ENHANCEMENT OF OFF-KEY PECKING BY ON-KEY PUNISHMENT¹

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Under a variable-interval food reinforcement schedule, some of a pigeon's pecking responses land on the wall area adjacent to the response key. These off-key pecks increase in frequency when key responses produce shocks and decrease when shock is removed.

Bachrach (1966) reported, and we have often informally observed, that some of the pecking responses made by pigeons land on the wall area adjacent to the response key of the standard operant conditioning chamber. These off-key pecks appeared to increase when shock was introduced contingent upon key pecking. In view of the implications for punishment theory of this informal observation, two experiments were conducted to measure objectively the off-key pecking phenomenon in the context of a punishment contingency for key-pecking responses.

METHOD

Subjects

Four experimentally naive Silver King pigeons, maintained for the duration of the experiment at 75% of free-feeding weight, were used in Exp. I; three similar birds were used in Exp. II.

Apparatus

Experiment I. A standard, two-key, Lehigh Valley Electronics pigeon chamber and relay control circuitry were used. The shock source for the punishment procedure was a 115-v, 60-cycle ac signal dropped through a series of resistors to produce a constant current value of 1 to 12 ma.

The value used was a 5-ma, 30-msec signal as measured when a 1 K resistor was in place of the bird. The shock was delivered to the bird

via a telephone cable from the ceiling of the chamber to internal electrodes (Azrin, 1959).

To measure off-key pecking responses, a false wall panel was spaced 4 mm in front of the regular wall of the chamber. The false wall panel had a hole the same size as the regular response key. Any pecks on this false panel produced vibrations that were picked up and transformed into an analog voltage signal by a crystal phonograph cartridge and modified phonograph needle. The analog signal was amplified and recorded on a TR-711 Technirite Electronics analog recorder. Key pecks were recorded on an adjacent digital channel and on impulse counters.

Experiment II. The same apparatus was used in Exp. II, except that the device used to pick up the pecks on the false panel was modified. Two difficulties with the phono cartridge device prompted the change in recording procedure used in the second experiment: (1) the force requirements necessary to activate the phono cartridge depended upon the spatial relationship between the peck and the phonograph needle; (2) the solid false panel did not permit an assessment of the location of the off-key pecks on that panel.

The system adopted in Exp. II is seen in Fig. 1. The panel has been split into three different sections labeled 4, 5, and 4 cm in width respectively from left to right. Each section of the false panel is, in effect, the paddle of a standard Lehigh Valley response key (LVE 1348) hinged by a 0.10160-mm shim stock and a microswitch arrangement. A peck of approximately 5-g force and a 2-mm displacement of the panel would activate the microswitch.

In recording off-key pecking, it was necessary to arrange the recording circuitry so that any off-key peck that occurred 50 msec before

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Fig. 1. Picture of wall panel, false wall panel, and associated dimensions as used in Exp. II.

or after a key peck was gated out. This prevented the counting of artifactual off-key pecks in which the base of the beak might hit the wall panel at about the same time as the tip hit the response key.

Procedure

Experiment I. After a session of standard shaping (successive approximation procedure), one session of 30 reinforcements delivered on a continuous schedule (CRF) was given. The reinforcer was a 3-sec presentation of grain. Then, daily 30-min sessions were conducted for the remaining three phases of the experiment.

Phase 1 consisted of a variable-interval 1 min (VI 1-min) food reinforcement contingent upon the key-pecking response. This phase continued until eight consecutive days of relatively stable performance had been maintained.

In Phase 2, the 5-ma, 30-msec shock contingent upon each key peck was introduced. Food reinforcement was maintained on the VI 1-min schedule. This phase continued until performance recovered to the prepunishment baseline or until eight days of relatively stable performance.

Phase 3 consisted of the removal of shock and the maintenance of the VI 1-min food schedule. Bird 4 did not suppress with the 5-ma shock and after 10 sessions in Phase 2, the intensity of shock was increased to 8 ma.

