Age- and sex-related differences in acquisition of a long-term active avoidance response in mice

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A significantly higher level of acquisition of an active jump-out avoidance response was achieved by 3-, 6-, and 12-month-old male mice, as compared to 1-month-old Ss. No such age-related differences in performance could be demonstrated in female mice. On the other hand, 1-month-old female mice achieved significantly higher avoidance levels than did males of the same age.

Several investigators have recently demonstrated age-related differences in acquisition of a passive-avoidance response (Riccio, Rohrbaugh, & Hodges, 1968; Riccio & Schulenburg, 1969; Brunner, 1969). These authors suggest that young animals are inferior to adults in passive-avoidance performance. However, Riccio, Rohrbaugh, & Hodges (1968) demonstrated that in rats acquisition of an active-avoidance response was relatively invariant over a wide range of ages. The purpose of the present investigation was to determine whether age- and sex-related differences in acquisition exist in a prolonged active-avoidance training paradigm in mice ranging in age from young adults to senile or presenile Ss.

SUBJECTS

The male Ss were 1-, 3-, 6-, and 12-month-old albino NICR Swiss mice, and the female Ss were either 1-month-old virgin mice or approximately 6-month-old mice that had had several litters. All animals were purchased from Harlan Industries, Cumberland, Indiana. With the exception of the 1-year-old males, all mice were housed in groups of five of the same age and sex per cage, and were maintained at a constant laboratory temperature of 25°C. Food and water were available ad lib. The 1-year-old males were housed in pairs in order to avoid excessive fighting without introducing the extraneous factor of isolation stress that would occur if the mice were housed singly.

APPARATUS

The test apparatus consisted of a wooden box, 10 x 10 x 4½ in., with a grid floor made of brass rods 1/10th in. in diam and 1/2 in. apart. A plastic "well," 4½ x 4½ x 4½ in., with a 2½-in.-wide deck around the top, was fitted into the box. The "well" had an open bottom that rested on the grid floor. An electromechanical automated programming system (Lehigh Valley Electronics, Fogelsville, Pa.) was connected to the grid floor through a scrambler that supplied a constant current for a constant time at a constant interval. A separate switch also allowed the manual reactivation of the shock at will.

PROCEDURE

Each mouse was dropped into the "well" on the cold grid. Five seconds later, a 0.8-mA shock was delivered to the feet of the animal for a period of 2 sec, which could be extended in increments of 2 sec for an indefinite length of time (by means of the manual reactivating switch), until the mouse escaped by jumping out of the "well" and onto the upper deck. Following an intertrial interval of 10 min, which the animal spends in its home cage, a second trial identical to the first was given, and then a third and final trial was administered following another 10-min intertrial interval. The process was repeated daily for 5 consecutive days, bringing the total number of trials for each S to 15 in the 5-day duration of the experiment. The total number of avoidances for each group of five mice was recorded, avoidance being defined by the mouse jumping out of the "well" within the 5-sec period prior to the onset of the shock. Analysis of the variance between each relevant pair of groups was carried out, and statistical analysis of the data was performed according to the Student t test (Steel & Torrie, 1960).

RESULTS

Figure 1 shows the relationship between age and learning in male mice 1, 3, 6, and 12 months old. (The relatively larger number of Ss in the 1-month-old male group is the result of cumulative data collected from a separate research program.) In general, the 3-, 6-, and 12-month-old males reached greater total avoidance levels in the 5-day period of the experiment than did their 1-month-old counterparts ($p < 0.001$ for each pair of groups compared). However, the performance levels between the 3-, 6-, and 12-month-old males were not statistically different from one another ($p > 0.05$ for each pair of groups compared).

In the females (Fig. 2), on the other hand, there was no significant difference between the two age groups used with respect to the total number of avoidances achieved during the 5-day period. However, the performance of both the young and older female mice was considerably better than that of the 1-month-old male Ss ($p < 0.001$ in either case) and was comparable to that of the 3-, 6-, and 12-month-old males.

DISCUSSION

At the outset of the study, it was hoped that the results would indicate a deficit in acquisition and/or retention in both the very young (1 month) and very old (12 months) mice. In such a case it would have been concluded that the mice develop greater acquisition and retention capabilities upon maturation, which then wane with the approach of senility. However, the 1-year-old male mice showed no evidence of such deficit in performance. Furthermore, no age-related differences in acquisition could be demonstrated in the female Ss. It is possible that at the age of 1 year the male mice are not old enough to exhibit deficits in acquisition or retention. In a study with human Ss, Levinson & Reese (1967) showed a strong age trend in rate of learning-set formation. Speed of acquisition was shown to increase from preschool through college age but was markedly slower in a group of older Ss 61 to 97 years of age. However, these authors acknowledged the difficulty of attributing the poorer learning-set performance in the older Ss to the effect of age per se and suggested that both organic deterioration, as well as socioenvironmental factors, may have contributed to the inferior performance.

