competitive behavior, then "dominant" Ss in the control group, which are relatively deprived to a much higher degree than their submissive counterparts, should show decreased success in competition from Condition 1 to Condition 2 testing.

Table 2b shows the relationship between the dominance hierarchies determined when all Ss were deprived equally and those hierarchies obtained when the dominant S received 48 and 72 h of deprivation. The extreme stability in dominance-submission evidenced in Table 2b tends to dispute the hypothesis that fatigue played any significant role in the original stability of the relationships found in the experimental group.

GENERAL SUMMARY

On the basis of these data, dominant-submissive behavior appears to be generalizable to different competitive situations. This evidence would disagree with Lindzey, Manosevitz, & Winston (1966), who found little generalization over different competitive situations.

Deprivation appears to have little affect on the stability of dominance-submission hierarchies, at least in the 24- to 72-h range.

This stability is evident not only when both Ss are members of a competing pair under the same level of deprivation, which would agree with data acquired by Schumsky & Jones (1966), but also is evident when members of the competing pair are under different levels of deprivation, which would seem to disagree with results found in rats with unequal motivation levels (Hsiao & Schreiber, 1968). The difference between results obtained in this study and those of Hsiao & Schreiber (1968) may be a function of differences in procedure. Motivational differentials in the Hsiao and Schreiber study were produced largely through different amounts of prefeeding before testing. This procedure cannot, therefore, be considered completely comparable to our procedures.

The high degree of relationship between dominance hierarchies obtained in limited access and social encounter situations was not found by Baenninger (1970) with rats. Again, however, differences in procedure may in part be responsible for differences in results. Baenninger (1970) tested groups of four Ss together in each competitive task. This procedure may produce a much different relationship among group members from those relationships found in a round-robin paired-comparison method.

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Strain differences in rotating wheel activity of the rat*

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Parametric comparisons of activity in a wheel were made for 694 rats from 12 inbred strains: ACI, A990, A35322, F344, INR, IR, MNR, MNR-a, MR, TS1, WAG. Where comparable, the data were consistent with the data of previous studies, though pointing toward different interpretations.

The rotating cage or activity wheel has long been one of the common measurement devices for motor activity. Rundquist (1931, 1933), in a selection study continued by Brody (1942, 1950), seems to have been the first to demonstrate the heritability of motor activity in rats, as measured in activity wheels. Fuller & Thompson (1960) have presented a rather detailed critical review of these and some of the other major works on the genetics of activity. However, the investigator who needs parametric data to select an appropriate strain for his research or to assess the comparability his have with others will be hard pressed if he uses rats rather than some other species which is genetically well documented. This study provides comparative data for wheel activity of 12 inbred strains of rats.

METHOD

The Ss were 694 rats from 12 inbred strains, bred and maintained in

the writer's laboratory as follows: ACI, black, agouti, Irish, 44 males and 29 females; A990, black, agouti, hooded, 25 males and 22 females; A35322, black nonagouti, hooded, 31 males and 27 females; F344, albino, nonagouti, hooded, 35 males and 31 females; INR, black, nonagouti, hooded, 21 males and 15 females; IR, dilute, nonagouti, hooded, 33 males and 31 females; MNR, albino, agouti, hooded, 10 males and 10 females; MNR-a, albino, nonagouti, hooded, 31 males and 29 females; MR, albino, nonagouti, hooded, 24 males and 22 females; TS1, black, agouti, Irish, 43 males and 47 females; TS3, black, nonagouti, 37 males and 36 females; WAG, albino agouti, hooded, 32 males and 23 females. The preceding lines are sometimes referred to in the literature by the following synonyms, respectively: Ax/C9935, August 990, August 35322, Fischer 344, Iowa Nonreactive or Hall Nonreactive, Iowa Reactive or Walker, Maudsley Nonreactive, Maudsley Nonreactive a subline, Maudsley Reactive, Tryon Maze Bright, Tryon Maze Dull, Wistar Albino. The INR, IR, TS1, and TS3 lines were derived from selective breeding and maintained for many

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Table 1
Rotating Cage Activity: Revolutions Over 4 Days, 1,000 Sec/Day

