OPERANT CONDITIONING IN THE NEWLY HATCHED CHICKEN¹

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Techniques are described for conditioning key-pecking reinforced with food and for recording cheeping in newly hatched chickens. A mirror in the test box is essential when conditioning isolated chickens up to five or more days old. Conditioning proceeds more rapidly when frequently pecked objects and materials that move when scratched are not present. Stimulus control over key-pecking is present in the three-day-old chicken and multiple fixed-ratio, fixed-interval schedule control develops in succeeding days. In young chickens, pecking and cheeping are inversely related. The newly hatched chicken is useful for pharmacological studies and appears to offer other advantages for behavioral studies.

The newly hatched chicken is unusual among young animals in that it has a versatile behavioral repertoire and fully developed cerebral electrical activity (Key and Marley, 1962). It is particularly suitable for studying central nervous system actions of sympathomimetic amines (Clymer and Seifter, 1947; Key and Marley, 1962; Dewhurst and Marley, 1964) because, as with other immature animals, its blood-brain barrier is apparently not fully effective (Bakay, 1956; Lajtha, 1957; Waelsch, 1955). Drugs that are poorly lipid soluble may thus penetrate more readily to the brain than in adult animals. Methods for recording and quantifying the effects of drugs on cheeping, movement and cerebral electrical activity in the young chicken have been described (Key and Marley, 1961; Dewhurst and Marley, 1963), as have operant conditioning procedures for use with older chickens (five weeks) (Lane, 1961). This paper describes the methods used in conditioning key-pecking as

an operant reinforced with food and in developing schedule-controlled performances in three-day and older chickens.

Conditioning key-pecking with food as the reinforcer in newly-hatched chickens presents problems which make training difficult. First, the presentation of food is not initially a highly effective reinforcer. Swallowing of food or water is a learned response not present on hatching (Cruze, 1935). It develops during the first few days. Second, the young chicken shows marked social proclivity and when isolated gives sustained "distress" cheeping, crouches near the stimulus light, or attempts to leap from the test box. Finally, food deprivation is hazardous during the rapid growth of the first few weeks after hatching.

METHOD

The apparatus is shown in Fig. 1. The dimensions were altered as the chicken matured. The reinforcer was a standard chicken starter delivered with a pigeon feeder (Lehigh-Valley). The diameter of the feeding orifice in the wooden floor was 1.5 cm for chickens under one month old and 2.5 cm for 1-6 month old chickens; the food cycle was 3 sec for the younger and 4-6 sec for the older chickens. The transilluminated response key was operated by a force of 20-25 g and was located 7 cm above the floor for young chickens and 15 cm or more for the older birds. A mirror was behind the feeding aperture and adjacent to the lighted response key.

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Fig. 1. Experimental chamber used to condition key-pecking in newly hatched chickens.

Cheeping was recorded as the integral of the voltage output from a crystal microphone in the test box (Dewhurst and Marley, 1963). Extraneous noise was excluded by testing the chicken in a relatively sound-proofed box. Other noise within the box was more difficult to exclude. It was limited to 1500-6000 c/s—the frequency of cheeping—by including a band pass filter between the microphone and the amplifier. There were three sources of noise. One was due to the bird scratching at the feeding orifice, sometimes after each peck, at other times only with every reinforcement; this was dampened by a rubber mat over the thick wood floor. A second noise was generated by the beak striking the lighted disc; this was diminished by covering the disc with a thin layer of crepe rubber. Noise from the magazine contacting the feeding aperture was reduced by raising the magazine slowly. With these precautions only cheeping was recorded.

Subjects and Procedure

Rhode Island Red chickens or crosses with the Rhode Island Red were obtained about 24 hr after hatching. During the first three days, when swallowing and accurate pecking were being established, approximately 10 chickens were housed together in a box lit by a 1.5 watt bulb attached to a 2 by 4 by 5 in. block of wood with a feeding hole 1.5 cm in diameter and about 4.5 cm deep. The intensity and position of the light relative to the feeding aperture were similar to that in the test box. Food was withheld for the first 24 hr and then small quantities were periodically placed in the feeding aperture so that the chickens

learned to feed from it. Food was withheld on the second night. On the third and subsequent days individual chickens were placed in the test box, magazine trained, shaped to peck the lighted response key, and finally maintained on a multiple fixed-ratio, fixed-interval schedule. Twenty chickens under 10 days old were conditioned in this series.