Experiment II. The procedure of Exp. I was used with the following exceptions: (1) the modification of the false panel device permitted measurement of the spatial distribution of the off-key pecks over the three sections of the panel; (2) the shock intensity was reduced to 4 ma, 30 msec; (3) the amount of off-key pecking obtained during the shaping and CRF sessions was recorded to trace the origin and

Fig. 2. On-key and off-key pecks per minute during prepunishment, punishment, and postpunishment phases of Exp. I.

development of off-key pecks during training; and (4) Phase 3 shock removal was not considered in the second experiment.

RESULTS

Experiment I

The performance of each of the four subjects during each of the three phases of the experimental procedure is illustrated in two-session blocks in Fig. 2. Only the last eight sessions of Phase 1 training are presented.

As had been informally observed, there was a substantial amount of off-key pecking under the VI 1-min food schedule in Phase 1. The introduction of shock produced an immediate decrease in the rate of key pecking and an increase in off-key pecking. This increase in off-key pecking developed gradually over sessions with the exception of Subject 1, which revealed a very rapid increase within two sessions. The removal of shock in Phase 3 produced an immediate increase in the rate of key pecking and a decrease in the rate of off-key pecking.

Of interest also is Bird 4, which did not reveal a substantial suppression in key pecking with the introduction of shock, and did not increase the rate of off-key pecking to any degree. The subsequent introduction of a more intense shock (8 ma) resulted in a suppression in key-pecking rate and an increase in off-key rate.

Experiment II

The performance of the three birds in Exp. II is presented in Fig. 3 as plotted in two-session blocks.

These data replicate the essential findings of Phases 1 and 2 in Exp. 1. Bird 1 revealed a threefold increase in the rate of off-key pecking after 12 sessions of punishment. Bird 2 revealed an immediate, dramatic increase in off-key pecking rates within two sessions.

Although Bird 3 revealed no increase in off-key pecking, the 4-ma shock produced a substantial suppression in key pecking. As such, this subject is the single exception thus far to our observation that a shock sufficient to suppress key pecking will produce an increase in off-key pecking. After 10 sessions with the 4-ma shock intensity, an 8-ma signal was introduced in an attempt to drive up the rate of off-key pecking in a manner similar to that accom-

plished with Bird 4 in Exp. 1. As is obvious in Fig. 3, the increase in shock intensity completely suppressed on-key pecking, yet the bird continued to make one to two off-key pecks per minute for the duration of the experiment (10 additional sessions).

Although off-key responses increase with the introduction of shock, this increase might have resulted from wing flapping and other shock-elicited responses rather than pecks. The data in Fig. 4 show the average number of off-key pecks as the pecks were distributed on the three sections of the false panel. This concentration of off-key pecks on the center panel during the shock sessions argues strongly against the suggestion that wing flapping and other shock-elicited behaviors are being measured. The elicited behaviors would be expected to be more randomly distributed across the three sections.

Figure 5 is an event record of the first 15 min of the second punishment session for Bird 2. If shock-elicited behavior is what is being measured in this situation, it would follow that the greatest frequency of such behaviors would occur immediately after the shock event (key peck). An examination of the data in Fig. 5 indicates that this is not the case. During the first 5 min of the session, when the inter-response intervals for key pecks are longest, the majority of off-key pecks are seldom observed to follow shock closely in time. In fact, observation of the bird indicated that the response to shock was a recoil from the response key rather than toward it. Later in the session, when the interresponse times are shorter, it is more difficult to determine the temporal relationship between shocks and off-key pecks.

