OPERANT CONTROL OF VOCALIZING IN THE CHICKEN

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The vocal behavior of human infants and adults can be modified by operant conditioning (Krasner, 1958; Rheingold, Gewirtz, & Ross, 1959; Lane, 1960a). Recently, operant-conditioning techniques have been used in modifying subhuman vocal behavior. Schedules of reinforcement have been shown to control the rate of vocalizing in the parakeet (Ginsberg, 1960) and in the chicken (Lane, 1960c). The latter study showed, furthermore, that periodic presentation of food independent of responding, or presentation of an empty food magazine, did not sustain high rates of chirping. Evidently, food influenced the rate of responding because its delivery was contingent on the vocal response and not because of its effect as an eliciting stimulus.

The research reported here permits a more detailed analysis of the rates of vocal responding generated by schedules of reinforcement. The relations between chirping and pecking in the chick under concurrent and conjunctive schedules of reinforcement are also examined.

METHOD

Each of four Bantam chicks (at 80 per cent of free-feeding weight²) was housed in a sound-insulated compartment for sessions of from 30 minutes to 6 hours. The experimental space, modeled after that used by Ferster and Skinner (1957, p. 14), included a Plexiglas response key, which could be transilluminated by colored lights, and a food magazine.³ A microphone mounted in the ceiling controlled a relay which reacted to about 95 per cent of the audible chirps by pulsing programming and recording equipment. The rate of chirping was observed under a variety of schedules of food presentation.

RESULTS AND DISCUSSION

Figure 1a shows the cumulative record for the chirp response of one chick under a fixed-ratio schedule of reinforcement (FR 20). After three 1-hour daily sessions of conditioning under this schedule, Bird 1 was run on the day shown for nearly 4 hours, receiving a total of 323 reinforcements. When removed from the experiment, the chick had a tightly filled crop. As the session progressed, pausing increased in duration and the bursts of chirps had a slightly lower rate. The over-all rate declined as satiation was approached. This cumulative record, obtained during the course of satiation under a short fixed-ratio schedule, is comparable with data for the peck response of the pigeon reported by Ferster

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²The chicks were about a month old at the start of the research. Because they were growing, they would have starved after continued maintenance at 80% of their free-feeding weights, as was initially determined. Therefore, every month they were given free access to food in their home cage for 2 days, and a revised "running weight" was computed.

³Chick starter crumbles were obtained through the courtesy of Wirthmore Feeds, Waltham, Massachusetts.

and Skinner (1957, pp. 73-77). Three other chicks gave similar rates of vocal responding under fixed-ratio schedules of reinforcement for chirping.

Following conditioning under FR 20 (Fig. 1a), Bird 1 was reinforced for chirping under a fixed-ratio schedule of somewhat higher value, FR 33. Initially, the cumulative record (Fig. 1b) shows negative curvature as well as marked postreinforcement pausing, but the rate of responding stabilizes toward the end of the session. Extinction of chirping after conditioning on FR 33 was programmed on the following day (Fig. 1c). When chirping is no longer reinforced, the rate of responding declines.

The operant control of pecking and of chirping in the chicken may be compared by examination of Fig. 2. Figure 2a shows the stabilized chirp performance under FR 20 for Bird 3. Figure 2b shows the stabilized peck performance under FR 20 for the same bird. The cumulative records obtained when chirping is reinforced under FR 20 and when pecking is reinforced under FR 20 are not distinguishable without their appropriate labels. Although the comparison has some face validity as a test of the premise that the chirp response is an operant, the similarity between the cumulative records is in good part fortuitous. Figure 2c shows the rate of pecking in extinction following peck conditioning under FR 20, while Fig. 2d shows the rate of chirping in extinction following chirp conditioning under FR 20. The peck rate during extinction following FR 20 decreased rapidly (Fig. 2c). The chirp rate during extinction following FR 20 decreased gradually and cyclically for this bird (Fig. 2d), somewhat less evenly for another bird (Fig. 1c). Both records

Figure 1. Bird 1. A: Rate of chirping under a fixed-ratio 20 schedule of reinforcement (FR 20); session continued beyond satiation. B: Rate of chirping under FR 33. C: Rate of chirping during extinction following conditioning under FR 33.