Deprivation was gauged both by the period of time without food and by the absence of food in the crop. Because the crop was filled by a relatively small amount of food, the session was at first limited to about 80 food presentations. When necessary, the chicken was subsequently fed until its crop was full. Under these conditions the chicken performed satisfactorily on successive days. If a day elapsed between sessions, sufficient food was given to fill the crop on that day; if two days elapsed, food was freely available the first, but withheld the second day. In a few instances repeated sessions were conducted at intervals on the same day, or a session was continued until the chicken's crop was engorged. By the various dietary restrictions, a degree of deprivation was maintained without impairing health. Growth was slowed in deprived chickens; at 14 days they weighed only 60-80% of the weight of freely-fed brood-mates. The chickens were housed on a hard or wire-mesh floor. If kept on sawdust or similar soft material, the hungry birds filled their crops with this, producing pseudo-satiation.

RESULTS

When first placed in the experimental box, the young chicken usually oriented in front of the mirror, apparently consoled by its reflection. If it did not move to the mirror, the chicken was placed in front of it. Under these conditions, "distress" cheeping was absent or minimal and the chicken was quickly trained to eat from the food magazine. As conditioning continued the chicken oriented toward the response key rather than the mirror. By the third day after hatching some chickens were shaped to peck the lighted response key (Fig. 2 and 3).

Invariably, chickens trained to respond in the presence of either a white or red key light did not respond initially when the color was changed (Fig. 2-5). This disruption was brief, but in some instances it continued even

C-2

Fig. 2. Cumulative-response records showing development of performance on multiple FR 30, FI 2 min. In this and subsequent figures downward strokes of the recording pen indicate the delivery of food. Record A (from three-day-old chicken) shows the end of the first session of shaping in the presence of a white key light. At *a* the first peck occurred, shaping was stopped and the schedule was FR 1. The key light was red between *b* and *d* (bar under record). The chicken did not respond after the key light was red until the white light was flashed on momentarily at *c*. At *e* the schedule was made FR 10 and pecking stopped. Record B (second daily session; fourth day post-hatching) started with FR 1 (white light), and changed to FR 10 at *a*, multiple FR 10 (white light), FI 1 min (red light) at *b*, and multiple FR 10, FI 3 min at *c*. The performance was maintained and showed characteristics of initial fixed-interval performance. Records C-F show the daily sessions for the seventh to tenth days after hatching. The schedule was changed to multiple FR 30, FI 3 min during Record D.

Fig. 3. Cumulative-response records showing development of performance on multiple FR 30, FI 3 min. The sequence of changes was similar to those shown in Fig. 2. In Record A (three days old) the first peck occurred at *a* in the presence of a white key light. The key light was red between *b* and *c*, *d* and *e*, and after *f* (bars under record). Pecking stopped when the key light first became red at *b* and began again when the key light became white at *c*. The rate continued to be higher in the presence of the white light, even though responses occurred and were reinforced in the presence of the red light (between *d* and *e*, and after *f*). Record B (fourth day) began with FR 1 (red). The schedule was changed to FR 10 (white) at *a*, and to multiple FR 10 (white), FI 3 min (red) at *b*. Records C and D show the performance on the fifth and eighth days. Records E and F show the performance on the ninth and tenth days. Notice that the interval rate increased after the FR parameter value was increased from 10 to 30 (Record E).

after a response had been reinforced in the presence of the new key color. For example, in Fig. 3A, a three-day-old chicken was shaped to peck a white response key on FR 1. The key light was red between *b* and *c*, *d* and *e*, and after *f* (bars under record). Pecking stopped when the key light first became red at *b*, and began again when the key light became white at *c*. Even though responses occurred and were reinforced in the presence of the red

light (between *d* and *e*, and after *f*) the rate of responding was much higher with the white key. In the experiment of Fig. 4A, the five-day-old chicken was shaped on FR 1 to peck a red key light. At *a*, the key light became white and apart from two subsequent brief bursts, pecking ceased. In contrast, the following day (Fig. 4B) the session began with FR 1 (red), and there was only a slight pause when the key light turned white at *a*.

Figures 2-4 show how performances developed on a multiple fixed-ratio, fixed-interval schedule in individual subjects. As early as the fourth day, performance on multiple FR 10, FI 3 min was initiated (Fig. 2 and 3), and within several sessions of 1 to 2 hr, characteristic patterns of responding were obtained on multiple FR 30, FI 3 min. An inter-

esting feature in Fig. 2-4 is that the pause after reinforcement was more pronounced and the rate of responding higher during the interval component after the FR parameter value was increased from 10 to 30. With successive sessions on multiple FR, FI, pausing at the beginning of the interval lengthened with consequent lowering of the rate. Thus, in two

Fig. 4. Cumulative-response records showing development of performance on multiple FR 30, FI 3 min. The sequence of changes was similar to those shown in Fig. 2 and 3, except that the initial shaping was in the presence of a red key light. Record A (first session; five days old) began with the first peck, and the key light became white at *a*. Record B (sixth day) began with FR 1 (red). There was a slight pause when the key light turned white at *a*. The schedule was changed to FR 3 at *b*, FR 10 at *c*, and multiple FR 10 (white), FI 3 min (red) at *d*. Records C-E show the succeeding daily sessions, ending with multiple FR 30, FI 3 min (Record E).

one-month-old chickens, after five sessions on multiple FR 25, FI 7 min, the average number of pecks per FI component was 230.2; after 18 sessions the average was 96.6.

