

Resistance to extinction in the developing chick: Effects of punishment and preextinction training

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The effect of punishment and amount of acquisition training on resistance to extinction of keypecking was determined in 1- and 4-day-old Vantress x Arbor Acre chicks. Socially reared 1- and 4-day-old chicks (N=96) were first autoshaped to keypeck for heat reward and then given an additional 12 or 84 acquisition trials before extinction testing. The extinction responses of one-half of the chicks of each age were also punished with wing shocks. Major findings were as follows: (1) When only 12 acquisition trials preceded extinction testing, 1-day-old chicks were less resistant to extinction than 4-day-old chicks under nonpunishment conditions, but they were more resistant to extinction than 4-day-old chicks under punishment conditions, (2) when 84 acquisition trials preceded extinction testing, 1- and 4-day-old chicks did not significantly differ in resistance to extinction under either the punishment or nonpunishment condition, and (3) punishment produced a decrease in the extinction responding of 4-day-old chicks following both 12 and 84 acquisition trials, but punishment produced a decrease in the extinction responding of 1-day-old chicks only when 84 acquisition trials preceded extinction testing. These results suggest that the 1-day-old chick, as compared to the 4-day-old chick, may be deficient in associative, rather than inhibitive, ability.

The age dependency of both keypeck and approach passive avoidance (PA) learning of the young chick was found recently to be related specifically to the number of reinforced acquisition trials given before punishment is introduced (Mattingly & Zolman, 1980). As in previous PA studies with chicks (e.g., Brown, 1976, 1977), 1-day-old chicks suppressed responding significantly less than 4-day-old chicks when tested for PA learning after minimal prepunishment training. But when given extensive prepunishment training, both 1- and 4-day-old chicks learned quickly to stop responding when punished, and no significant age differences in PA learning were observed.

In these PA tests, separate groups of chicks were given either immediate or delayed response-contingent punishment. As expected, for 4-day-old chicks, delayed

punishment resulted in less response suppression than did immediate punishment, regardless of the amount of prepunishment training. For 1-day-old chicks, however, delayed punishment produced less response suppression than did immediate punishment only after extensive prepunishment training. The absence of a delay-of-punishment effect for 1-day-old chicks after minimal prepunishment training indicated that these chicks did not learn the appropriate stimulus- and response-punishment contingencies during PA testing, and it suggested that the inferior PA performance of 1-day-old chicks, as compared to 4-day-old chicks, was because of an associative deficiency. Increasing the amount of prepunishment training was assumed, therefore, to increase the 1-day-old chicks' sensitivity to the appropriate stimulus- and response-shock contingencies to a level comparable to that of the 4-day-old chick (see Mattingly & Zolman, 1980).

The purpose of the present study was to determine whether the amount of acquisition training is also important in producing age-dependent differences between 1- and 4-day-old chicks in resistance to extinction. One- and 4-day-old chicks were first trained to keypeck for heat reward, and then, following either 12 or 84 reinforced acquisition trials, the chick's responses were

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nonreinforced. In addition, the extinction responses for one-half of the chicks of each age group were also punished with wing-shocks. This punishment condition was included to determine whether the presentation of both reinforcement and punishment simultaneously in previous experiments (Mattingly & Zolman, 1980) was a significant factor in producing age-dependent differences in PA learning.

METHOD

Subjects and Rearing Procedures

Ninety-six Vantress x Arbor Acre chicks were incubated and hatched at 37°C-38°C and 58%-60% relative humidity. The chicks were removed from the dark hatching incubator within 4 h after hatching, banded, and then reared in groups of 20-25 in white Plexiglas brooder compartments (56 x 33 x 23 cm) in a 35°C room. Food and water were available ad lib until 15 h prior to testing, at which time food was removed. The brooder room was illuminated with fluorescent light from 6:00 a.m. to 11:00 p.m. One-half of the chicks began testing when 1 day old (mean = 22.4 h, SD = 1.2), and the remainder began testing when 4 days old (mean = 98.3 h, SD = 2.7).

Apparatus

Behavioral testing was performed in four conditioning boxes designed for testing young chicks using heat reinforcement (see Zolman, Pursley, Hall, & Sahley, 1975). Each box was housed individually in a Forma Scientific incubator (Model 3665) in which the ambient temperature was set at 10°C ($\pm 1^\circ\text{C}$). Another Forma Scientific incubator with an auxiliary 2,000-W heater was set at 35°C, and plastic ductwork connected each cold incubator with this heat source. The temperature of the air flowing under each conditioning chamber was maintained at 35°C, and the ambient temperature on the wire floor of each chamber was maintained at 10°C. Heat onset in each box was controlled by solenoids that, when activated, displaced two circular butterfly valves. One valve instantaneously diverted the warm 35°C air up through the conditioning box, and the other valve opened to replace in the airflow system the same amount of warm air as that diverted. A 28-V light bulb (GE 1820) located under each conditioning chamber was also turned on, so that reinforcement consisted of both heat and light onset. A white masking noise of 76 dB re 20 $\mu\text{N/m}^2$ was delivered through a 10-cm speaker on the back wall of each conditioning incubator and was generated by a Grason-Stadler white-noise generator (Model 901).

