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ORGANIZATION OF BEHAVIOR IN THE ALBINO RAT

By

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Submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in the Faculty of Philosophy, Columbia University

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I

INTRODUCTION

For a number of years now studies have been conducted upon the organization of behavior in human beings—notably the work of Spearman, Kelly, Thurstone, Garrett, and others. For an even longer time a legion of investigators have been studying animal behavior; but the study of the organization of and relationships within animal behavior is of comparatively recent origin.

Work along this line started as an attempt to determine the reliability of the various instruments—especially the mazes—being used in animal experimentation. In the last fifteen years there have been many of these studies, of varying degrees of experimental and mathematical sophistication, culminating in the recent careful work of Tolman, Stone, Leeper, Heron, and particularly Tryon. The earlier work has been reviewed by Leeper (15), Spence (24), and Tryon (34). Some of it is outlined in Table 1, together with more recent work.

An examination of this table shows us that the earlier studies reported quite low reliabilities. Even these low correlations were partly spurious, inasmuch as different animals were given different numbers of trials. Most of the more recent studies found distinctly higher reliabilities, many of them comparing favorably with those found in human work. The corrected coefficient of .9876 reported by Tryon (34) for 141 rats on a 17-unit multiple-T maze compares very favorably with

TABLE 1

RELIABILITIES OF SCORES IN ANIMAL EXPERIMENTS

A. MAZES

Experimenter	Date	Animals	Maze	Trials correlated	How computed	Correlation		Median
						(Raw r's)		
Webb (40)	1917	Groups of 6-11 rats	Carr	Mastery	Learn vs. relearn	Trials	—.37 to .13	
						Errors	—.25 to .56	
						Time	—.60 to .45	
Hunter (10)	1922	36 and 25 rats	Circular	Mastery	Make vs. break	Trials	.31	
						Total time	.13	
						Total dist.	—.02	
						Net time	.36	
			Single-T	Mastery	Make vs. break	Time	—.04	
						Errors	—.07	
Hunter (9)	1922	25 rats	Single-T	Mastery	Different tenths correlated		.12 to .59	.32
		36 rats	Circular				—.08 to .40	.12
		24 rats	Complex circular				—.12 to .69	.18
Tolman (30)	1924	82 rats	Rectangular	10	Odd vs. even trials	Errors 1-10	.28	
						2-10	.30	
						3-10	.38	
						Weighted	.43	
						Corrected	.51	
					Time	Crude	.59	
						Weighted	.53	
						Corrected	.52	
Tolman & Davis (31)	1924	13 rats	Rectangular	3-10	Odd vs. even trials	Crude errors	.27	
						Corr. errors	.45	
						Crude time	.12	
						Corr. time	.63	
			Carr	3-10	Same	Crude errors	.02	
						Corr. errors	.34	
						Crude time	.19	
						Corr. time	.57	

TABLE 1 (*Continued*)

Experimenter	Date	Animals	Maze	Trials correlated	How computed	Correlation	
Hunter & Randolph (11)	1924	19 rats	T maze	30	Odd vs. even trials Time	(Raw r's) .69	
							Median
Hunter & Randolph (12)	1926	32 goats	Single-T	9	Correlated time on single trials	—.01 to .7	.30
					Groups of 3 trials Errors	.25 .06 .32	
Tolman & Nyswander (32)	1927	25 rats	Multiple-choice	3-10	Odd vs. even trials	.48	
					Half vs. half trials	.03	
		24 rats	Circular	3-14	Odd vs. even trials	.56	
					Half vs. half trials	.22	
		42 rats	Carr	3-16	Odd vs. even trials	.60	
					Half vs. half trials	.37	
		15 to 21 rats	3 way	3-25 and 3-10	Odd vs. even trials	.44 to .60	
					Half vs. half trials	.34 to .60	
		18 to 24 rats	Right-left	2-17 and 3-32	Odd vs. even trials	.69 to .88	
					Half vs. half trials	.34 to .59	
		20 to 36 rats	T maze	3-10	Odd vs. even trials	.56 to .72	
					Half vs. half trials	.41 to .65	
		25 rats	Multiple-T maze	4-19	Odd vs. even trials	.83	
					Half vs. half trials	.82	
						(Corrected r's)	
					Errors:		*Median*
Stone & Nyswander (27)	1927	205 rats of different ages	12-unit multiple-T maze	Various groups of the first 30	Odd vs. even trials	.59 to .97	.93
					Odd vs. even blinds	.71 to .96	.87
					Half vs. half blinds	.66 to .96	.85
					Segments of trials	.46 to .97	.86
					Time:		
					Odd vs. even trials	.76 to .97	.90
					Half vs. half trials	.74 to .87	.88

TABLE 1 (*Continued*)