It should be noted that at no time throughout the study was any spontaneous avoidance detected on the first day of trials during the 5-sec period prior to the onset

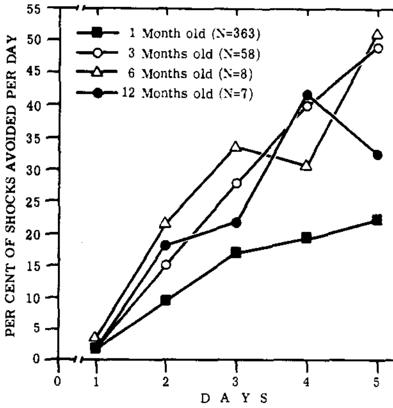

Fig. 1. Avoidance performance of male mice of different ages (N = number of groups of five mice each).

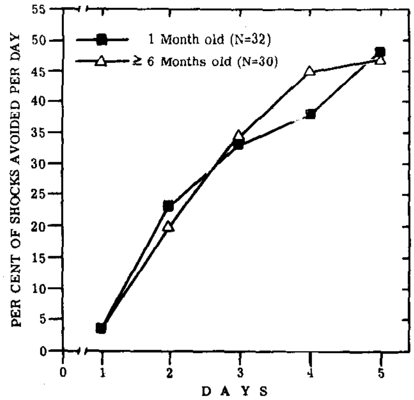

Fig. 2. Avoidance performance of female mice of different ages (N = number of groups of five mice each).

of the first shock. It is therefore concluded that all avoidances performed by the Ss are the net result of memory of the previous trial or trials, and not due to spontaneous tendencies or handling. This view is further supported by the very low level of avoidance achieved throughout the first day of trials, even after the mice had received more than one shock to the feet.

The possibility that the differences in the levels of acquisition or retention of the various age groups may be the result of a differential sensitivity to the shock is ruled out by the observation that, with only a few exceptions, all Ss studied escaped from the "well" within 2 sec of the onset of the shock. Any differences in sensitivity to the shock between the age groups or sexes would have been reflected in differences in escape latencies. Furthermore, no observable difficulty could be detected with regards to the ability of any of the age groups to escape from the "well." Physical performance, therefore, played essentially no part in the recorded differences in levels of learning among the various groups.

It is not known at the present time why young, 1-month-old female mice consistently performed substantially better than their male counterparts [a phenomenon previously demonstrated in rats by Levine & Broadhurst (1963)], nor is there an explanation for the failure to demonstrate age-related differences in performance in the female Ss in this experimental setup. The possible involvement of the sex hormones in brain maturation is suggested by the work of Curry & Heim (1966), who demonstrated that postnatal administration of estradiol to female rats resulted in an early laying down of the myelin sheath around nerve fibers in the brain. Although the nature of this mechanism is not elucidated, it is possible that estradiol, both endogenously as well as exogenously administered, by accelerating the process of myelination, may enhance functional brain maturation. Furthermore, Beatty & Beatty (1970) showed that female rats receiving testosterone both in infancy and in adulthood exhibited the inferior avoidance performance characteristic of males in an active-avoidance situation.

A possible alternative explanation for the inferior performance of the 1-month-old male mice, as compared to their female counterparts in this study, is suggested by the observation (Kulkarni & Rahwan, unpublished data) that male mice tend to exhibit a "freezing" tendency if the same training paradigm described above is intensified by shortening the intertrial intervals. This incompatible behavior is not appreciably evident in the females. Accordingly, the possibility cannot be ruled out that some degree of "freezing," although not grossly discernible in the present design, may have contributed to the inferior performance of the young males, as compared to the females.

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Effects of litter size on nursing time and weight of the young in guinea pigs*

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Fifteen female guinea pigs were observed with their offspring for Days 1-28 postpartum. The larger the litter (one to four animals), the greater the percentage of nursing time. With the exception of the four-animal litters, the smaller the litter, the greater the weight of the young. Finally, there was no relationship between litter size and the number of positive or negative nursing responses directed toward each pup.

Female rats rearing large litters behave less maternally than females rearing small litters (Seitz, 1959). Seitz's test of maternal behavior consisted of nine observational measurements; for each measure the female was rated on a scale of 0 through 4, with 4 indicating strong maternal behavior. Females with a litter of 3 animals had a mean score of 21.33, while females with a litter of 12 had a score of 13.92. Recently, Grota & Ader (1969) confirmed Seitz's finding, using time with the young as their measure of maternal behavior. Total time with the litter decreased more rapidly for females with litters of 12 animals than for females with litters of 4 animals. In contrast, Schneirla, Rosenblatt, & Tobach (1958) report that with cats, the larger the litter, the greater the percentage of nursing time.

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The present study examines the relationship between litter size and nursing behavior in a third species, the guinea pig.

SUBJECTS AND MAINTENANCE

The 15 females and their offspring were from a genetically heterogeneous stock reared in our laboratory. On the day of parturition the females ranged in age from 156-212 days. In all cases this was the female's first pregnancy. Guinea pig chow and water were available at all times. The laboratory had a thermostat which maintained the temperature at approximately 74°F. The animals were on a natural light cycle with observations taking place from February 10 to May 5, 1970.

PROCEDURE

On the day of parturition 2 of the 15 females had their litter sizes altered. In one