A constant-current shock was supplied to each box by a Grass stimulator (Model S48) connected to a Grass stimulus isolation unit (Model PSU6). Shock was delivered to each chick through 12-mm Wachenfeldt nickel-silver wound clips attached to the wing web near the elbow of each wing. A 10-mm female Amphenol contact was attached to each wound clip. In each conditioning box, a pair of male Amphenol contacts, connected to 25-gauge insulated wires, completed the shock circuit when mated to the female contacts. A small rubber band suspended above each conditioning box removed excess slack from the shock harness, thereby allowing the chick unrestricted movement in the small conditioning box.

A response key in each box was 4 cm from the floor and tilted away from the chick at a 135-deg angle from the plane of the hardware cloth floor. These response keys were mounted directly on IEE 12-unit in-line projectors that were used to present the stimuli on the transparent keys. The stimulus and reinforcement contingencies were programmed and controlled by a BRS/LVE Interact computer control system, and response latencies in .1 sec were recorded.

Procedure

All chicks were given two autoshape, one acquisition-extinction, and then three extinction sessions. For one-half of

the chicks of each age group, three additional acquisition sessions were given between the last autoshape session and the acquisition-extinction session. Each session consisted of 24 trials separated by an intersession interval of about 20 min. The chicks were removed from their home brooder 1 h before training and isolated in individual white Plexiglas cylinders (20 x 15 cm). After each test session, the chicks were returned to their isolation cylinders.

During autoshaping, the chicks were trained to peck a white bar (3.2 x 22 mm) presented vertically on a red background. The autoshaping sequence of events was (1) key-light onset for 16 sec, (2) key-light offset with 8-sec reinforcement (35°C air and light), (3) 5-sec intertrial interval (ITI) with houselight on, (4) key-light onset, and so on. If the chick pecked the key at any time during the 16-sec stimulus duration, reinforcement was delivered immediately and a new trial was begun after the 5-sec ITI. Immediately following the first autoshape session, all chicks' wings were clipped before the chicks were returned to their isolation cylinders. Before the second autoshape session, the male plugs were inserted to adapt the chicks to the shock harness before extinction testing was started. During autoshaping and throughout the experiment, the chick was given a "free" reinforcement while being placed in the test box. Chicks that made 12 or more responses during the second autoshape session were used in subsequent testing.

Following autoshaping, one-half of the chicks of each age group were given 12 acquisition trials before extinction and the rest were given 84 acquisition trials. Acquisition trials were the same as autoshaping trials, except reinforcement was response contingent. The single acquisition-extinction session included 12 acquisition trials followed by 12 extinction trials. All extinction trials were the same as acquisition trials, except responses were not reinforced; rather, if the chick responded, it remained in the dark for 8 sec before the 5-sec ITI was initiated. In addition, the extinction responses of one-half of the chicks in each age group were also punished with a 5-mA wing shock of .5 sec duration. On the subsequent extinction sessions, the nonreinforcement and punishment contingencies were in effect beginning on the first trial. Chicks assigned to the punishment and nonpunishment conditions were matched based on their percentage of response trials during the second autoshape session.

Statistical Evaluation

An analysis of variance with repeated measures was used to determine statistical significance levels for both response latencies and percentage of trials on which the chicks responded (response trials). As the latency and response trial data led to similar conclusions, only the analysis of percentages of response trials is given. The analysis of variance was performed across 12-trial blocks and was supplemented, when appropriate, by Newman-Keuls tests. Also, since nonreinforcement and response-contingent shock conditions were begun on Trial 13 in the single acquisition-extinction session and then were continued through all subsequent extinction sessions, the chicks' performance on the acquisition-extinction session was analyzed separately from their performance on the subsequent extinction sessions.