Experimenter	Date	Animals	Maze	Trials correlated	How computed		Correlation	
Stone (25)	1928	201 rats of different ages	Carr	Various groups of the first 20	*Errors:*			*Median*
					Odd vs. even trials		.38 to .87	.72
					Half vs. half blinds		—.04 to .67	.45
					Segments of trials		.12 to .69	.35
					Time:			
					Odd vs. even trials		.25 to .98	.83
					Segments of trials		—.07 to .99	.59
Shirley (22)	1928	29 rats	8-cul maze	Mastery	Odd vs. even trials	Errors	.62	
						Time	.84	
					Odd vs. even trials minus 1 & 2	Errors	.80	
						Time	.95	
				3-8	Odd vs. even trials	Errors	.73	
						Time	.94	
Husband (13)	1929	43 rats	Warden, multiple-U	6-15	Odd vs. even trials	Errors	.88	
Miles (17)	1930	58 rats	Elevated multiple-T	Mastery	Odd vs. even trials, errors		.34	
				4-13			.88	
			Alley multiple-T	Mastery	Odd vs. even trials, errors		.86	
				4-13			.84	
Heron (7)	1930	196 rats in various groups	12-unit multiple-T	Two series of 20 each	Same methods used by Stone & Nyswander, with similar results			
					Test vs. retest, with about 200 days interval		(Raw r's) .38 .38	
Tryon (34)	1930	141 rats	17-unit multiple-T	2-19	Odd vs. even trials	Errors	(Corrected r's) .9376	
			20-unit multiple-T	2-19	Same		.9682	
Leeper (15)	1932	202 rats in various groups	12-unit multiple-T	Various parts of 30 trials	*Errors:*		(Raw r's)	*Median*
					Odd vs. even trials		—.44 to .90	.62
					Segments of 10 & 15		—.16 to .65	.46
					Segments of 3 trials		—.27 to .90	.37
					Time:			
					Odd vs. even trials		—.20 to .56	.58
					Segments of 10 & 15		—.21 to .69	.41

Experimenter	Date	Animals	Maze	Trials correlated	How computed	Correlation
Ruch (19)	1930	20 rats	12-unit multiple-T Food reward	2-25	*Errors:*	
					Odd vs. even trials	.68
					Odd vs. even blinds	.83
					Half vs. half blinds	.59
					Half vs. half trials	.46
					Time:	
					Odd vs. even trials	—.01
					Half vs. half trials	—.18
		19 rats	Same, but escape from water	2-25	*Errors:*	
					Odd vs. even trials	.90
					Odd vs. even blinds	.64
					Half vs. half blinds	.51
					Half vs. half trials	.57
					Time:	
					Odd vs. even trials	.65
					Half vs. half trials	.11
Commins, McNemar, & Stone (5)	1932	256 rats	Multiple-T	40	*Errors:*	(Corrected r's)
					Odd vs. even trials	.97
			Elevated multiple-T		Same	.86
			Elevated multiple-U		Same	.56
Tomilin & Stone (5)	1934	136 rats	Warden, multiple-U	20	*Errors:*	
					Odd vs. even trials	.95
			Warden, multiple-U reversed pattern	40	Same	.88
			Elevated multiple-T	16	Same	.71
			Same maze, reversed pattern	10	Same	.50
Dunlap (5)	1933	119 chicks	Warden, multiple-U	8	Odd vs. even trials — Errors	.85
					Time	.89
					Time+errors	.86

TABLE 1 (*Continued*)
B. Tests Other Than Mazes

Experimenter	Date	Animals	Apparatus	Trials correlated	How computed		Correlation	
							Raw	
Hunter (10)	1922	16 rats	T discrimination box	Mastery	Make vs. break		.23	
Heron (6)	1922	28 rats	Inclined-Plane problem box	Mastery	Odd vs. even trials	Time	.17	
					Omit trials 1 & 2		.50	
					Omit trials 1-4		.34	
					Omit trials 1-6		.44	
					Omit trials 1-8		.63	
					Odd vs. even tenths	Time	.23	
					Omit tenths 1 & 2		.35	
					Omit tenths 1-4		.41	
					Omit tenths 1-6		.46	
					Omit tenths 1-8		.54	
		20 rats	Inclined-plane problem box	12, in two groups of 6, with 60 days between	Trials 1-6 vs. 7-12		—.10	
					Trials 3-6 vs. 9-12		—.22	
								Median
					Individual trials		—.26 to .37	—.01
Hunter & Randolph (11)	1924	15 rats	Sawdust box	30	Odd vs. even trials	Time	.25	
Stone (26)	1928	153 rats	Multiple-discrimination	Various fractions of 40	*Errors:*		(Corrected *r*'s)	
								Median
					Odd vs. even trials		.05 to .99	.65
					Segments of trials		—.39 to .98	.53
			Same—reversed cue	Same	Odd vs. even trials		.57 to .92	.84
					Segments of trials		.22 to .93	.77