Figure 2. Bird 3. A: Rate of chirping under FR 20. B: Rate of pecking under FR 20. C: Pecking and concurrent chirping during extinction following ratio reinforcement of pecking. D: Chirping during extinction following ratio reinforcement of chirping.

show a more gradual decline than is found characteristically with the peck response of the pigeon in extinction following fixed-ratio reinforcement (Ferster & Skinner, 1957, p. 58).

In Fig. 2c the rate of concurrent, unreinforced chirping was recorded during conditioning and extinction of pecking. The record shows that during conditioning of pecking, a low rate of chirping was also maintained, and that during extinction of pecking, the rate of unreinforced chirping also declined. Four sources of the nonindependence of the two responses may be considered: (1) Overlap in the topography of the two responses;⁴ however, the peck and the chirp are uniquely compatible in topography and show little overlap (Lane, 1960b); (2) Unconditioned elicitation of chirping by the food presented contingent on pecking; however, chirping continues after reinforcement of pecking is discontinued (Fig. 2c); (3) Overlap in the reinforcement history of the two responses; the chirping may have been a "superstitious" response (Skinner, 1948), maintained by the concurrent fixed-ratio reinforcement of pecking, and then extinguished when pecking was extinguished; (4) "Intrinsic" interaction among the probabilities of emission of compatible concurrent operants in condition-

⁴Ferster (1957) reports an experiment in which a chimpanzee operated two toggle switches under concurrent fixed-ratio (right hand), variable-interval (left hand) food reinforcement. In general, the cumulative records show independence of the two responses, although reinforcements in the variable-interval record tend to occur during pauses in the ratio performance. Sidman (1958) reports nonindependence of lever-pressing responses under concurrent variable-interval food reinforcement and shock avoidance.

ing and/or extinction; the concurrent decrement in the rate of chirping during the extinction of pecking may have an analogue in the phenomenon called "irradiation of inhibition" (Pavlov, 1927) in respondent conditioning.

Like other operants, the rate of emission of chirps may be brought under the control of discriminative stimuli. Fixed-interval and extinction schedules, each associated with a different-colored light, were alternated (mult FI 2 minutes ext 2 minutes). Initially, the rates of chirping observed during S_1 , the stimulus correlated with the FI condition, and S_2 , the stimulus correlated with the ext condition, are of approximately the same value (Fig. 3a). Terminally, high rates of responding are observed during S_1 , when food is presented contingent on chirping, and low rates of responding during S_2 , when food is never presented. However, S_2 is terminated by the presentation of S_1 , a stimulus paired with primary reinforcement. As a result, superstitious responding has an opportunity to develop in S_2 ; it probably accounts for the "scalloped" form of the S_2 intervals. Morse (1955) also has found scalloping in the extinction member of multiple schedules during discrimination training of key pecking in the pigeon. The scalloped appearance of the record during the FI component is typically obtained with other operants (Ferster & Skinner, 1957, p. 143).

Figure 3b shows the effect on the rate of chirping when the schedules of reinforcement associated with the discriminative stimuli were interchanged, extinction now programmed under S_1 and fixed-interval under S_2 . Differential responding was established within one

Figure 3. Bird 1. A: A visual discrimination (DISCR) with the chirp response obtained under a multiple schedule of reinforcement, with fixed-interval (S_1) and extinction (S_2) components (mult FI 2 minutes ext 2 minutes). B: Chirp performance during discrimination reversal. The same multiple schedule is used (mult FI 2 minutes ext 2 minutes), but the pairing of stimuli and components is reversed. C: Chirping during the extinction component (S_1) of the discrimination-reversal schedule (cf., Record B).

session. Figure 3c plots the extinction member of the multiple schedule separately. Initially, the extinction segments are scalloped in form, reflecting prior fixed-interval conditioning under this stimulus (Fig. 3a). The rate of chirping is soon extinguished in this member, however.