Strain	Males			Females		
	N	Mean	SD	N	Mean	SD
ACI	44	379.7	228.2	29	770.5	282.7
A990	25	243.5	100.5	22	445.5	156.3
A35322	31	509.3	187.7	27	923.2	331.1
F344	35	377.3	324.9	37	479.9	199.4
INR	21	432.4	113.2	15	528.7	158.3
IR	33	330.9	185.2	31	521.4	322.0
MNR	10	741.7	238.1	10	1301.4	336.7
MNR-a	31	535.6	214.6	29	901.0	240.0
MR	24	345.0	226.0	22	592.4	315.4
TS1	43	342.1	165.1	47	719.3	240.8
TS3	37	416.9	170.9	36	662.8	284.8
WAG	32	542.9	271.4	23	1005.4	314.1

years by partial inbreeding. More recently, they have been maintained by full sib mating. Animals in this study from these four strains had been inbred six or more generations. Ss from the remaining lines were inbred a minimum of 20 generations. More detailed information on the strains and their maintenance has been reported elsewhere (Harrington, 1968).

Animals were placed in Wahmann activity wheels for 16-2/3-min (1,000 sec) periods daily for 2 weeks. The wheels were located in a primary animal maintenance space. The procedures were carried out as part of the normal daily caretaking activities. The location provided visual isolation only. Since the wheels were within a few feet of each animal's home cage, the auditory conditions probably were equivalent to those of the home cage. The first 10 days were considered as adaptation time. Data recorded were the total revolutions of the wheel for the last 4 days.

RESULTS AND DISCUSSION

Means and standard deviations for each of the 12 strains by sex within strain appear in Table 1. The data for each of these 24 strain-sex groups were examined separately and tested for normality. Neither significant deviations nor trends from the normal distribution were found. On the other hand, the homogeneity of variance yielded results close to, but varying about, $p = .05$. There was a slight correlation between the group means and group variances.

Not unexpectedly, an unweighted means analysis of variance showed significant strain differences ($F = 8.30$, $df = 11/11$, $p < .001$), sex differences ($F = 71.1$, $df = 1/11$, $p < .001$), and Strain by Sex interaction ($F = 3.76$, $df = 11/670$, $p < .001$).

A correlation between means and variances usually points toward a square root transformation. Transforming the activity scores eliminated the trend to inhomogeneity. By Bartlett, Cochran, or Hartley methods, $p > .50$ for

homogeneity of transformed data. An analysis of variance of transformed variates showed the same magnitude of strain and of sex effects found with the raw data. However, with transformed variates, the Strain by Sex interaction was almost eliminated ($p = .045$) and could be considered nonsignificant relative to sample size and the magnitude of other effects.

These data provide an interesting example of the problems of scale transformations. The square root transformation led to homogeneity of variance. It also eliminated a highly significant interaction in an analysis of variance, indicating that the interaction could be attributed to the measurement method rather than to underlying behavioral events. However, the sex-within-strain groups, which showed normally distributed raw data, showed skewed distributions under transformation. Methodologically, this demonstrates that a scale transformation to solve one statistical problem may create another problem. Behaviorally, it hints at a possibility for further investigation. If a transformation of data has different effects between groups than it has within groups, then the between-group variation may stem not only from different sources, but also from different mechanisms than does the within-group variation.

For a parameter usage, it should be noted that the procedures were intended to yield estimates toward the upper limits of the standard deviation. The presence of other activities during experimentation should have increased the variability of the data vis-à-vis a more isolated and controlled environment. Thus, for purposes of data comparison on research design, one could reasonably expect that error variance would not exceed the magnitudes reported here.

Fuller & Thompson (1960) commented on testing a discrepancy between Broadhurst's (1958a,b) finding albinos more active than hooded animals while Carr & Williams

(1957) had found the converse. The present data, though using a different procedure, include the hooded strain (A35322) common to both studies and the two albino strains (WAG, F344) in the respective studies. This direct comparison shows that, as Fuller and Thompson speculated, the differences indeed lie in the different albino strains used and not in the coat color genes, at least by this measure. The hooded A35322 showed activity levels intermediate between the active WAG used by Broadhurst and the relatively inactive F344 used by Carr and Williams.

Searle (1949) found lower wheel activity in Tryon Maze than in Tryon Maze Dull rats and arrived at an interpretation which implies a negative correlation between activity and maze performance. The TS1 males were less active than the TS3 males, in agreement with Searle's observations. However, the situation is reversed for females of these strains. It has been found that on a Hebb-Williams maze, the TS3 female is superior to the TS1 female (Harrington, 1968). Thus, considering only the Tryon-derived animals, there is some tendency for negative correlation of activity and maze performance. This hypothesis fails when additional strains are considered. The two most active strains were also the most efficient in maze performance (Harrington, 1968).

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