TABLE 1 (*Continued*)

Experimenter	Date	Animals	Apparatus	Trials correlated	How computed	Correlation
						(Raw *r*'s) *Median*
Shirley (21)	1928	45 rats	Revolving wheel	20 days	Odd vs. even days	.98
					Sections of 5 days	.83 to .98 .90
				10 days	Odd vs. even days	.98 & .96
						(Corrected *r*'s)
Williams (41)	1929	25 rats	Visual-discrimination	Mastery	Odd vs. even trials Errors	.96
Commins, McNemar, & Stone (3)	1932	155 rats	Triple-plate problem box	11-25 or 11-30	Odd vs. even trials	.67 to .83
		256 rats	Light-discrimination box	40	Odd vs. even trials	.72
Rundquist (20)	1933	Groups of about 20 rats	Revolving wheel	10 days	5 days vs. 5 days	Raw *r* in the high .80's
						(Corrected *r*'s)
Dunlap (5)	1933	119 chicks	Rotor	2-7	Correlation between some combination of odd vs. even trials	.85
			Tunnel	2 fastest		.78
			Vocalization	4		.91
			Periscope	2-7		.64
			S maze	1-6		.74
			Prob. box A	1-4		.76
			Prob. box B	1-5		.70
			Alternate stimulus	2-6		.68
			Directional tendency	1-5		.75
Tomilin & Stone (33)	1934	136 rats	Multiple-light-discrimination	30	Odd vs. even trials Errors	.66
			Same—reversed cue	50	Odd vs. even trials Errors	.95

those of any mental tests now available in the human field.

The higher correlations found in the later work may be due in part to more careful technique. They are probably due to a greater extent to improved instruments. The multiple-unit mazes now in use are both more uniform and more difficult than most of the earlier tests, and both these factors are conducive to higher reliability. Tryon lists the following factors as making for higher reliability: (1) more material in test; (2) test-broken individuals; (3) a carefully controlled situation; (4) objective scoring; (5) considerable spread of ability in the group; (6) presence of irrelevant correlated variables (an undesirable source of high reliability); (7) correlation of comparable measures. These factors explain the higher reliabilities found for the recent work, including the very high reliability found by Tryon.

Another source of difference in the size of the reliability coefficients is the variety of ways of computing them. Examination of Table 1 will reveal almost as many ways of computing reliability as there are experimenters. Even the recent workers are not agreed as to the most satisfactory technique. Consider the following six methods: (1) correlating the score on the odd *vs.* even trials; (2) correlating odd *vs.* even blinds; (3) correlating the first half *vs.* second half of the blinds; (4) correlating one segment of trials with another; (5) correlating test with retest; (6) correlating scores on two different mazes. Stone and his co-workers use methods 1, 2, 3, and 4; Tryon favors method 1; Leeper, method 3; Heron, method 5; Spence, method 6. Apparently no method completely satisfies the two requisites of correlating completely comparable measures and of correlating measures which are free from irrelevant correlated factors. The results from method 1 are almost certainly too high, and those from methods 5 and 6 are probably too low. We cannot say with assurance in which direction the other methods err. But whatever method we may use, we must be fully aware of its limitations.

Intercorrelations between two or more tests were reported as one of the first approaches to the problem of the reliability of the individual tests. Later on, intercorrelations were studied for their own sake. Earlier studies were limited to two or three tests; more recently experiments have been extended to include a wider variety of performances. In Table 2 we outline some of the earlier results. We shall consider the more recent work in some detail.

More extensive studies have been published by Commins, McNemar, and Stone (3), by Tomilin and Stone (33), and by Dunlap (5).

Commins, McNemar, and Stone calculated their intercorrelations from data obtained in the course of two other studies. The first study yielded records for several groups of rats on a multiple-T maze, a triple-platform problem box, and the Stone multiple-discrimination box. The reliabilities of these tests were all fairly high. However, the medians of the raw intercorrelations for the six groups for which results were computed were:

TABLE 2
INTERCORRELATIONS

Experimenter	Date	Animals	Tests used	Test reliabilities	Correlation
					(Raw r's)
Bagg (1)	1920	90 mice	Simple maze vs. multiple choice	?	.11
Heron (6)	1922	22 rats	Circular maze vs. problem box	?	.01 to .09
Hunter & Randolph (11)	1924	23 to 37 rats	(1) T maze (2) Straightaway (3) Sawdust box	?	—.16 to .18
Tolman & Davis (31)	1924	13 rats	Rectangular vs. Carr maze	.22 to .77 .04 to .73	Raw .16 to .66 Cor. .6 to 1.0+
Liggett (16)	1925	48 chicks	T maze straightaway	?	—.04 to .19
Williams (41)	1929	Two groups of 25 rats	Visual-discrimination vs. multiple-T maze	.96 .88	Raw .16 & .08 Cor. .17 & .09
Miles (17)	1930	38 rats	Errors, elevated vs. alley multiple-T maze	.84 .86	Raw .50 Cor. .59
Tryon (35)	1931	141 rats	17-unit vs. 20-unit multiple-T maze	.9876 .9682	Raw .77 Cor. .79
Leeper (15)	1932	66 rats	Multiple-T maze vs. mirror image of same maze	Not given for all cases	—.08 to .71 *Median* .30
Shirley (22)	1928	29 rats	Revolving wheel vs. 8-cul-de-sac maze	About Time .90 .97 Errors .89	Raw time —.40 Raw errors —.12 Cor. time —.43 Cor. errors —.13
		17 rats	Same	Same	Raw time —.46 Raw errors —.36 Cor. time —.49 Cor. errors —.40
Rundquist (20)	1933	24 and 31 rats	Revolving wheel vs. maze	Both quite high	Raw: —.36 to .13 Median —.06

Platform box vs. Light-discrimination	.10
Platform box vs. T maze	.02
Light-discrimination vs. T maze	.01

The three tasks seemed to have nothing in common.

The second study gave results for the multiple-T maze, the light box, and two patterns of elevated mazes. When all the groups were combined, a population of 256 animals was obtained. For this group, the corrected correlations between the mazes were .56, .65, and .66. The correlations between the light box and the mazes were all close to zero. There appeared to be a community of function among mazes, but this community did not extend to a discrimination habit.

Further light is thrown on this question by the results of Tomilin and Stone (33). Records were obtained for 136 rats on six tests, namely: (1) multiple-U maze; (2) reversed pattern of same; (3) elevated multiple-T maze; (4) reversed pattern of same; (5) multiple-light-discrimination box; and (6) the same with reversed cue. The corrected correlations between mazes ranged from .48 to .86 with a median at .61. The corrected correlation between the two discrimination habits was .66. The median correlation between a maze and a discrimination test was —.02. There seemed to be factors common to the maze habits and factors common to the discrimination habits, but nothing common to the two.

The most extensive study of the interrelations of animal performances is that of Dunlap (5). His subjects were 119 young chicks. These he tested on a variety of simple tests, including several simple maze-type tests—a straightaway tunnel, an S-shaped maze, and a multiple-U-shaped maze; measures of activity—rotor, periscope, vocalization, problem-box situations; and tests of directional tendency. The reliabilities of the tests were estimated by correlating odd *vs.* even trials and correcting by the Brown-Spearman formula. These reliabilities are included in our Table 1.

The intercorrelations of the different tests were then determined. These were almost all positive and, when different measures from the same test were eliminated, low. The raw correlations between the ten variables which Dunlap used in his final analysis ranged from —.02 to .47 with a mean of .205. The corrected correlations range from —.03 to .65 with a mean somewhere between .25 and .30. Apparently these tests have something in common, though not very much.

Dunlap applied the methods of tetrad analysis to his intercorrelations in order to determine the best pattern of factors to explain them. He feels that the correlations cannot be explained satisfactorily by a pattern of one general factor plus factors specific to single tests, and fits more complicated patterns to the data. He concludes that the complex patterns are very provisional and may well need to be revised with future work, but that the evidence indicated that more than one factor must be postulated to explain the intercorrelation of these abilities in the chick.

My own problem was similar in general to that of Dunlap. I proposed to test a number of albino rats on as wide a variety of problems as possible, to determine the reliabilities of the various scores obtained, and to find the correlations between them. This table of correlations was then to be examined by the current methods of factor analysis, in an endeavor to trace the relationships existing among the various scores.

II

APPARATUS AND PROCEDURE

The subjects in the experiment were male albino rats, approximately 60 days of age when obtained from the dealer (Breeding and Laboratory Institute in New York City). The rats were run in groups of 18, obtained upon the follow dates: July 17, August 28, and October 23, 1933, and January 3 and February 13, 1934. The homogeneity of the groups is not known, but it is known that the animals were taken from about twenty different litters.

The rats were kept in the laboratory for 12 days before they were started on the experiment proper. During this time they were put through a standard routine of handling and taming, which consisted of about six minutes a day of handling, petting, etc., by the experimenter. Care was taken to keep this treatment as nearly the same as possible for each animal.

Ninety animals started the experimental routine, but there were always some who became conditioned against one or another of the pieces of apparatus and would not run. These failures were almost all in the earliest tests, and these failing animals were discarded, except in one case which will be mentioned later. Our results are based on the complete records of sixty-four animals.

