than Racing Homers, we repeated the experiment with three naive White Carneaux pigeons (292 WP, 293 WP, and 294 WP). We used the fewest conditions that seemed necessary to produce the effect, namely: (*i*) pairing, followed by (*ii*) uncorrelated presentations, followed by (*iii*) presentations of the dot alone. The dot moved from left to right at a rate of 1.7 cm/sec in all conditions. Two of the three subjects showed the same effect as in experiment I. Some re-

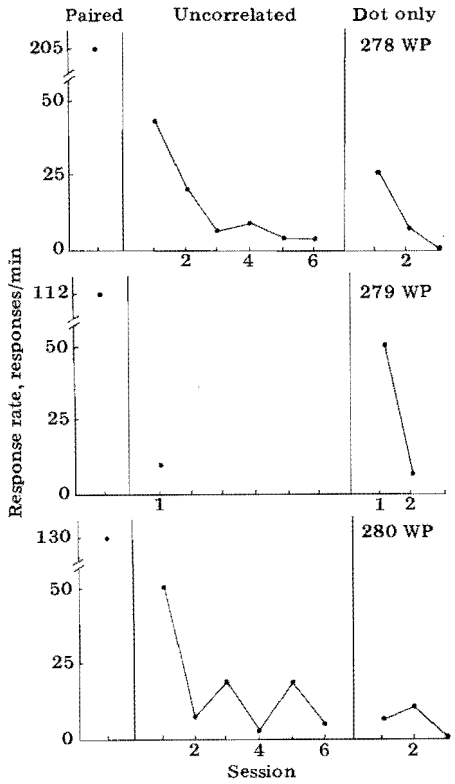

FIG. 4. Average rates of responding for the three subjects in the fourth condition of experiment II. Resurgence is indicated for the first and possibly the second subjects.

surgence was evident in the third subject. During pairing, the average rate of responding was between 200 and 275 per min for all subjects. Between four and nine sessions of uncorrelated presentations were then conducted, which reduced the rate of responding to between 5 and 15 responses per min. Given the dot alone, subjects 292 WP and 293 WP did not peck for between 8 and 20 min and then began pecking at high rates throughout the remainder of the session. The average session rates for these subjects were 98.3 and 85.5 per min, respectively. A second extinction was complete within four sessions.

DISCUSSION

We conclude that:

(*i*) The resurgence effect is replicable.

(*ii*) It is not easily accounted for by current knowledge about either operant or respondent behavior. Current formal theories of response strength would not predict resurgence (5, 6).

(*iii*) It does not necessarily originate through Pavlovian contingencies. It may follow a history of response-dependent reinforcement.

(*iv*) It may be related to a history of adventitious reinforcement, which necessarily occurs in automaintenance.

(*v*) It may be a frustration or adjunctive phenomenon, but if so, it requires a history of pecking the conditioned stimulus.

(*vi*) It may be due to a restoration of conditions present during conditioning, as in spontaneous recovery (7), though it is difficult to specify the details or to suggest relevant tests at this point.

(*vii*) The data suggest that response-independent reinforcement does not "extinguish" responding in the usual sense, though it produces a substantial decrement. Apparently the tendency to respond under other conditions remains.

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