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# Effect of drive level upon age of onset of 24-h retention of discriminated escape learning in infant mice

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Mice, 9 and 11 days old, received 24 training trials in a T maze to the goal opposite their first-trial choice at either .1- or .2-mA shock levels. Half of the mice within each age and shock level group were retested 24 h later at the training level, the remaining half were retested at the other shock level. Maturation controls without prior training were also trained under each of the retest conditions for previously trained groups. The training results indicated that while 11-day-old mice made more correct turns than 9-day-old mice, both age groups showed comparable rates of improved performance over trials independent of shock level. Upon retest, mice trained at 11 days of age demonstrated significant retention of the previously trained correct goal, while mice trained at 9 days of age did not differ from controls. This age-related difference in retention was independent of shock level during both training and retest trials.

Attempts to determine the underlying physiological bases of complex adult behavior, such as learning and memory, are plagued by numerous problems, particularly the probable involvement of widespread physiological activity in even relatively simple tasks. One approach, which may alleviate at least some of these problems, involves study of organisms during the early developmental period, when maturational alterations in the brain may be monitored and correlated with behavioral change. While this approach also provides complications due to the vast number of developmental changes through time (Riesen, 1971), there would appear to be certain advantages in studying the organism during a period of less complex behavioral and physiological functioning than the adult.

Although there have been numerous reports of learning and memory differences between young and adult animals (cf. Campbell, Riccio, & Rohrbaugh, 1971; Campbell & Spear, 1972), relatively little research has been directed to determination of the onsets of learning and memory capacities. Several recent studies, however, have reported that 24-h retention of a discriminated escape task first appears in Swiss-Webster mice by 11 days of age (Nagy & Murphy, 1974; Nagy & Sandmann, 1973), a time when numerous maturational changes in brain function are occurring (cf. Himwich, 1970). But, before this onset of retention can be attributed to the developmental functioning of physiological processes underlying a memory capacity, it must clearly be established that the apparent age-related retention is actually due to maturational factors rather than to specific task parameters used. In the previous studies, training and retention tests were comprised of 25 escape trials in a T maze at .1 mA shock level. While both 9- and 11-day-old mice demonstrated improved escape performance during training, only the 11-day-old group showed evidence of retention for the trained goal when retested 24 h later. The purpose of the present study was to determine whether the same age-related retention effects would be found when other drive or shock levels were employed.

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## METHOD

### Subjects

The subjects were 120 Swiss-Webster albino mice, born and reared in 30.4 x 18 x 12.8 cm polyethylene cages with wire-grid tops and wood chips on the floor. Separate groups of 20 males and 20 females received escape training at 9 or 11 days of age. The mothers remained with the pups at all times except during the training sessions and were on ad-lib food and water. The colony and test rooms were maintained at 24 ± 1°C.

### Apparatus

The apparatus was a Plexiglas T maze, 6.2 cm high and 3.4 cm wide throughout. The stem was 18.8 cm long, with a removable door 5 cm from the closed end, forming the startbox; each arm was 9.2 cm long. The maze was placed upon a grid floor, constructed of 1-mm-diam stainless steel rods spaced 3 mm center to center, such that the grids were parallel with the stem and perpendicular to the length of the arms. A scrambled ac shock source (Harvard Instrument Co., Model 3121) delivered either .1 or .2 mA 60 Hz constant current to the grid floor.

### Procedure

At either 9 or 11 days of age, a mouse was removed from its home cage and placed into the startbox, facing the choice point. After 5 sec, the door was removed, shock initiated, and a running time meter started. On the 1st trials, all mice received shock offset upon reaching within 6 mm of the end of either goal arm. On all subsequent trials, shock offset occurred when each mouse reached the end of the goal arm which was opposite its first trial choice. If the mouse failed to reach the "correct" goal arm within 300 sec, it was gently prodded to the correct goal and shock was terminated. A 300-sec maximum latency was assigned for such trials. A total of 25 trials (including Trial 1) was administered with a 45-sec intertrial interval, during which time the mouse was held in the experimenter's closed hand. Following training, mice were returned to their home cages until

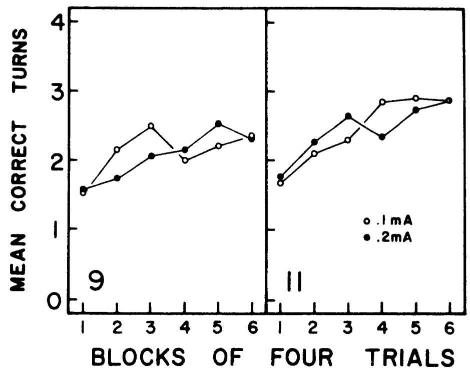


**Figure 1. Mean number of correct choice point turns during training as a function of age, training shock level, and trial blocks.**

retesting. Within each age group, half of the mice of each sex were trained at .1 mA, the remaining half at .2 mA, according to a split-litter design.