Each animal received the 12-day taming routine described above, and was then put through the standard 39-day experimental routine. The order and time of the different tests was kept the same for the several

TABLE 3

SCHEDULE OF EXPERIMENTATION

Day	8:00 A. M	9:00-10:00 A. M.	4:00 P. M.
1	Maze C preliminary	Jenkins Problem Box preliminary	Maze A prelim.
2	Same	Same	Same
3	Same	Same	Same
4	Maze C trial 1	Same	Same
5	2	Jenkins Problem Box trials 1-2	Maze A trial 1
6	3	3-4	2
7	4	5-6	3
8	5	7-9	4
9	6	10-12	5
10	7	13-15	6
11	8	16-18	7
12	9	19-22	8
13	Maze D trial 1	23-26	9
14	2	27-30	10
15	3	31-35	11
16	4	36-40	Maze B trial 1
17	5	41-45	2
18	6	46-50	3
19	7	51-55	4
20	Latch Box preliminary feeding	56-60	5
21	Same	61-65	6
22	Same	66-70	7
23	Same	71-75	8
24	Latch Box prelim. trials	76-80	9
25	Latch Box trial 1	Latch Box trial 2	Latch Box trial 3
26	4	5	6 Columb.
27	7	8	9 Obstr.
28	10	11	12 Prelim.
29			Columbia Obstr.—hunger
30	"CR" preliminary		"CR" preliminary
31	Same		Same
32	Same		"CR" sound trials 1-10
33	"CR" sound trials 11-20		21-30
34	31-40		41-50
35	51-60		61-70
36	"CR" light trials 1-10		"CR" light trials 11-20
37	21-30		31-40
38	41-50		51-60
39	61-70		71-80

On days 2-15 rats ran in revolving wheel for periods of four hours each day groups of rats. Table 3 shows how the tasks were temporally distributed.

In general, the animals were experimented with for three or four hours in the morning, and again at the end of the afternoon, about four hours later. The animals were fed on whole wheat bread and milk. They got a little food in the apparatus, when they completed their task; and received their main feeding for ten minutes in the afternoon, at the conclusion of the day's experimentation. Records were obtained for each animal on ten different tests, as follows:

Revolving-wheel activity cage
Warner-Warden maze (2 patterns—A and B)
Elevated T maze (2 patterns—C and D)
Jenkins circular problem box
Latch problem box
Warner's conditioned-response test (two different stimuli)
Columbia obstruction apparatus (new model)—hunger drive

Let us now consider the apparatus, procedure, and scoring for each of these tests in more detail.

Revolving Wheel Activity Cage

A measure of a certain phase of voluntary activity was obtained from the amount that the animal ran in a revolving wheel. The apparatus was made by G. H. Wahmann Mfg. Co., and followed the design of Spaeth. A revolution counter recorded half-turns made by the wheel in either direction.

Due to the limited number of wheels available, it was necessary to run each rat every third day. Each animal was run for five four-hour sessions. The animals were run from eleven or twelve in the morning to three or four in the afternoon on days 2-15, between the morning and afternoon sessions on the other tests.

The first session for each rat was considered preliminary training.

The score for each animal on this test was the total number of turns of the wheel registered on the second, third, fourth, and fifth sessions.

Warner-Warden Maze

This maze is described in the *Archives of Psychology,* No. 92. Two patterns were used—A and B. These are shown in Figure 1.

The animals were run in Maze A on the afternoons of days 1-15 of the experimental session. On days 1 and 2 they were fed for two minutes in the entrance box of the maze and for about three minutes in the goal box of the maze. On days 3 and 4 the entrance box and goal box were placed next to each other, and the animals were allowed to run from the entrance box to the goal box, where they got a nibble of food. This was repeated five times each day. The sliding cardboard doors of the entrance and goal box were operated during these runs, in order to accustom the rats to them.

On days 5-15 the rats ran through the complete maze from entrance box to goal box, and were allowed to eat in the goal box for about 30 seconds. One trial was run each day.

Days 1-5, including the first trip through the maze, were considered preliminary training.

On days 1 and 2 records were kept of the amount of time that each rat spent in eating, out of the two min-

