AVERSIVE CONTROL WITH THE PIGEON¹

H. S. HOFFMAN and M. FLESHLER

THE PENNSYLVANIA STATE UNIVERSITY

Previous research using aversive stimulation with pigeons has been concerned with punishment and with conditioned anxiety (Brush, Bush, Jenkins, John, & Whiting, 1952; Ferster & Skinner, 1957). Punishment involves the pairing of an aversive stimulus with a response. Conditioned anxiety, on the other hand, is contingent upon the presentation of a stimulus which has previously been paired with an aversive stimulus. Both of these operations typically act to suppress ongoing positively reinforced behavior.

In contrast, the present research has focused upon the reinforcing effects of the removal of aversive stimulation. The sequence of studies reveals the simultaneous refinement of techniques in three general problem areas: (1) the method of aversive stimulation; (2) the response measured; and (3) the actual experimental manipulations.

Electric shock was used as the aversive stimulus, and the method of application was gradually improved until an efficient, reliable technique was found. The first technique attempted was shocking the pigeons' feet through the grid floor. Various arrangements of grids, electrode pastes, and shocks were used in an effort to obtain reliable shock; but, in general, such shocks did not yield consistent effects. We next turned to electrodes fastened to the toes of one foot. Although this method provided adequate stimulation, the electrodes occasionally broke loose, because of the vigorous movements to which they were subjected during shock. The method was then changed to one in which a loop of 0.125-inch-thick aluminum wire was permanently fastened around the base of each wing.² The loops were adjusted so as to be snug, but not to produce swelling. Shock was administered to the bird via a set of leads which terminated in spring-loaded clips. These clips were attached to the wing bands at the start of each experimental session. This system has proved to be a convenient and reliable method of shock stimulation with the pigeon.

In our initial efforts at aversive control, we attempted to develop a situation in which the bird would peck a key to terminate a pulsing shock.³ We worked with satiated naive birds and used a method of successive approximation (shaping). The *E* would turn on shock and maintain it at a level which yielded fairly vigorous movements but not flight. The *E* would then wait until the bird approached the key during its essentially random movements. At this point, shock would be terminated. After a few such reinforcements, the bird usually was to be found in the vicinity of the key shortly after shock was turned on. At this point the *E* would withhold reinforcement until the bird had emitted a response which approximated the desired key peck.

Invariably, the results of such hand shaping were disappointing. Either the behavior would become superstitious, or responses would cease to be emitted. Thus, a bird might learn to place its beak within millimeters of the key; but if it were not reinforced con-

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²Suggested by Dr. Wendell I. Smith, Bucknell University (personal communication).

³A pulsing A.C. shock (about 1 per second) seemed, in general, to yield more consistent aversive effects than did steady-state shock. In all of the studies reported in this paper, shock was generated by a Foringer apparatus. However, we have recently begun to use a Variac, without external series resistance, to supply shock. In general, the wing-band technique of shock administration yields a relatively constant resistance (between 15,000 and 30,000 ohms). We find that with the Variac set at about 10 volts, the shock is sufficient to produce the desired effect with most birds.

sistently for this behavior, it would lose the response completely. On the other hand, repeated reinforcement strengthened only the behavior of placing the beak near the key, so that even when operant pecks occurred and were reinforced, the increment in response strength would be insufficient to change the previously acquired topography (placing beak up to key).

The most readily observable problem in shaping under aversive stimulation is that the aversive stimulus elicits a variety of unlearned responses, any of which might compete with the desired behavior. This does not seem to be the case in most drive states where positive reinforcement is used.

A second factor is concerned more directly with the shaping process. In shaping, it is often necessary to withhold reinforcements until unwanted responses drop out. Then, the *E* can selectively reinforce the one response which most nearly approximates the desired behavior. Under food deprivation, the process is straightforward. When the *E* withholds reinforcement, the bird will usually emit a long-enough series of responses to yield a response which qualifies for reinforcement. The situation in shaping under aversive stimulation is somewhat different. If reinforcement is withheld (by permitting shock to stay on after a response has occurred), responding often stops immediately. Apparently, the failure to terminate shock is functionally equivalent to punishment. The effect is most pronounced in the early stages of shaping. In later stages the response persists a bit, but seldom to an extent comparable with that which obtains with shaping under food deprivation.

These factors converge to make for a situation in which hand shaping is inefficient. We needed a technique for slowly and precisely shifting the criteria for reinforcement and reducing the number of unreinforced responses, but, at the same time, without permitting the behavior to become superstitious. We have resolved the problem in two ways: (1) by requiring a "simpler" response; and (2) by using mechanical aids in the shaping process.

The methods we use involve a light-beam photocell arrangement. Figure 1 illustrates the significant details of the apparatus. Here, the bird is reinforced by shock termination when it lifts its head into the beam.

The headlifting response has a number of properties which make it useful in studies of aversive control with pigeons. For one thing, its topography and location in space can be controlled automatically. But perhaps more important is the fact that without prior training a rudimentary form of the response is occasionally emitted during shock itself. While the

Figure 1. The photocell apparatus.

operant level of headlifting during shock is not high, the response quickly undergoes an increase in strength when reinforced by shock termination.

We develop the headlifting response in stages. First, the bird is hand-shaped over to the beam at the front end of the box. In this phase of the shaping process the beam is at the normal height of the bird's head and can be easily broken when the bird gets into the correct position. (At this and in all subsequent stages of the work with photocells, the response was defined as the entry into the beam. Holding was not reinforced.)

When the onset of shock causes the bird to enter the beam with short latency, the photocell is moved upward; and after short latencies are achieved at this new level, it is again moved higher. The process is continued until the photocell is at a height such that the pigeon does not break the beam in its movements about the box but it can make a clear-cut response which will break the beam.