A record was kept of the amount of off-key pecking which occurred during the shaping and CRF training sessions. By definition, a certain number of successive approximations to the off-key response must be reinforced during shaping. It seems likely, therefore, that the off-key pecking behavior originates during shaping and is maintained during subsequent sessions. Bird 1 emitted 95 off-key pecks during one shaping session, Bird 2 emitted 63, and Bird 3 emitted 130 and 210 during the two shaping sessions required. These three subjects had 20, 31, and 52 off-key pecks respectively during the one CRF session of 30 reinforcements. Figure 3 shows a slight downward

Fig. 3. On-key and off-key pecks during prepunishment and punishment phases of Exp. II.

trend in the rate of off-key pecking during subsequent VI 1-min sessions. The final rate of off-key pecking before shock does not have any relationship with these earlier recorded off-key pecks.

It might be noted that off-key pecking has been observed to be prominent also during the

early phases of an autoshaping procedure which has been described by Brown and Jenkins (1968) as an automated method of training the bird to peck the key. Hence, the off-key pecking observed during shaping sessions in the present research would not seem to be a function of the shaping procedures used.

Fig. 4. Average number of responses per session on each of the sections of the false wall panel during prepunishment and punishment phases of Exp. II.

Fig. 5. First 15 min of second session of punishment for Bird 2 in Exp. II. Paper speed at 1 mm per sec.

DISCUSSION

This phenomenon has implications for several theoretical analyses of the effects of punishment. There have been two basic assumptions from which punishment theorists have started their analyses of the effects of punishment. In the strong version of the negative law of effect, which was initially suggested by Thorndike (1913), it was assumed that any event which was unpleasant or painful would weaken the response (or assumed S-R bond) which preceded that event. For a variety of reasons, which have been described by Schuster and Rachlin (1968), the negative law of effect in any of several possible strong forms was abandoned by more recent theoretical positions in favor of the alternative response hypothesis. The basic assumption of all versions of this latter hypothesis is that the organism actively develops some alternative mode of responding during the punishment contingency which has the property of escaping the primary aversive event and/or stimuli which have acquired aversiveness through pairings with the primary aversive event.

As Azrin and Holz (1966) suggested, there has seldom been any attempt to measure directly the assumed alternative mode of responding in research concerned with the effects of a punishment procedure upon performance. Instead, it has commonly been assumed that the absence of the punished response was a sufficient basis for inferring the presence of the alternative response.

The present data show that the animal will develop and maintain some alternative mode of responding during punishment. It should be emphasized, however, that the direct measurement of this behavior does not exclude the independent possibility that the negative law of effect is appropriate to account for the reduction in frequency of the punished response (key pecking).

The increase in off-key pecking during punishment raises several questions about the causal relationship between the decrease in frequency of the punished response and the increase in frequency of the alternative response. For example, do all responses in the organism's repertoire increase in frequency in the absence of the punished response? If not, a complete analysis of the effects of a punishment contingency needs an explicit set of rules

to predict which and how many responses will be selected and increase in probability. Given an accurate rule of response selection, under what conditions can one apply a competing response analysis in which the assumption is made that the suppression in punished behavior is caused by the development of a competing response or responses? It would seem to be a difficult, if not impossible, task to demonstrate such a causal relationship empirically, even under conditions similar to the present research where alternative responses are directly measured.

Various versions of the alternative response assumption have answers to some of the above questions; but we would suggest that none of them imply that a response like the off-key peck would be the response selected by the bird as an alternative mode of responding during punishment of key pecking. Guthrie (1935, p. 158) was quite explicit in stating that the simple pairing of the termination of the aversive event (shock) with a response was a sufficient condition for the development and maintenance of that response. He referred to elicited responses as prime candidates for such contiguous pairings. Miller and Dollard (1941) also suggested that elicited respondents paired with the reduction in pain (escape responses) were candidates for development during punishment. They differed from Guthrie in that a reduction in pain as well as contiguity was necessary for the development and maintenance of the alternative response. However, the data in Fig. 4 and 5 argue against the notion that off-key pecking is a shock-elicited behavior. The off-key peck does not appear to be systematically paired with shock offset in this context. These data, in conjunction with informal observations that respondent behaviors rapidly disappear in this situation, make the "elicited response" version of the alternative response hypothesis described by Guthrie or Miller and Dollard difficult to accept as accounts of punishment in these experiments.