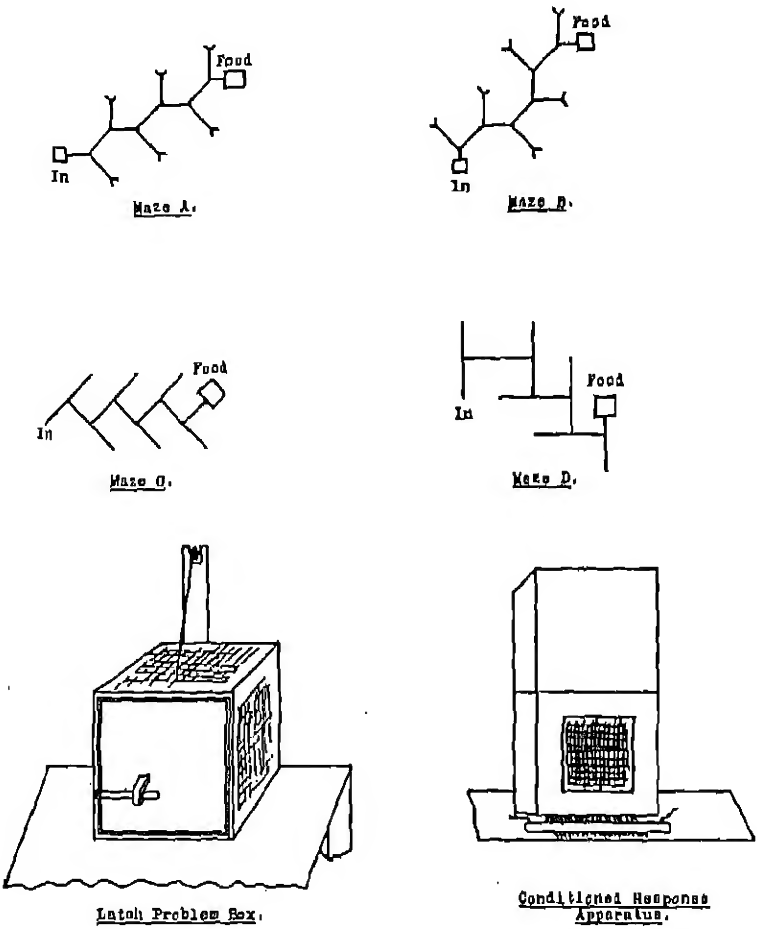

FIGURE 1
DIAGRAMS OF APPARATUS

utes that it was in the entrance box. These records were combined with similar ones from the Jenkins problem box and the Columbia obstruction apparatus into a score which has been called "Feeding on Preliminaries."

On days 5-15 a complete record was kept of each rat's path through the maze and of his time from entering the maze to entering the goal box. The errors made by the rat in traversing the maze were tabulated in three groups:

"A errors"—entering a blind alley while progressing toward the goal box
"B errors"—entering a blind alley while proceeding in the reverse direction
"C errors"—retracing the true pathway

Each unit of the maze that was incorrectly entered was counted as one error. A tabulation was made of the number of each kind of error for each rat for each trial. The scores on the maze consisted of the sum of the times, or of any single kind of errors, on trials 2-11.

Maze B (second pattern of the Warner-Warden maze) was run in the afternoon on days 16-24. The only preliminary training was the first trial on the maze. Procedure, scoring, etc., were the same as for Maze A. Scores were summed for trials 2-9.

Elevated T Maze

The two patterns of this type of maze were constructed especially for this experiment. In design they resembled somewhat those of Miles (17) and of Dennis (4). They were constructed of planed two-by-fours, fastened together with angle-irons so that the two-inch edge formed the pathway. The rats' pathway was about 15 inches above the level of the maze table.

Two patterns were used—C and D. These are shown in Figure 1.

Maze C was run the first thing in the morning (about 8 o'clock) on days 1-12. On days 1, 2, and 3, the animals were fed in a cage upon the food platform for two minutes. On days 4-12 the rats were placed upon the elevated pathway at the starting end and were allowed to find their way to the food. If they fell off, which happened very rarely and only upon the first trial, they were replaced at the spot from which they fell.

The preliminary training consisted of the three days of feeding and the first run through the maze.

The same records of errors were kept as in the other mazes. In the case of time, however, two separate records were kept. Time was noted from the moment that the rat was put down upon the maze at the starting point to the moment that he left that section of the maze; this has been called "Time to start." The time from leaving the starting section of the maze to reaching the food platform was also recorded; this has been called "Time to run." The scores were the sums of each type of time or errors for trials 2-9.

Maze D was run the first thing on mornings 13-19, with no preliminary training except the first run through the maze. The scores for the maze were the sums on trials 2-7, and were obtained in the same way as for Maze C.

Jenkins Problem Box

The Jenkins problem box used in this experiment is the same as that used by Riess (18) and described by him. It consists of two concentric circular cages. The inner one is the food compartment. The outer one is the reaction compartment, and contains three plates set into the floor, on some combination of which the animal is required to step. There is an entrance compartment opening into the reaction cage. The door of the entrance compartment is raised to admit the rat to the reaction compartment at the beginning of a trial, and the door of the food compartment is opened when the rat steps on the required plates.

In the present experiment the animals were required to step on any one plate in order to be admitted to the food compartment. Previous workers (23, 18) with this apparatus have used as their first problem the stepping on a certain specific plate. It was not until the experiment was well under way that it was discovered that another procedure had been used before. The other procedure seems better than that which we used, in that it permits the formation of a fairly specific habit. In the problem used here, the rat was rewarded for doing one thing on one trial, and then for doing something quite different on a subsequent trial.