Figure 2 shows the latencies of the escape responses during the first session with a naive satiated bird (a small Homer). It also illustrates the speed with which shaping proceeds with most birds. In this figure, each point represents the mean latency of headlift for 10 trials. The schedule was such that a response provided the bird with 8 seconds of escape from shock. When shock came on, however, it remained on until terminated by a headlift.⁴

In Fig. 2, hand shaping was begun at *a* and the photocell was used from *b* onward. At *b* the photocell was 7 inches above the floor of the box; at *c* the photocell was set at 9 inches, where it remained for the rest of the session. This record is typical of the ones we have ob-

Figure 2. Mean latencies of escape responses during first session with a naive satiated bird.

⁴The circuit was also arranged so that responses during the "safe period" would postpone the onset of shock for another 8 seconds. Despite this contingency, however, we observed no such "avoidance" responses during this or subsequent sessions. We have not yet tested the effects of prolonged exposure to the schedule.

tained under schedules where the response provides a fixed interval of no shock and there is no warning stimulus. As this record shows, the bird quickly learned to escape, and we see, also, a gradual shortening of the latencies.

For all birds, the response has a fairly stereotyped topography. With the onset of shock the head shoots up. This interrupts the beam and terminates the shock. However, the bird does not withdraw its head when the shock stops; rather, it continues to interrupt the beam for some seconds, and then very gradually draws its head downward.

One bird was run in the photocell apparatus for 11 sessions, each of which lasted from 2 to 4 hours. The program for this bird differed from the previous ones in that shock was preceded by a warning stimulus, consisting of a 1000-cycle-per-second tone at about 50 decibels sound-pressure level.⁵ Shock began 4 seconds after tone onset. Responses during this 4-second interval terminated the tone and prevented the shock from coming on. Responses that occurred after shock began terminated both the tone and the shock. The next tone-shock combination appeared 12 to 20 seconds later, depending upon the latency of the previous response. Responses during silence had no effect on the schedule.

In the first session, the pigeon's reactivity to a wide range of shock was tested and the shock level was set. The schedule was then started with the photocell in such a position that if the pigeon was at the front of the box, the beam would be broken. When the pigeon broke the light beam consistently with a short shock latency, the photocell was moved higher; and after the latencies were short at this level, it was again moved. However, although this third height was within easy reach for the pigeon, it was too large an increment, and the bird shortly stopped making the earlier reinforced responses. Shaping was begun again the next day; and by lifting the cell in very small increments, it was possible to obtain headlifting by the end of the session. Each time the photocell was raised, a long period of stabilization was permitted before the next increment was added. As a result, two more sessions were required before the final height was reached.

The bird's reaction to a given level of shock was quite variable. For this reason, it was necessary to monitor the early portion of each session to insure that the shock was intense enough to yield short escape latencies. In general, for escape to occur, shock intensity had to be high enough to cause a sharp jerk of the wings with each pulse; and, even then, the bird might occasionally fail to respond.

It was observed that small changes in the over-all stimulus situation resulted in unusually long latencies. If, for example, an observer entered the room, escape latencies might show a large increase. This is somewhat surprising, considering the levels of shock that formed the background for these contaminating stimuli.

For purposes of analysis, the bird's headlifting responses have been classified in three ways: interval responses, avoidance responses, and escape responses. Interval responses occurred during silence and did not affect the schedule. Avoidance responses occurred during the tone, but before shock came on. They turned off the tone and prevented shock onset. Escape responses occurred during tone-shock, and turned both off. In general, interval responding was negligible.

Figure 3 is a portion from the middle of the record for the third session which typifies responding for that session. Here, the bird is escaping with short latency but not avoiding. Through the long course of responding that ensued, the majority of escape latencies were

⁵With other birds a tone of the same frequency and amplitude had previously been used as a discriminative stimulus for food-reinforced behavior.

Figure 3. Responses during the third session of avoidance schedules.

about 1 second, although longer latencies (up to 10 seconds) were scattered throughout with no apparent order. Exceptionally longer escape latencies were usually limited to the beginnings of sessions and to instances where shock adaptation had taken place. In these cases, the shock level was increased and subsequent escape latencies decreased.

Figure 4 graphically depicts the very slow emergence of the avoidance response. It is a plot of the percentage of avoidance responses per 100 tones. As this figure indicates, the number of these responses remains at a low operant level over Sessions 3, 4, 5, and 6, although local rates vary somewhat. Sessions 7, 8, and 9 show an increasing rate of avoidance. (The programming circuit failed in Session 9, cutting the session to only 50 tones.) Session 10 has a very low avoidance rate at first; but, by the end of the session, the rate had reached 30%. In Session 11 the rate quickly increases to a very high level. Figure 5 shows

Figure 4. Development of the avoidance response.

Figure 5. Responses during the 11th session of avoidance schedule.

a part of the actual record from this period. In this session, as many as 11 avoidance responses occur in a row, and the local rates tend, in general, to be high.

Shortly after this new level of avoidance behavior had been reached, a second equipment failure forced us to terminate the experiment.

These studies show that aversive stimulation may be used to develop and maintain operant behavior in the pigeon. In the past few years, Russian and Japanese investigators (Bokov, 1955; Tsuge, Shima, & Koga, 1957) have begun to report success at respondent conditioning in pigeons using shock as the unconditioned stimulus, but they report difficulties and the necessity for special experimental techniques. Moreover, these investigators interpret their results as suggesting fundamental differences along the phylogenetic scale. While the very slow development of avoidance in our own work is consistent with their interpretation, other factors, such as incomplete acoustic isolation, may have slowed the learning.

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*These articles are not generally available in translation. We have a small supply of our own working translations, however, and copies of these may be obtained by writing to the senior author.