A Comparison of Sprague-Dawley and Wistar Albino Rats on Maze Learning Ability

Daniels
A COMPARISON OF SPRAGUE-DAWLEY AND WISTAR ALBINO RATS ON MAZE LEARNING ABILITY

by

Richard W. Daniels

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Richard W. Daniels
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Historical Background

Historically, the question of a genetic basis of behavior developed somewhat parallel with the increase of interest in the field of comparative psychology. Some of the earliest research in the area was carried out by Yerkes and Bagg.

Yerkes (1913), using wild captured Norway rats and tame hooded ones, investigated the possibility of a hereditary linkage involving savageness. Bagg (1916, 1920) studied mice, seeking a possible connection between coat color and differential performance in a maze and in a multiple choice apparatus. Burlingame (1927), in reviewing Tolman's 1924 study on inheritance of maze learning ability in the rat, indicated that this study involved the selective breeding of bright and dull rats. Maze performance of the strains differed significantly, with the bright strain showing consistently better performance than the dull. In the 1930's and early 1940's, Tryon published an extensive series of articles dealing with individual differences in rats as
shown with individual performance in a T-maze learning task. Tryon (1931, 1931a, 1939) found that the differences in performance were not significantly related to the factors of age, weight, sex, pigmentation, visual acuity, or various other sensory components. As a result of this research, Tryon eliminated several variables which might have been used to explain performance differences among rats.

Studies have also been done in an attempt to uncover the factors affecting the traits of emotionality and aggressiveness in rats. Hall (1938) selectively bred emotional and non-emotional animals using the amounts of defecation and urination as the measurement of emotionality in a highly illuminated open-field test. After the animals were subjected to the test situation, Hall rated his rats and selectively mated emotional and non-emotional strains. Then, in 1942, in conjunction with Klein, Hall studied the individual differences in aggressiveness exhibited by his emotional and nonemotional strains. Using behavior such as the baring of teeth, and initiation of attacks as indicators of aggressiveness, Hall found a large difference between the behavior exhibited by the two strains. The rats rated as non-emotional initiated significantly more attacks than the rats rated as emotional. Thus there was an indi-
cation of a negative correlation between emotionality and aggressiveness.

Other experimenters have dealt with the problems of emotionality and aggressiveness. Farris and Yeakel (1945) investigated the emotional behavior of gray Norway and Wistar albino rats, and found a high positive correlation between aggressiveness and emotionality. Results obtained by these investigators were diametrically opposed to those reported by Hall and Klein (1942), and indicated the possibility that performance differences were due to genetic factors. Thompson (1953, 1956), studying the inheritance of behavior in mice, obtained results in open field activity indicating a constant, between-strain variance which was highly significant. These results were interpreted by Thompson as evidence of the influence of genetic factors.

In 1957, Carr and Williams, using hooded (August line 35322), albino (Fisher line), and black rats, found significant differences between hooded and albino, and hooded and black rats in exploration of a Y-maze. No significant difference was found in the black and albino comparison. Broadhurst (1958), investigating strain differences as determinants of emotionality in the rat, obtained results different from those reported by Carr and Williams. Scores
obtained in an open field activity led Broadhurst to con­clude that the albino strain (Wistar) explored significantly more than the hooded (August line 35322) strain. Thompson's (1956) study with mice using both a Y-maze similar to that used by Carr and Williams, and an open field situation similar to that used by Broadhurst, led to a correlation of around 0.6 for exploratory behavior in the two test situations. In the light of Thompson's findings the differing results reported by Carr and Williams, and Broadhurst are possibly attributable to differences in the genetic make-up of the rats. Although the hooded strains used by these experimenters were the same in both cases, the albino strains differed; Carr and Williams used a Fisher line and Broadhurst a Wistar line.

Strain and sex differences in susceptibility to ulcer­ation in rats has been the subject of a study carried out by Sawrey and Long (1962). Rats of the Long-Evans, Wistar, Sprague-Dawley, and Nebraska hooded strains were tested in an approach-avoidance conflict situation. All animals were run under a 23-hour deprivation schedule. The experimental apparatus involved a box with food and water at opposite sides. The conflict situation was produced by electrically charging the grid floor immediately in front
of the food and water, with the center of the grid remaining uncharged. To reach food or water, the rat had to walk on the charged grid. Strains indicating the greatest resistance to ulceration in this situation were male and female Nebraska hooded, and female Wistar animals. Females of the strains were more resistant to ulcer formation than were the males.