Figures 5 and 6 show how responding developed on FR. A pause after reinforcement consistently occurred on FR 30, but not on FR 10. The slow development of key-pecking shown in Fig. 6A occurred only in this chicken and is atypical. Observation suggested that behavior adventitiously reinforced during shaping delayed development of key-pecking. Figure 6 shows also the first session on VI 2 min after FR 30, during which responding was well maintained for over 7 hr.

Variations in the early training procedures were used in other experiments. Although the feeding hole in the home cage speeded magazine training, it was not essential; key-pecking was conditioned in four-day-old chickens deprived for 24 hr with no prior special training. Two out of six chickens four days old were conditioned to peck a key requiring more than 25 g to break the contact. Once magazine trained, the conditioning of

pecking proceeded rapidly when competing behaviors were prevented. The young chicken has a strong tendency to peck and scratch, and the presence of floor material that moved when scratched, faeces, screw heads, and reflecting surfaces distant from the key greatly hindered conditioning.

The role of the mirror was studied. Without the mirror, the isolated four or five-day-old chicken could not be conditioned. But one or both of a pair placed in the box together, or a single chicken, with a second one visible behind a transparent screen, was easily conditioned. With increasing deprivation, less overt behavior toward the mirror was displayed, and two out of three chickens nine days old and deprived of food for 36 hr were conditioned with the mirror covered and reflecting surfaces shrouded.

In young chickens up to five days old, or in slightly older chickens not severely deprived, the removal of the mirror (or a visible chicken) invariably disrupted performance. When the schedule was FR (1 to 30), the conditioned pecking would either cease immediately or

Fig. 5. Cumulative-response records showing development of performance on FR in chickens C-5 and C-6. Record A for C-5 (5 days old) shows the performance on FR 3 during the second daily session. At *a* after 250 reinforcements it was removed from the test box for 45 min; when replaced in the box it responded steadily for 125 additional reinforcements. The schedule was FR 10 in Records B and C on the two following days. In Record C the mirror was covered between *a* and *b*, and between *c* and *d*. No responses occurred in the absence of the mirror. Record D shows the performance on FR 10 on the following day with no mirror present (eighth day after hatching). Record A for C-6 (six days old) began with the end of shaping and the first peck in the presence of the red key light (at *a*). The key light became white at *b*, and the schedule became FR 10 at *c*. Records B and C are for the succeeding daily sessions on FR 30.

Fig. 6. Cumulative-response records showing slow development of performance on FR and transition to VI 2 min. Behavior adventitiously reinforced during shaping delayed the development of key-pecking. In Record A (three days old) the first peck occurred at *a*. The schedule was FR 1 in Record B, FR 10 in Record C, and changed to FR 30 at *a* in Record D. Records E and F are the succeeding daily performances on FR 30, and Record G shows the initial session on VI 2 on the ninth day after hatching.

continue for up to 1 or 2 min before the chicken stopped pecking and began "distress" cheeping. Figure 5C (top) shows the result of eliminating the mirror for a seven-day-old chicken. The chicken was pecking on an FR 10 schedule. The mirror was covered between *a* and *b* and between *c* and *d*. On removing the cover at *b*, pecking did not begin immediately. However, responding was sustained in the absence of the mirror the next day (Fig. 5D). In some experiments, by reshaping with "free" reinforcements, chickens under five days old would resume responding without the mirror, but it was not sustained and eventually gave way to "distress" cheeping. Thus, disrupted responding on eliminat-

ing the mirror differed from that following a change in the color of the key light in that the latter was more transient.

Especially in younger chickens, pecking was accompanied by cheeping. Generally the two were inversely related, but as Lane (1961) has observed, they are not incompatible. With the fast-sustained pecking on fixed-ratio reinforcement, cheeping was minimal until satiation (Fig. 7) or extinction occurred, when cheeping was considerable. In this experiment, in which cheeping occurred in irregular bursts, the character of the cheeping changed as pecking gradually dwindled, giving way to loud distress calls repeated at a frequency of about 1/sec as pecking ceased. On the multiple FR, FI schedule as shown in Fig. 8, cheeping was usually maximal soon after the beginning of the FI component and declined as pecking accelerated during the remainder of the interval and ensuing ratio. This reciprocal relation was best seen in multiple schedules with longer intervals (FR 25, FI 7 min or FR 25, FI 10 min) and tended to be obscured by the higher rate of initial pecking in schedules with short intervals (FR 25, FI 3 min). In this regular repetition of maximal cheeping after the beginning of the interval, distress calls were not heard. The large amount of cheeping at the start of the interval generally occurred when the chicken had moved away from the mirror and the key light. This pattern of maximal cheeping just before pecking begins in the interval is reminiscent of Skinner and Morse's (1957) finding that on fixed-interval reinforcement of lever-pressing, a rat housed in a running wheel tends to run just before lever-pressing is initiated. In that experiment it was assumed that running was essentially independent of adventitious reinforcement, since within each interval running had declined to zero at the time of reinforcement. In the present experiments a similar pattern of concurrent cheeping under fixed-interval reinforcement was found, under conditions that indicate that the cheeping pattern is modulated by reinforcement. Other less common patterns of cheeping occurred. Sometimes cheeping was distributed bimodally with a nadir at the middle and maxima at the beginning and end of the interval, or it was minimal initially and subsequently increased. In the three chickens maintained on multiple fixed-interval, fixed-ratio schedules from soon after