Following training, mice within each training shock level group at the two ages were divided into two retention groups, equated for the number of correct turns made during training. The first retention group was retested at .1 mA, the second at .2 mA. Each of these groups, comprised of five males and five females, was retrained 24 h later for 25 trials to the goal arm which was correct during original training. Forty like-sexed littermates of trained mice served as maturation controls and received 24 training trials to the goal opposite their first choice at 10 or 12 days of age and at shock levels of .1 or .2 mA.

The two performance measures used for training and retention tests were correct choice point turns and running speeds. Choice point turns were defined as the goal arm that each mouse entered (one-half body length) upon first reaching the choice point on each trial. Running speeds were the reciprocal latencies required to reach the end of the correct goal arm from the startbox on each trial.

## RESULTS AND DISCUSSION

### Original Training

The original training scores for each performance measure were separately analyzed by factorial analyses of variance with one repeated measure. The factors were age, training shock level, retest shock level, sex, and trial blocks. Sex and retest shock level were not reliable as main effects (all $Fs < 1.0$), did not interact with any other factor for either performance measure and have been combined in the figures.

The mean number of correct choice point turns for Trials 2-25 is presented in Figure 1 as a function of age, training shock level, and blocks of four trials. The possible range of mean correct turns is 0-4 per trial block. The analysis showed that 11-day-old mice made more correct turns than 9-day-old mice ($F = 7.81$; $df = 1,64$; $p < .01$), and that correct turns increased over training trials ($F = 11.20$; $df = 5,320$; $p < .0005$). The failure to find an Age by Trial Block interaction, or any other interaction with age, indicates that although 11-day-old mice made more correct turns than those 9 days old, both age groups improved performance over the training session at comparable rates. As suggested by the figure, training shock level had little effect upon the number of correct turns at either age ($F < 1.0$; $df = 1,64$) and did not interact with any other factor.

Latency to reach the correct goal on each trial, recorded to the nearest .1 sec, was converted to a speed score by taking the reciprocal of each score. The mean speed scores during training are depicted in Figure 2 as a function of age, training shock level, and blocks of five trials. It is clear that mice trained at .2 mA reached the correct goal faster than mice trained at .1 mA at each age ($F = 14.19$; $df = 1,64$; $p < .0005$). The differences in running speeds within each age may be attributed to differences in drive or shock level since the shock groups within each age did not differ in the number of correct turns made during training. In addition, age was significant as a main effect ($F = 29.54$; $df = 1,64$; $p < .0005$) and interacted reliably with training shock level and trial blocks ($F = 2.55$; $df = 4,256$; $p < .05$).

Because 11-day-old mice made more correct turns than 9-day-old mice, the speed data do not reveal whether the faster running speeds exhibited by those 11 days of age were due to maturation or to fewer errors made in the T maze. Therefore, an analysis was conducted on running speeds for only those trials which were errorless, i.e., subjects ran directly to the choice point, made the correct turn, and reached the end of the goal arm without any other turns in the alley. This analysis indicated that the only significant effects were due to shock level ($F = 23.13$, $df = 1,72$; $p < .0005$) and age ($F = 34.75$; $df = 1,72$; $p < .0005$). Therefore, it may be concluded that 11-day-old mice ran faster than 9-day-olds at each shock level because of increased motor coordination and maturation in addition to making fewer maze errors.

In summary, the original training data indicate that although shock level affected running speeds at each age, it had no effect upon the number of correct choice point turns. In addition, the failure to find significant effects due to retest shock level group or any interactions with that factor suggests that the subgroups within each shock and age condition were equivalent in both performance measures prior to retention testing.

### Retention

The retest scores for each performance measure were separately analyzed by factorial analyses of variance as

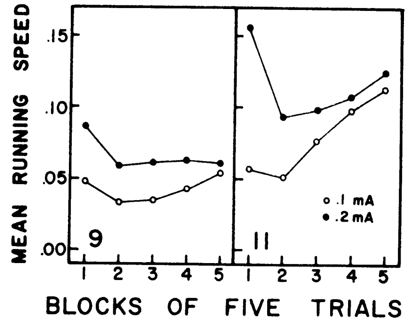


**Figure 2. Mean running speeds during training as a function of age, training shock level, and trial blocks.**

was done for the training scores, with the addition of data for maturation control subjects. These analyses indicated that sex and original training shock level were not reliable as main effects (all Fs < 1.0) nor did they interact with any other factors for either measure. Therefore, sex and original training shock level groups are combined in the figures.