Williams, Zerof, and Carr (1962), using the Y-maze apparatus previously employed by Carr and Williams in the 1957 study, investigated exploratory behavior exhibited by the offspring of crosses of the three strains of rats. The animals used included hooded, albino, and black rats of the strains used in the 1957 Carr and Williams study. Breeding crosses were made between hooded and black, hooded and albino, and black and albino strains. Results obtained from testing the progeny of these crossbreedings indicated that all animals having a hooded parent explored significantly less than those with no hooded parent.

An investigation of the topic of hereditary and environmental aspects of dominance behavior has been made by Uyeno (1960). Using animals of the Wistar strain, Uyeno bred selectively for dominant and submissive traits. Uyeno found that animals born of previously rated, dominant
parents were more dominant than their parents. This relationship did not, however, hold for the progeny of submissive parents. Uyeno also discovered that progeny of dominant parents were less dominant when reared by a dominant mother than when reared by a submissive mother, indicating an apparent environmental effect on behavior.

Nakamura and Anderson (1962), studying avoidance behavior differences within and between strains of rats, discovered an interesting and useful fact. Because of inconsistent results obtained in the early part of their study the experimenters decided to retest animals obtained from two different vendors. After retesting it was found that on an avoidance problem the performance scores of animals from the same vendor were alike, while animals obtained from different vendors yielded significantly different results. This finding points out that genetic differences, as exhibited by performance measured, may well exist within a single strain of animals when obtained from different breeding laboratories.

This review of literature indicates that a firm base has been established from which further research on the genetic determinants of behavior may be initiated. The attention of psychologists involved in research on the
determinants of behavior seems to be focusing on genetic variables and their effects on behavior. What had previously been thought of as environmentally caused behavioral differences now have become the subjects of genetic investigations. Of late, a wider variety of animal strains and problem areas have been used to test the effects of these genetic variables on behavior. This trend appears to be paralleling the developing interest in the field of comparative psychology.

Some results which seemed to indicate, or be based on, strain differences have been weakened by a failure to control for the specific factor of supplier differences. The influence of this factor was clearly demonstrated in the Nakamura et al. (1962) study. Significant differences between strains were found only after the supplier variable was taken into consideration.

It was the general purpose of this study to examine the operation of genetic differences and variables in a learning situation. Specifically, animals obtained from the same vendor and of the same coat color were chosen. The animals used were rats of the Wistar and Sprague-Dawley albino strains obtained from the Charles River Breeding Laboratory, Wilmington, Massachusetts. It was assumed that
the pregnant female animals obtained from this vendor represented a random sample of his breeding stock of pure strains. Since relatively few genetically-oriented studies have centered attention on strains of animals which have not been bred for specific behavioral traits in a learning situation, it was considered highly desirable to compare selected strains on a standard learning task. Because it was desirable to use a task of sufficient complexity to give an indication of any genetic differences in performance, a multiple unit T-maze with seven choice points was used as the learning task.
Method

Subjects

The Ss for this study were seven male and three female Sprague-Dawley (SD) albino rats, and ten male and seven female Wistar (W) albino rats. All Ss were obtained from litters of pregnant female (PF) rats ordered from the Charles River Breeding Laboratories, Wilmington, Massachusetts. The PF rats were received in two shipments, one PF of each strain per shipment, arriving fifty five days apart. Each PF was placed in a wire cage 15 inches long by 18 inches wide by 10 inches high. The wire cages contained a wooden living compartment 11 inches long by 5 inches wide by 6 inches high.

With the exception of the SD-PF of the second shipment (#2), all PF's whelped within 24 hours after arrival. The SD-PF #2 whelped en route to the experimental laboratory. This PF delivered fifteen pups, five of which died before arrival with nine more dying in the first 24 days.

Cages for the mothers (PF's) and pups (Ss) were kept in a separate experimental room in the animal laboratory. The room was painted a flat black and lighting was pro-
vided by eight 40 watt fluorescent bulbs approximately 9 feet above the floor.

Previous experimentation (Stone, 1929) has shown that the maximum learning rate for white rats in mazes is reached between thirty and 75 days. As a result of this finding, it was decided to run the Ss in the present experiment at 41 days.

Controls

Because this experiment was concerned with investigating the specific effects of strain differences on performance, an attempt was made to hold certain variables constant. Four variables were actively controlled:

1. All PF's were obtained from the same vendor;
2. both strains of rats were albino;
3. age of Ss at the onset of training was the same;
4. maintenance, handling, and training schedules were the same.