RESULTS

Acquisition-Extinction Session

The mean percentages of response trials across the first acquisition-extinction session and the three subsequent extinction sessions for the 12- and 84-acquisition-trial chicks are plotted in Figures 1 and 2, respectively. Overall, chicks given only 12 acquisition trials responded on fewer trials during the acquisition-extinction session than chicks given 84 acquisition trials [$F(1,88) = 5.29$, $p < .05$]. Also, chicks in the punishment condition responded on fewer trials than chicks in the nonpunish-

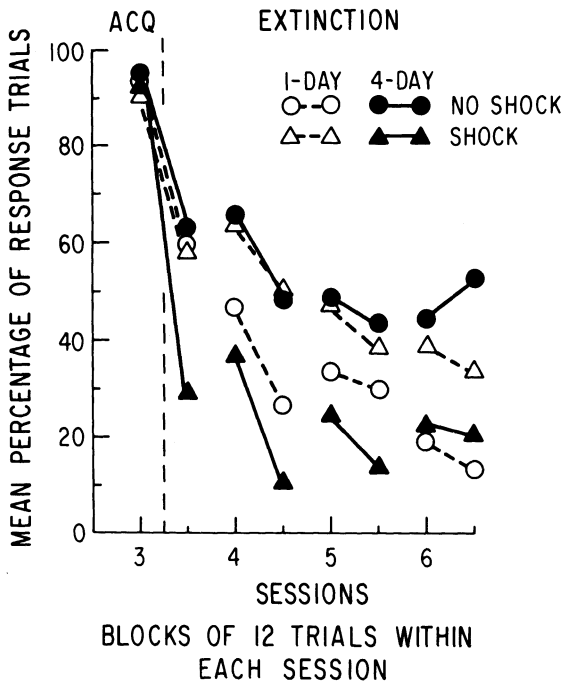


Figure 1. Mean percentages of response trials across blocks of 12 trials during extinction testing for 1- and 4-day-old punished (shock) and nonpunished (no shock) chicks given minimal preextinction training.

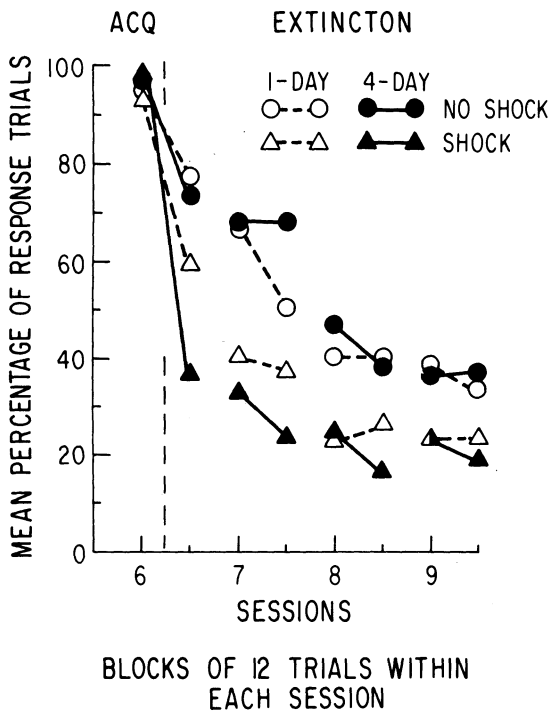


Figure 2. Mean percentages of response trials across blocks of 12 trials during extinction testing for 1- and 4-day-old punished (shock) and nonpunished (no shock) chicks given extensive preextinction training.

ment condition [$F(1,88) = 18.40, p < .001$], but this difference in responding between punished and nonpunished chicks was greater for the 4-day-old chicks than for the 1-day-old chicks [Age by Condition interaction, $F(1,88) = 4.21, p < .05$].

As may be seen, all groups decreased responding when the extinction contingency was initiated on the second block of 12 trials [block effect, $F(1,88) = 192.13, p < .0001$]. However, this decrease in responding was greater for the 4-day-old chicks than for the 1-day-old chicks and was also greater for the punished than for the nonpunished chicks [Age by Block interaction, $F(1,88) = 10.36$, and Condition by Block interaction, $F(1,88) = 16.06, p < .01$, respectively]. These significant main effects and first-order interactions, however, were qualified by a significant Age by Condition by Block interaction [$F(1,88) = 7.25, p < .01$]. Analysis of this interaction with individual Newman-Keuls tests revealed that (1) all groups responded equivalently prior to extinction onset (Block 1) and all groups significantly decreased responding following extinction onset ($p < .05$ in each case), (2) the 1-day-old punished chicks responded on significantly more extinction trials than the 4-day-old punished chicks ($p < .05$), whereas the extinction responding of the 1- and 4-day-old nonpunished chicks was not significantly different, and (3) the 4-day-old punished chicks responded on significantly fewer extinction trials than did their nonpunished agemates ($p < .05$), but the 1-day-old punished and nonpunished chicks did not differ significantly in their responding on the initial extinction trials.

