Age differences in one-trial passive avoidance learning

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Rats ranging in age from 20 days to 120 days were tested in a spontaneous one-trial passive avoidance situation. It was predicted that younger animals would perform more poorly due to an immature hippocampus. Although the results were not conclusive, younger rats did appear to be deficient in inhibiting an established response.

Recent findings by Douglas & Kowal (1968) have suggested that behavioral changes accompany postnatal maturation of certain areas of the brain, particularly the limbic system. Altman (1966) has indicated that a large proportion of cell division in the hippocampus is completed postnatally in the rat. The experiment to be reported here examines passive avoidance, a class of responses known to be impaired by lesions (Kimble, Kirkby & Stein, 1961; Schwartzbaum & Spieth, 1964) and electrical stimulation (Kasper, 1964) of the limbic system. The prediction which is being tested is that relatively immature rats show a deficiency in one-trial passive avoidance.

SUBJECTS

Seventy-four naive hooded rats of the Long-Evans strain bred from a colony at the U.C. psychology laboratory were assigned to various age groups. There were 37 males and 37 females in the study. Their ages at the start of training were the following: 20, 25, 30, 35, 40, 45, 50, 55, 60, and 120 days old. All groups consisted of seven Ss except the oldest group that had 11 Ss. Ss were weaned at 20 days of age, hand gentled and maintained in group cages on Rockland Laboratory Rat Diet and water.

APPARATUS

The Ss were trained in an apparatus similar to the one described by Chorover & Schiller (1965). The apparatus consisted of a 50-cm square box constructed of plywood with flat gray walls and a grid floor of .63-cm aluminum rods spaced 1.5 cm apart. Located against the rear wall of the box was a 12.5-cm square platform 5 cm high. The platform was connected to a microswitch which operated a Standard electric timer and a Scientific Prototype shock source that was set to deliver a .7-mA footshock (FS) for .5 sec.

PROCEDURE

Subjects received one trial per day beginning at the ages specified previously. On each trial Ss were placed on the platform and their step-down latencies (SDL) were recorded. The first three days consisted of habituation trials in which Ss were permitted to step down and explore the test box for approximately 10 sec. On Trial 4 Ss received FS immediately upon stepping completely off of the platform. Ss again remained on the grid floor for 10 sec before being returned to their home cages. Twenty-four and 48 h later Ss were tested for retention. Retention Trials (5 and 6) consisted of the same procedure as that employed for habituation trials unless the rat remained on the platform for 60 sec, in which case the trial was terminated.

RESULTS AND DISCUSSION

Figure 1 shows the median SDL for each age group on Trials 4, 5, and 6. It is apparent that the SDL for Trial 4, prior to shock does not differ among the groups. There appears to be an increase in SDL with increasing age for retention Trials 5 and 6. The Kruskal-Wallis one-way analysis of variance by ranks (Siegel, 1956) was performed on SDL to test the null hypothesis that the 10 samples were drawn from the same population. The null hypothesis was not rejected ($H = 8.6$ for

Fig. 1. Median step-down latencies before (Trial 4) and after (Trials 5 and 6) the single-shock treatment.

Trial 5 and $H = 6.6$ for Trial 6). However, planned Mann-Whitney tests were done between the 20-day-old group and every other group for Trials 5 and 6. Most of these comparisons showed that the SDL for older groups were significantly longer than for the youngest group. These differences are shown in Table 1. An overall comparison of males and females using the Mann-Whitney U-test revealed no significant difference ($U = .06$).

These findings plus those of Douglas (1968) would appear to lend tentative support to the idea that some behavioral changes which occur developmentally may be due to postnatal maturation of the hippocampus. Several investigators (Kirby, 1963; Doty, 1966) have maintained that in simple avoidance conditioning, young animals can learn as well as older animals. The present paradigm is one which seems intuitively simple and the results do not necessarily support the hypothesis of no developmental change as suggested by Kirby and Doty.

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Table 1
A Mann-Whitney Test Comparing Step-Down Latencies of the 20 Day Old Group with Every Other Group was Performed. All Differences are in the Predicted Direction.

Comparison	Differences	
	Trial 5	Trial 6
20-25	n.s.	n.s.
20-30	n.s.	n.s.
20-35	n.s.	*
20-40	.01	.01
20-45	n.s.	.01
20-50	.05	.01
20-55	.05	.01
20-60	*	.01
20-120	.05	.01

* Approached significance

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reliability of this trend, correlation between number of early alternations (Trials 1-30) and total correct choices throughout training was computed. A significant positive correlation was found [$r(8) = +.68$, $p < .05$]. Of course it is conceivable, though unlikely, that strong alternation tendency may be an incidental characteristic of fast learners without contributing causally to rapid learning.

A positive relationship between alternation and discrimination performance also has been reported by Lester (1967). In Lester's study, rats who alternated more on a pretest of exploratory tendency learned a later T maze discrimination more rapidly than rats who alternated less on the pretest. Lester did not report whether the same difference in alternation obtained early in T maze training, but it seems probable that it did. However, Clayton (1966) found no relationship between extent of alternation behavior (related to intertrial interval) and T maze acquisition. It is not at all obvious why different results were obtained in Clayton's and the present experiment, but one possibility immediately suggests itself. This is the difference in problem difficulty in the two experiments. In Clayton's study, choice was between reward vs nonreward, and all groups acquired the discrimination within 36 trials. The present study involved reward for both alternatives, and learning was much slower. Perhaps this difference provides a clue to the mechanism underlying the observed relation between alternation and rate of acquisition in the free-trial group of the present study.

Why should frequent alternation facilitate a difficult discrimination? One possibility is that frequent alternation is accompanied by an increase in LFA experiences. But examination of the data obtained from free-trial animals revealed no correlation between number of early alternations and total errors on all trials for the same period. Thus, it appeared that alternation exerted a positive effect on acquisition performance not attributable to increased experi-

ence with the LFA. Perhaps frequent alternation of stimuli, by providing many opportunities to compare stimuli in close temporal proximity, somehow served to draw attention to, and thus emphasize, the difference in reward magnitude associated with the LFA and MFA. Any advantage resulting thereby might reasonably be expected to exert greater influence in a difficult discrimination task than in a relatively simpler one, which would account for the discrepant results of this and the Clayton study.

Finally, might not the same factor be operating in the forced-trial condition? Frequent alternation is inherent in most forcing schedules. For example, the schedule employed in the present study, which is typical, involved a minimum of three alternations in each daily block of six trials. Perhaps the facilitation of discrimination with forced trials in the present study resulted, at least in part, from the frequent alternation involved. Consideration of such a factor does not, of course, discount the possible contribution of added experience with the LFA for this group. Clearly, additional research manipulating these two variables independently will be required to assess their relative contribution to the enhancement of discrimination performance.

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NOTES

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NOTE

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