Apparatus

Two pieces of apparatus were employed, a straight runway (Fig. 1) and a multiple unit T-maze (Fig. 2).

Pretraining runway. The wooden runway was painted a flat black with a clear plastic top. The overall dimen-
FIGURE 1. Straight runway used for pretraining.
FIGURE 2. Multiple unit T-maze used for training.
sions were: 33 inches long by 4 3/4 inches high by 3 3/4 inches wide. The start box (SB) and goal box (GB) were each 9 3/4 inches long, and both were equipped with a transparent plastic guillotine door. A black cloth curtain was placed across the runway midway between the SB and GB doors. Both doors were operated manually from the SB end. Illumination was provided by the experimental room lights which were located 6 feet above the runway.

Training maze. The maze was constructed of wood painted a flat black with a clear plastic top. The overall dimensions of each T-unit were: base and top, 20 inches long by 3 3/4 inches high by 4 inches wide. The base of each T-unit intersected the top 6 1/2 inches from one end and 9 1/2 inches from the other end. The start box (SB) measured 6 1/2 inches long, and the goal box (GB) 8 1/2 inches long. Both SB and GB were equipped with transparent plastic guillotine doors. Black cloth curtains were placed across the entrance to each wing of the T-units.

Recording devices. A 1/10 second stop watch was used to time the latency. The number of errors per trial were recorded by E on special data sheets.
Procedure

Handling of each $S$ was initiated on the 29th day after birth. All $S$s were handled for three minutes a day for seven days prior to pretraining. At the conclusion of the seventh day of handling all $S$s in phase 1 (pups produced by 1st shipment PF's) were placed on 22 hours food deprivation, and all $S$s in phase 2 (pups produced by 2nd shipment PF's) were placed on 15 hours of food deprivation. The 15 hour deprivation schedule was used with phase 2 animals because the 22 hour schedule used with phase 1 animals proved to be too severe and several animals were lost.

Pretraining. Pretraining trials were initiated on the 36th day (hereafter experimental day #1) after birth for all animals. Pretraining lasted four days. Each $S$ was given two consecutive runway trials per day. Reward for traversing the runway was two .045 gram J.P. Noyes food pellets which were placed in a baby food jar top at the end of the runway GB. After completion of the two trials on experimental day #4 all animals had evidenced adaptation to the guillotine doors and the curtain, through decreased latency measures. At this point it was decided that adaptation was sufficient and training was initiated.
after 24 hours of ad lib food for all animals.

Training. On the sixth experimental day each animal, under 22 hours of food deprivation, was placed in the maze and allowed to explore until the GB was entered. Reinforcement consisted of two .045 gram J.P. Noyes food pellets placed in a baby food jar top located at the end of the GB. Latency and number of errors were recorded. Latency was recorded from the time the SB door was raised until the animal entered the GB a sufficient distance to lower the GB door. An error was defined as the projection of a Sa head past the curtain of an incorrect alley. If, during a trial, a Sa reversed anywhere in the maze, a special reversal error was recorded and errors for entering culs de sac were recorded as above. Each Sa received four trials per day, and training was continued until the learning criterion of two errorless trials was achieved.
Results

Three measures of learning were employed with which to make comparisons between strains: latency, number of trials to criterion, and number of errors per trial. Data for each of these measures were subjected to a strain x sex factorial analysis of variance for unequal cell frequencies.

One female animal in the Wistar phase two (second shipment) group was eliminated from the study because of refusal to run the maze. With this one exception, data for all subjects of each strain were grouped for statistical analysis. A summary of the analyses of variance is presented in Table 1., and mean values for performance of each strain are presented in Table 2. No significant values for $F$ were found for any of the strain comparisons, i.e. latency, errors, or number of trials to criterion. Latency was the only performance measure to yield a significant $F$ value (significant at the .05 level, $F$ equals 5.27, df equals 1 and 1) for the sex comparisons.
TABLE 2

Mean Strain Values for Performance Measures

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<th>LATENCY</th>
<th>ERRORS</th>
<th>TRIALS</th>
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<td>SPRAGUE-DAWLEY</td>
<td>79.19</td>
<td>2.70</td>
<td>13.29</td>
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<tr>
<td>WISTAR</td>
<td>165.33</td>
<td>3.80</td>
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TABLE 1