Extinction Sessions

Across the subsequent three extinction sessions, the chicks continued to decrease their responding across sessions and blocks [session effect, $F(2,176) = 36.23, p < .0001$; block effect, $F(1,88) = 17.70, p < .0001$; and Session by Block interaction, $F(2,176) = 6.43, p < .01$]. Overall, the punished chicks responded on fewer trials than the nonpunished chicks [condition effect, $F(1,88) = 177.70, p < .0001$], but the magnitude of this punishment effect was dependent upon both the age of the chick and the amount of its prior acquisition training [Age by Condition interaction, $F(1,88) = 11.46, p < .01$, and Age by Training by Condition interaction, $F(1,88) = 4.45, p < .05$]. As may be seen in Figure 1, after minimal acquisition training, punishment differentially affected the extinction responding of the 1- and 4-day-old chicks. As expected, the 4-day-old punished chicks responded on significantly fewer trials than the nonpunished 4-day-old chicks across the last three extinction sessions (Newman-Keuls tests, $p < .05$). In contrast, the punished 1-day-old chicks responded on significantly more extinction trials than the nonpunished 1-day-old chicks ($p < .05$). Moreover, in the nonpunishment condition, the 1-day-old chicks responded on significantly more extinction trials than the 4-day-old chicks

($p < .05$), whereas, in the nonpunishment condition, the 1-day-old chicks responded on significantly fewer trials than the 4-day-old chicks ($p < .05$).

After extensive acquisition training, the 1- and 4-day-old chicks responded comparably across the last three extinction sessions (Figure 2). Indeed, the punished chicks of both ages responded on significantly fewer trials than the nonpunished chicks ($p < .05$), and the 1- and 4-day-old chicks did not significantly differ in extinction responding in either the punishment or nonpunishment condition ($p > .05$ in each case). Interestingly, the extinction responding of the 4-day-old chicks in the punishment and nonpunishment conditions did not significantly change as a function of prior acquisition training. The amount of acquisition training, however, did significantly affect the 1-day-old chicks' extinction responding. For the nonpunished 1-day-old chicks, increasing acquisition training significantly increased extinction responding ($p < .05$), whereas, for punished 1-day-old chicks, increasing acquisition training significantly decreased extinction responding ($p < .05$).

DISCUSSION

It is evident that age-dependent differences in resistance to extinction in the young chick depended upon the amount of acquisition training given before extinction testing. Following limited acquisition training, the 1-day-old chick was less resistant to extinction than the 4-day-old chick under nonpunishment conditions, but more resistant to extinction than the 4-day-old chick under punishment conditions. After extended acquisition training, however, the 1-day-old chick was not significantly different from the 4-day-old chick in resistance to extinction in either the punishment or the nonpunishment condition. The amount of acquisition training also determined the effect of punishment on resistance to extinction of the 1-day-old chick. After minimal acquisition training, 1-day-old chicks responded more during extinction when punished than when nonpunished, whereas, after extensive acquisition training, 1-day-old chicks, like 4-day-old chicks, stopped responding more quickly when their extinction responses were punished.

These extinction findings are consistent with the associative learning deficit proposed previously to explain the significant effects of prepunishment training on the PA learning of the 1-day-old chick (see Mattingly & Zolman, 1980). For instance, after minimal acquisition training, the 1-day-old chick stops responding more quickly than the 4-day-old chick during extinction under nonpunishment conditions, indicating that the response or associative strength of the 1-day-old chick was probably less than that of the 4-day-old chick even though terminal acquisition performance was comparable for chicks of the two ages. Similar learning-performance differences between young and mature rats have also been observed (e.g., Egger & Livesey, 1972; Klein & Spear, 1969; Potash & Ferguson, 1977). After extended acquisition training, the 1- and 4-day-old chicks did not significantly differ in resistance to extinction; these data suggest that associative strength was comparable for chicks of the two ages.

After limited acquisition training, the 1-day-old chick also responded more during extinction when punished than when nonpunished. This paradoxical effect of punishment was unexpected, but it is consistent with the view that 1-day-old chicks are deficient in associative ability. In avian imprinting studies, aversive stimulation has been found to have both an associative and a motivation effect on behavior (DePaulo, Hoffman, Klein, & Gaioni, 1978; Ratner, 1976). The associative effect usually results in an avoidance of those responses or stimuli paired with the aversive stimulation, whereas the motivation effect of shock nonspecifically energizes behavior. If the 1-day-old chick is deficient in associative ability, then after minimal acquisition training, shock should have more of a motivating effect on the 1-day-old chicks' responding and, therefore, should produce an increase rather than a decrease in extinction responding. After extensive acquisition training, however, punishment should have both associative and motivation effects on the 1-day-old chicks' extinction performance, and therefore, 1-day-old chicks, like 4-day-old chicks, should stop responding more quickly during extinction when punished than when nonpunished. These extinction results, therefore, are consistent with those of previous PA studies and indicate that the amount of acquisition training is an important determinant of whether age differences in withholding behavior between 1- and 4-day-old chicks are observed.

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