Fig. 7. Reciprocal relation between pecking and cheeping on FR 15 in a 14-day-old chicken. Cumulative responses are shown in A and cheeping integrals per minute in B. Cheeping occurred mainly during pausing.

hatching until four months of age, cheeping became much less marked at about the third month and no longer increased when pecking paused or stopped.

DISCUSSION

Schedule-controlled patterns of responding characteristic of multiple fixed-ratio, fixed-interval reinforcement can be developed in chickens under 10 days old. In view of the immaturity of the subjects, it is especially interesting that schedule performances were sustained throughout daily sessions of 1 to 2 hr. The presence of a mirror (or another chicken) was necessary when initially conditioning key-pecking in chickens under five days old, but otherwise standard conditioning procedures were used and the results were essentially like those obtained with older subjects.

Aside from its potential use in physiological, pharmacological, and developmental studies of behavior, the young chicken has certain advantages as a subject for teaching laboratories or in experiments in which large numbers of animals were used. Young chickens are inexpensive (5 cents each or less), easily obtained, and conveniently housed in containers such as cardboard boxes. A cardboard box partitioned by a vertical panel housing a response key, stimulus lights, a magazine and a mirror is a satisfactory experimental chamber. Young chickens can be conditioned in an open room with very little interference from ambient sights and sounds, yet stimulus control of key-pecking is evident during the first experimental session. Chickens only a few days old need less than 24 hr deprivation before use, and chickens up to 10 days old can be satiated on FR 1 several times within one day.

Fig. 8. Relation between pecking and cheeping on multiple FR 25, FI 7 min in the two-month-old chicken. Cumulative responses are shown in A and cheeping integrals per minute in B. Cheeping is maximal soon after the beginning and markedly diminishes towards the end of the interval. The arrows on the cheeping record (B) indicate occurrence of the FR component.

With older chickens it is possible to maintain rates of 3 to 4 responses/sec on FR 25 and 1 to 2 responses/sec on FI 7 min and continue a session on multiple FR 25 FI 7 for over 24

hr (over 400 reinforcements). Ultimately the size of the maturing chicken minimizes its advantages.

REFERENCES

- Bakay, L. *The blood-brain barrier*. Springfield, Ill.: C. C. Thomas, 1956, p. 36.
- Clymer, N. V. and Seifter, J. M. A method of screening sympathomimetic amines for stimulant action on the cerebrum. *J. Pharmacol. exp. Ther.*, 1947, **89**, 149-152.
- Cruze, W. W. Maturation and learning in chicks. *J. comp. Psychol.*, 1935, **19**, 371-408.
- Dewhurst, W. G. and Marley, E. Quantification of behavior and cerebral electrical activity under controlled conditions. *J. Physiol.*, 1963, **168**, 1-3P.
- Dewhurst, W. G. and Marley, E. Differential effect of sympathomimetic amines on the central nervous system. In *Animal Behaviour and Drug Action*. Ciba Foundation Symposium, 1964, 175-190.
- Key, B. J. and Marley, E. A simple technique for recording the electrocorticogram in small animals. *J. Physiol.*, 1961, **155**, 29-30P.
- Key, B. J. and Marley, E. The effect of the sympathomimetic amines on behavior and electrocortical activity of the chicken. *Electroenceph. clin. Neurophysiol.*, 1962, **14**, 90-105.
- Lajtha, A. The development of the blood-brain barrier. *J. Neurochem.*, 1957, **1**, 216-227.
- Lane, H. Operant control of vocalizing in the chicken. *J. exp. Anal. Behav.*, 1961, **4**, 171-177.
- Skinner, B. F. and Morse, W. H. Concurrent activity under fixed-interval reinforcement. *J. comp. physiol. Psychol.*, 1957, **50**, 279-281.
- Waelsch, H. Blood-brain barrier and gas exchange. In H. Waelsch (Editor), *Biochemistry of the developing nervous system*. New York: Academic Press, 1955, 187-207.

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