The mean number of correct turns made during retest for Trials 2-25 is shown in Figure 3 as a function of age, retest shock level group, original training (prior training or naive controls), and blocks of four trials. The analysis indicated that 12-day-old mice made more correct turns than 10-day-olds ($F = 27.67$; $df = 1,96$; $p < .0005$), and that correct turns increased over blocks of trials ($F = 12.77$; $df = 5,480$; $p < .0005$). Since neither the main effects of original training shock level or retest shock level nor interactions with these factors were significant (all $ps > .10$), groups with prior training within each age were combined and compared to the appropriate combined control groups at each age by t tests. Mice trained at 9 days of age did not differ from naive controls when retested at 10 days of age ($t = .32$; $df = 58$). In contrast, mice trained at 11 days of age made more correct choice point turns when retested at 12 days of age than did controls ($t = 3.22$; $df = 58$; $p < .01$).

The mean running speed scores during retention testing are shown in Figure 4 as a function of age, retest shock level group, original training (prior training or naive), and blocks of five trials. The analysis demonstrated main effects due to age ($F = 132.99$; $df = 1,96$; $p < .0005$), retest shock level ($F = 13.00$; $df = 1,96$; $p < .001$), original training ($F = 4.28$; $df = 2,96$; $p < .025$), and trial blocks ($F = 40.11$; $df = 4,384$; $p < .0005$). These results indicate that running speeds were faster with both higher shock levels and prior training. It is interesting to note that at 12 days of age, mice with prior training, and retested at .1 mA, ran faster than control mice tested at .2 mA. This result, in combination with the fact that 12-day-old mice with prior training ran increasingly faster over trials than controls, resulted in significant Age by Trial Block and Original Training by Trial Block interactions (both

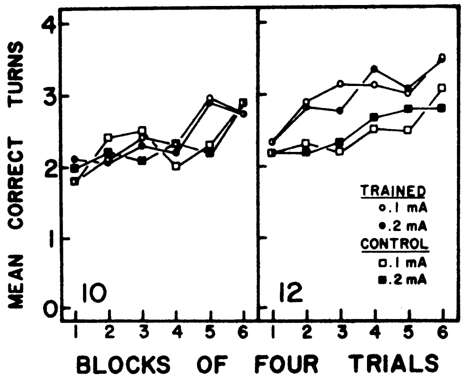


**Figure 3. Mean number of correct choice point turns during retest as a function of age, retest shock level, training groups, and trial blocks.**

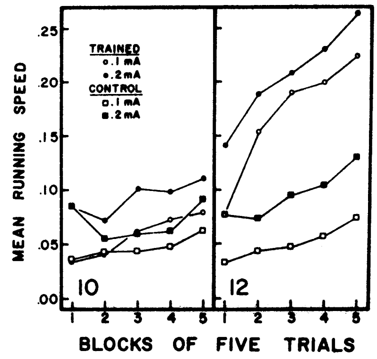


**Figure 4. Mean running speeds during retest as a function of age, retest shock level, training groups, and trial blocks.**

$ps < .0005$). Because 12-day-old trained mice made more correct turns than controls, it cannot be determined whether the faster speeds were due to fewer errors or to prior training experience. Therefore, an analysis of variance was conducted on speed scores for errorless trials for all groups. The only significant effects were due to age, shock level during retest, and prior training (all $ps < .005$). It is clear that prior training experience results in faster running speeds for both age groups even when no errors are made in the maze.

In summary, the retention data showed that 9-day-old mice did not exhibit 24-h retention of prior choice point training at either shock level, whereas 11-day-olds demonstrated significant retention independent of shock level. On the other hand, running speeds reflected only retest shock levels and prior experience with training and/or shock; they failed to reflect differences in retention performance as evidenced by the choice point measure.

Overall, the results of this investigation are in agreement with earlier data indicating 24-h retention of a learned discriminated escape response occurring by 11 days of age in mice. While it is necessary to evaluate other task parameters to determine whether this discrimination can be retained for 24 h at earlier ages, the data are in accord with the hypothesis that the onset of this retention ability is related to maturation rather than to specific task parameters such as shock level.

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