Alternative to the single-process theories are a variety of two-process theories which assume that two types of learning take place during punishment. First, stimuli paired in time with the primary aversive event (shock) acquire aversive properties. Second, any response that escapes the acquired aversive stimuli develops and is maintained as an alternative mode of responding during punishment. The response

is typically thought of as an avoidance response in the sense that the primary aversive event is prevented or avoided by responses that escape the assumed acquired aversive stimuli.

Dinsmoor's (1954, 1955) version of the two-process position suggested that the proprioceptive feedback associated with the punished response becomes aversive and that the organism will make a response other than the punished response in order to escape such aversive stimulation and avoid the primary aversive event. Schoenfeld (1950) gave similar emphasis to the controlling properties of proprioceptive stimulation associated with punished responding. It is equally easy to isolate suggestions that salient environmental stimuli acquire aversive properties as a result of pairings with the primary aversive event or its many assumed after-effects (e.g., Estes, 1944, p. 36).

Although it is as difficult to refute the assumed properties of interoceptive stimulation as it is to prove that such properties are operating, the reported data do not readily support this position. Both responses are pecking responses and one would assume that the proprioception associated with a peck on the response key is nearly identical to the proprioception associated with a peck several centimeters to the side of the key; at least identical enough that common sources of feedback should acquire some aversive properties. Similarly, if the response key has acquired aversive properties, the implication is that the organism will develop modes of responding that remove that source of stimulation from its environment (e.g., turning its back). The data in Fig. 4 indicate that the bird does not even increase the distance of off-key pecking from the response key during punishment.

Although the preceding arguments and comments are tentative, they elucidate some of the problems which punishment theory has failed to define operationally. Most of the above questions are testable only in terms of the direct measurement of the alternative response. The present data represent a pre-

liminary analysis of the alternative response assumption in one situation, and as such (1) provide general support for the previously untested assumption that the organism does systematically develop an alternative mode of responding during a punishment contingency; (2) provide evidence against the notion that the alternative mode of responding the organism selects is one elicited by the primary aversive event; and (3) point out that the direct measurement of an alternative mode of responding during punishment is not a sufficient basis for assuming that the alternative response competes with the punished response and, as such, causes the suppression in punished response frequency.

REFERENCES

- Azrin, N. H. A technique for delivering shock to pigeons. *Journal of the Experimental Analysis of Behavior*, 1959, 2, 161-163.
- Azrin, N. H. and Holz, W. C. Punishment. In W. K. Honig (Ed.), *Operant behavior: areas of research and application*. New York: Appleton-Century-Crofts, 1966. Pp. 380-447.
- Bachrach, A. J. A simple method of obtaining a scatter distribution of off-key pigeon pecking. *Journal of the Experimental Analysis of Behavior*, 1966, 9, 152.
- Brown, P. L. and Jenkins, H. M. Auto-shaping of the pigeon's key-peck. *Journal of the Experimental Analysis of Behavior*, 1968, 11, 1-8.
- Dinsmoor, J. A. Punishment: I. The avoidance hypothesis. *Psychological Review*, 1954, 61, 34-46.
- Dinsmoor, J. A. Punishment: II. An interpretation of empirical findings. *Psychological Review*, 1955, 62, 96-105.
- Estes, W. K. An experimental study of punishment. *Psychological Monograph*, 1944, 57 (3 Whole No. 263).
- Guthrie, E. R. *The psychology of learning*. New York: Harper, 1935.
- Schoenfeld, W. N. An experimental approach to anxiety, escape, and avoidance behavior. In P. H. Hoch and J. Zubin (Eds.), *Anxiety*, New York: Grune and Stratton, 1950. Pp. ???
- Thorndike, E. L. *Educational Psychology*. Vol. 2. *The psychology of learning*, New York: Teacher's College, Columbia University, 1913.

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