This problem box was run as the second problem on the mornings of days 1-24. The animals were run from 9 or 10 o'clock until 11 or 12.

On days 1 and 2 the animals were fed for 3 minutes in the food compartment. Records were kept of the amount of time spent in eating, as part of our score "Feeding on preliminaries." On days 3 and 4 the door of the food compartment was left open and the animals were allowed to find their way to food, without being required to step on a plate. Two such trials were given on each of these days. The regular trials of the experiment were given on days 5-24. The number of trials per day started at two and was gradually increased to five.

In all, eighty trials were given. The first thirty trials, together with the training on days 1-4, were considered preliminary training. The scores on this apparatus were based on the records of the last fifty trials.

Four different scores were obtained for this problem box. The first score was a measure of a certain phase of activity in the reaction compartment, namely, the number of quadrants entered. Secondly, a record was kept of the number of perfect trials. A perfect trial was arbitrarily defined as one in which the animal entered no unnecessary quadrants and completed the trial in less than 15 seconds. In the third place, the time between the opening of the entrance compartment door and the entrance of the rat into the reaction compartment was noted. We also kept a record of the time from entrance into the reaction compartment to entrance into the food compartment.

Latch Problem Box

This piece of apparatus was made in the laboratory for this experiment. A diagram of it is given in Figure 1. It consists of a rectangular cage set upon an elevated platform. The wooden door in the front of the cage swings in and up when the catch is released, permitting the animal to get to the food which is placed inside. The latch is a simple wooden bar, set out from the front of the cage, upon which the animal must push down. When the catch is released, a weight and pulley system swings the door up out of the way.

The rats worked at this problem on the mornings of days 19-24 and on both morning and afternoon of days 25-28. On days 19-23, both before and after the day's run on the Jenkins problem box, each rat was placed on the platform of the latch box and allowed to go into the cage and eat for 15 seconds, the door being left open. On day 24 two trials were given—one in the early morning and one in the late morning—with the latch of the problem box just barely caught, so that any slight jar would release it. This training, together with the first two regular trials, was considered preliminary training.

Twelve trials with the latch fully caught were given on days 25-28, three trials being given each day--one early in the morning, one late in the morning, and one in the afternoon. Each time the rat succeeded in getting into the cage he was permitted to eat for 15 seconds. A time limit of ten minutes was set, and an animal who did not get in in that time was returned to his cage and recorded as having failed for the trial. In this test there were two rats who failed continuously, because they never happened to hit the latch, and not because they refused to work. It was decided not to throw out the complete records of these rats, but to give them a score on this test just worse than the worst of the rats who did not fail.

The only record that was kept for this test was time to get to the food. The score was the sum of the times on trials 3-12.

Conditioned-Response Tests

There is room for considerable doubt as to whether the tests to be discussed under this heading should be called conditioned responses at all. If the name is to be applied, it must be with rather a broad definition.

The apparatus used here was the same as that used by Warner (38),[1] as shown in Figure 1. The apparatus was essentially a wooden box with an observation window on one side and a floor made of metal rods. The box was divided in the middle by a low fence of metal bars. The fence was always electrified, and the apparatus was arranged so that either half of the floor could be electrified.

First the animals were trained to jump from one side of the fence to the other when they received an electric shock. Then a buzzer was sounded for ten seconds before the shock was given, in order to train the rats to jump to the buzzer and avoid the shock. Finally a change of illumination—a 100-watt bulb added to a flashlight bulb—was used instead of the buzzer as the signal of the shock.

On the morning of days 30, 31, and 32 and the afternoon of days 30 and 31, ten trials were given with shock alone. The animal was put in the box and presently the shock was administered. The animal was shocked until he managed to get across the fence. He was then

[1] I take this occasion to thank Dr. Warner for permitting me to use his apparatus.

permitted to rest in peace for a minute, after which the shock was again administered until he crossed the fence, and so on for ten trials. These fifty trials and the first ten trials with the buzzer were considered preliminary training.

On the afternoon of days 32, 33, 34, and 35 and the morning of days 33, 34, and 35, ten trials were given with buzzer and shock. On these trials the buzzer was sounded continuously, and if after ten seconds the rat had not crossed the fence, the shock was administered until he did. Then after an interval of from 45 to 70 seconds another trial was given. The animal could and did jump across the fence between trials without incurring any penalty. He could also jump more than once when the buzzer was sounded.

Records were kept of the number of times the animal crossed each time the buzzer was sounded and of the number of times that the animal crossed in the interval between trials. These were used as two separate scores. "Crossings to buzzer" was the number of trials, out of sixty, on which the animal crossed to the buzzer and escaped the shock. "Crossings between buzzers" was the number of crossings that the animal made during the time between trials. These scores were summed for trials 11-70.