Summary of Analyses of Variance

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<tr>
<td></td>
<td>MS</td>
<td>df</td>
<td>F</td>
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<tr>
<td>SEX</td>
<td>1.56</td>
<td>1</td>
<td>2.89</td>
</tr>
<tr>
<td>STRAIN</td>
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<td>33.40</td>
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<tr>
<td>INTERACTION</td>
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<td>1</td>
<td>.09</td>
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<tr>
<td>EXPERIMENTAL ERROR</td>
<td>.54</td>
<td>22</td>
<td>1455.2</td>
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</tbody>
</table>

* Denotes significant at .05 level.
Discussion

The purpose of this study was to investigate genetic differences between Sprague-Dawley and Wistar strains of albino rats as measured by performance on a learning problem. It was assumed that the PF animals used represented a random sample of the vendor's breeding stock of pure strains. The results obtained through analyses of variance of the data for the three performance measures indicate that no strain differences exist as measured by the conditions of this study. Two major factors which appear relevant to an evaluation of the results are problem difficulty and age of the Ss at the time of testing.

The choice of a multiple unit T-maze as the problem with which to test learning ability was made because it was thought that this problem was sufficiently difficult to demonstrate possible strain differences. The evidence, however, does not indicate the problem was as difficult as had been anticipated. Scores for trials to criterion, for example, were much lower than had been expected for the learning of this type of problem. The mean number of
trials for all Ss to reach criterion was only eight. Further indication of the level of difficulty of the problem was obtained through error scores. Errors on the initial trials, as expected, were quite high. The surprising factor was that, with few exceptions, error scores dropped to two or three per trial as early as the third or fourth trial, with some animals reaching criterion on the third trial. It is entirely possible that the problem used did not present the Ss with sufficient difficulty to allow any strain differences which may exist to be clearly demonstrated.

The performance is even more striking when one considers the factor of the age of the Ss. Testing was done while the Ss were between 41 and 45 days of age. A majority of studies dealing with maze learning in rats have employed animals 75 days and older. The speed with which the Ss in the present experiment learned the performance task perhaps indicates a differential learning ability correlated with the age, or maturational level, of the Ss employed.

Liu (1928), in an early study dealing with the relationship of learning ability to age in maze performance,
reported a rapid increase in the learning ability of rats during the 30 to 75 day age range, with a gradually decreasing ability as the animals approached 250 days of age. Anderson and Smith's (1932) study, dealing with performance as related to age and nutritive condition in the white rat, showed results similar to those reported by Liu. Anderson and Smith reported that the 31 and 71 day old groups were the most active of the four groups (31, 71, 111, and 115 days) used when tested in the modified Hampton Court maze and revolving drum. These workers also found that, after 71 days, activity decreased as a function of age. Observations of performance in the present study indicate a high level of activity in the 41 to 45 day age range, and may be taken as further evidence in support of Liu's and Anderson and Smith's results.

The possibility exists that the critical level of performance ability had not been reached by either of the strains used when they were tested at such a relatively young age. Demonstration of strain differences could perhaps be obtained through the use of a longitudinal study in which the two strains are compared at various intervals from birth through specified periods of adulthood. The use of a longitudinal design would permit
identification of the critical age at which maximum performance is reached and would also allow a more sensitive comparison of strains.

The significant sex difference that was found in this study demonstrates the superiority of female animals of both strains on the latency measure, and is in agreement with findings of other tests under similar conditions. Campbell, Teghsoonian, and Williams (1962), reporting results of their starvation study, which dealt with activity, weight loss, and survival time as a function of complete food deprivation in rats, stated that for the 54 and 100 day old groups females were more active than males of the same age. The present author believes that the onset of estrus alone might be a sufficient variable to explain the obtained sex difference. The onset of estrus has been firmly established as a factor affecting the activity levels of female rats, thereby becoming a direct influence on their performance on a perceptual-motor task. The significant results obtained in the present study reflect the possible relationship between measures of latency (activity level) and onset of estrus.
Summary

The purpose of this study was to examine the possibility of differences in the learning ability of two strains of laboratory rats. Ten Sprague-Dawley and 17 Wistar albino rats were required to learn an enclosed multiple unit T-maze with seven choice points. The two groups were compared on three performance measures: trials to criterion, errors per trial, and latency. An analysis of variance for unequal sample sizes yielded nonsignificant results on all measures for strain comparisons. A significant F ratio (F equals 5.27, df equals 1 and 1) at the .05 level was obtained for sex differences on the latency measure. Results were discussed in light of the level of difficulty of the problem, and the age of the Ss at the onset of training.
References


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