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ventilation system also provided a masking noise, and a 6-W lamp provided illumination. A one-way window permitted observation of S. A Richter bottle was available through one wall and was connected through a touch-sensitive relay to a counter which recorded the number of licks. The conditioned stimulus (CS) was a moderate intensity, 10-kHz tone. The unconditioned stimulus (US) was a 1-mA scrambled footshock delivered through the grid floor of the chamber. The CS and US durations were controlled by interval timers.

PROCEDURE

The procedure followed the one-trial CER paradigm of Leaf & Muller (1965) and Lubow & Siebert (1969). The water bottles were removed from the home cages, and 24 h later each S was placed in the test chamber with the water tube available. Each S was allowed to make 200 licks. At the end of this session, water bottles were replaced in the home cage. On the following day (Day 2), each S was placed in the test chamber, and the drinking spout was not available.

One-half of the Ss in each age group received one pairing of tone and shock (Group E). The paired stimuli were presented 60 sec after S had been placed in the chamber. The CS duration was 10 sec and the last second overlapped with the onset of the 1-sec footshock. The Ss were then immediately removed from the chamber and returned to the home cage. Control Ss (Group C) received an unpaired presentation of tone and shock. Sixty seconds after S was placed in the chamber, the US came on for 1 sec. Ten seconds

Age differences in the development of the conditioned emotional response

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Rats aged 25, 50, or 120 days were tested for suppression of drinking behavior during the presentation of a fear-producing CS. The youngest group did not show any evidence of drinking suppression when compared to more mature rats or to a pseudoconditioning control group of the same age. These results are discussed in terms of fear conditioning and the ability of young rats to inhibit consummatory responses.

Three recent studies have indicated that there are maturational differences in the ability of rats to inhibit a punished response (Brunner, 1969; Riccio et al, 1968; Riccio & Schulenburg, 1969). One hypothesis suggests that a developmental change in a general inhibitory mechanism may be affecting performance (Campbell & Thompson, 1968). For example, weanling rats fail to show above chance spontaneous alternation (Kirkby, 1967) and internal inhibition is weak in very young birds (Vince, 1959). Douglas & Kowal (1968) have advanced the view that such age-related changes in inhibitory ability may be related to the postnatal development of the limbic structures of the brain, which are thought to be involved in the ability to withhold responding in the presence of changed environmental contingencies (Kimble, 1969).

The experiment reported here continues the investigation of age differences in fear conditioning. The conditioned emotional

response (CER) is known to be markedly attenuated by disruption of the limbic system (Brady & Conrad, 1960; Goddard, 1965; Trafton, 1967). It is hypothesized that immature rats will tend to continue making a consummatory response in the presence of a stimulus previously associated with shock.

SUBJECTS

Thirty-six naive hooded rats of the Long-Evans strain were assigned to three age groups. The adults (120 days) were obtained from a commercial breeder. The 25- and 50-day-old rats were bred from a colony maintained at the University of Cincinnati. Each group consisted of six males and six females. The Ss were weaned at 20 days of age and maintained in group cages with water and rat chow continuously available.

APPARATUS

The apparatus was a 9.5 x 8.5 x 11 in. operant-conditioning chamber. The opposite walls of the box were either Plexiglas or aluminum and the cover was Plexiglas. The chamber was housed in a ventilated sound-attenuated enclosure. The

Fig. 1. Mean latencies to first 10 licks after CS presentation for conditioned (experimental) and pseudoconditioned (control) Ss.

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Fig. 2. Mean latencies to first 100 licks on the adaptation day and prior to CS presentation on the test day.

after shock offset, the tone came on for 10 sec. At the close of this session, water bottles were removed from the home cages for the next 24 h.

On the third day, Ss were placed in the test chamber with the drinking tube available. The time to complete the first 100 licks was recorded. Immediately upon completion of 100 licks, the tone was presented for 10 sec. The time to completion of 10 licks following the CS was recorded. If S failed to complete 10 licks within 300 sec, the session was terminated and a latency of 300 sec was recorded.

RESULTS

All analyzed data in this experiment were transformed (square root) in order to obtain homogeneity of variance. Figure 1 shows mean latencies to the first 10 licks for the 25-, 50-, and 120-day-old experimental and control groups. A 2 by 3 analysis of variance indicated a significant age effect ($F = 21.55$, $df = 1,30$, $p < .01$). There was relatively less evidence of conditioning in the control groups. The significant interaction of age and CS-US contingency ($F = 4.45$, $df = 2,30$, $p < .05$) indicated that older rats differed between experimental and control conditions. The youngest group did not exhibit any difference between the experimental and control contingencies. The analysis of variance of latencies to first lick following the CS onset also showed the difference between age groups. The 25-day-old group had the shortest latencies ($F = 6.98$, $df = 2,30$, $p < .01$). Further, the 25-day-old Ss tended to show less generalized fear to the apparatus. The time to complete the first 100 licks on the test day differed for the three age groups

($F = 6.12$, $df = 2,30$, $p < .01$). The oldest Ss had the longest latencies for the first 100 licks. This may demonstrate a generalized fear of apparatus cues. The same age difference was not found on Day 1 (adaptation) when the 25-day-old group had relatively longer latencies for completion of the 200 licks. Figure 2 shows latency to the first 100 licks on the adaptation and test days. An analysis of variance showed a significant difference between the adaptation and the test sessions for time to completion of the first 100 licks ($F = 38.12$, $df = 1,33$, $p < .01$). The interaction of Days by Groups was also significant ($F = 15.56$, $df = 2,33$, $p < .01$). This suggests that the increase in time to completion of the first 100 licks does not apply to the 25-day-old experimental group. Figure 2 indicates that there is a slight decrease in time to completion of 100 licks on the test day for the 25-day-old groups.

DISCUSSION

The results of the study reported here indicated that there are large developmental changes in the acquisition or expression of the CER. In a recent experiment which studied the CER in rats between 40 and 360 days of age, it was concluded that "acquisition of the CER is inversely related to age [Paré, 1969]." This hypothesis seems unwarranted in view of the present study in which weanling rats showed no evidence of the CER. Further, the 50-day-old group showed somewhat less evidence of the CER than the oldest group. Campbell & Campbell (1962) employed 15 CS-shock pairings and found no age effect in CER retention immediately and 21 days after training. It is probable that maturational changes essential to the one-trial CER occur between weaning and 40 to 50 days of age in the rat.

The results of the present experiment support but do not differentiate between two hypotheses. It is possible that shock-motivated fear is not conditionable with one trial in rats that are 25 days old. The finding that young rats continue to make fear-motivated responses in extinction as long as adults (Kirby, 1963; Campbell & Campbell, 1962) reduces the generalizability of an explanation which implicates the development of fear. Rohrbaugh & Riccio (1968) reported that weanling rats displayed less avoidance of a compartment in which they had been shocked than did adults. This would seem to support the notion that immature rats are less fearful, except that no measure was made in that study of active escape of cues associated with shock. The measured response was total time spent during one

long session in the "fear" compartment as compared to the "safe" compartment. This response is similar to passive avoidance and might indicate an inadequate inhibitory mechanism. Whether age differences in passive avoidance and the CER will be related to fear conditioning or a general inhibitory mechanism remains to be determined.

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