Multiple schedules may also be used to separate the effect of food as a reinforcer from its effect as an eliciting stimulus in controlling the rate of vocal responding. The contingencies of reinforcement for the two members of the multiple schedule are chosen so that disparate rates of responding are generated during the presentation of S_1 and S_2 , but the frequencies of reinforcement in S_1 and S_2 are the same. Figure 4 shows the rate of vocalizing

Figure 4. Bird 4. A: Rate of chirping under a multiple schedule with fixed-interval (S_1) and reinforcement-of-zero-rate (S_2) components (mult FI 2 minutes DRO 2 minutes). B: Rate of chirping under the DRO component (S_2) of mult FI 2 minutes DRO 2 minutes (cf., Record A) during the development of a discrimination.

when fixed-interval reinforcement was alternated with differential reinforcement of no responding⁵ (mult FI 2 minutes DRO 2 minutes). High rates of responding were observed during the stimulus accompanying fixed-interval reinforcement (S_1), and low rates during the stimulus accompanying reinforcement for no responding (S_2). However, the frequencies of reinforcement during S_1 and S_2 were equal when the rate of responding stabilized: Approximately 2 minutes after either stimulus was presented, a reinforcement was received. Evidently, the difference in the rate of responding in the two members of the multiple schedule is attributable to the different contingencies of food reinforcement.

It was shown earlier that fixed-ratio reinforcement and subsequent extinction of pecking influenced the rate of concurrent chirping. Figure 5 shows the effect on these two operants

⁵Under this schedule, reinforcement is presented after a period of no responding of at least n minutes.

of explicitly programming reinforcement for both responses. First, pecking was reinforced under FR 10 for two sessions; concurrent, unreinforced chirping was also recorded (Records A, B, C, and D). Then, the response key was removed and chirping was reinforced on FR 10. Figure 5e shows that the rate of chirping during this first session of conditioning under FR 10 was not so high as the rate of concurrent chirping observed during conditioning of pecking under FR 10 (Records B and D). Reinforcement was then programmed for 5 sessions on a conjunctive schedule, requiring 10 pecks and 10 chirps, in any order, for reinforcement (conj FR 10_p FR 10_c). Concurrent pecking and chirping during

Figure 5. Bird 2. A: Pecking during an initial session of ratio reinforcement for pecks. B: Concurrent chirping during ratio reinforcement of pecks (cf., Record A). C: Pecking during the second session under FR 10_p. D: Concurrent chirping during the second session under FR 10_p. E: Chirping under fixed-ratio reinforcement for chirps (FR 10_c). F, G: Rates of pecking and chirping under a conjunctive schedule of reinforcement for concurrent operants, Session 1 (conj FR 10_p FR 10_c). H, I: Rates of pecking and chirping under conj FR 10_p FR 10_c, Session 5. J, K: Pecks emitted in excess of the FR 10 contingency (extra pecks) during Sessions 1 and 5.

Sessions 1 and 5 are presented separately in Fig. 5 (Records F, G, H, I). No appreciable change in the rates of pecking and chirping occurred from Session 1 to Session 5. It was observed during Session 1 that the bird characteristically emitted the total 10 pecks prior to emitting the total 10 chirps. That is to say, after meeting the peck contingency, the bird would continue to peck and chirp until reinforcement arrived. Records J and K (Fig. 5) show the cumulative number of "extra pecks" emitted during conditioning on Days 1 and 5, respectively. The rate of emission of extra pecks during the fifth session of conditioning under the conjunctive schedule is lower than that observed during the first session.

SUMMARY

Four Bantam chicks were used in a study of the operant control of subhuman vocalizing. Schedules of reinforcement were shown to control the rate of chirping in the same way as they control other motor responses in subhumans. Under discrimination procedures in which two types of multiple schedules were used, chicks responded selectively to the visual stimulus associated with food reinforcement for chirping.

The relation between the chirp response and the peck response was examined. The cumulative records obtained when pecking is reinforced under a fixed-ratio schedule closely resemble those obtained when chirping is reinforced under the same schedule. Analysis of concurrent chirping and pecking suggested an interaction between the probability of emission of these two operants, despite the fact that they involve little or no topographical overlap. The properties of pecking and chirping under a conjunctive schedule of reinforcement were examined.

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