On the morning and on the afternoon of days 36-39, ten trials were given with light and shock. The procedure and results were analogous to those for the buzzer. Records were kept for all eighty trials, and gave the two scores "Cross to light" and "Cross between lights."

Columbia Obstruction Apparatus

(Hunger Drive)

The apparatus used in this test was the new model of the Columbia obstruction apparatus, described by Warden (37). This test was given on the afternoons of days 26-29. On days 26 and 27, after the afternoon trial on the latch problem box, each rat was put in the entrance compartment of the obstruction apparatus and was allowed to explore and eat in the apparatus for 3 minutes. No shock was on, and the door in the alley between the entrance and goal compartments was removed. Food was placed in the goal compartment. The amount of time spent in eating was recorded and was combined into the score "Feeding on preliminaries." On day 28 the door was replaced, and the rat was allowed to make 5 crossings from the entrance box to the goal box without shock, getting a bite of food each time. On day 29 the animals, one-day hungry, were allowed four crossings without shock, and on the fifth crossing the shock was turned on. The training up to this point constituted the preliminary training.

After the shock had been turned on, records of the animal's behavior were kept for a ten-minute period. Records were kept for each separate minute, and included approaches (orientations toward the goal compartment), contacts (shocks received), and crossings to the food.

Approximately the same shock was used as was used in the Columbia drive studies (36)—500 volts and .050 milliamperes—but the results are not comparable. In

III

RELIABILITY OF TEST SCORES

Now we come to a consideration of the reliabilities of the various measures taken. In general, these were determined by correlating the sum of the scores on the odd days with the sum of the scores on the even days, and correcting by the Brown-Spearman formula ($R=\frac{2r}{1+r}$). Any deviations from this procedure will be noted in specific cases.

Some recent workers in the field object to this method of computing reliabilities, saying that the correlation is rendered spuriously high by the presence of irrelevant correlated factors in the two halves of the test. This is a very sound criticism. However, the procedure is the most standard one, and any other that we might substitute for it suffers either from the same difficulty or from the difficulty of not correlating comparable things. In the present case we at least know in which direction the error is likely to be, which is more than we can say for some of the other techniques. So we will correlate odd *vs.* even days, remembering that the correlations we get are probably too high.

Let us go through the list of variables, considering the reliability obtained for each.

REVOLVING WHEEL

Variable 1. The total score was the number of turns on days 2-5. The reliability was computed by correlating the number of turns on days 2 and 5 with the number of days 3 and 4. The correlation obtained was: Raw—.96, Corrected—.98. Apparently four four-hour sessions in a revolving wheel give one a very stable measure of that phase of a rat's activity. This high reliability agrees well with the results of Shirley (21) and Rundquist (20). (See Table 1).

Maze A. (Warner-Warden)

Variables 2, 3, 4, 5. The correlations are for odd *vs.* even trials on trials 2-11.

			Raw	Corrected
Var.	2	"A errors" (Forward into blind alley)	.68	.81
	3	"B errors" (Retracing into blind alley)	.53	.69
	4	"C errors" (Retracing true path)	.78	.88
	5	Total time (Entrance box to goal box)	.73	.84

The reliabilities here are fairly satisfactory. Though they do not measure up to those obtained with more difficult mazes and better controlled conditions by Tryon (34), Stone and Nyswander (27), and Heron (7), they are higher than those reported by earlier maze workers, and higher than the general run of those reported recently by Leeper (15).

Maze B. (Warner-Warden)

Variables 6, 7, 8, 9. The correlations are for odd *vs.* even trials on trials 2-9.

			Raw	Corrected
Var.	6	"A errors"	.63	.77
	7	"B errors"	.65	.79
	8	"C errors"	.69	.81
	9	Total time	.84	.91

It is interesting to note that in these mazes the retracing errors give as high or higher reliabilities than the forward-going errors. This may afford some confirmation of the experimenter's feeling that "tameness" may enter into the score on a maze of this type and degree of difficulty as much as, or more than, "intelligence."

Maze C. (Elevated Maze)

Variables 10, 11, 12, 13, 14. The correlations are for odd *vs.* even trials on trials 2-9.

			Raw	Corrected
Var.	10	"A errors"	.31	.47
	11	"B errors"	.36	.53
	12	"C errors"	.32	.49
	13	Time to start running	.71	.83
	14	Time to run	.31	.47

The reliabilities on this maze are all low, with the exception of "Time to start." The only consistent element of a rat's behavior on the elevated maze was the time that he remained still before beginning to run. Observation of the animals leads the experimenter to believe that this is, in large measure, a manifestation of tameness. The low reliabilities of the other measures may be in part a function of the timidity of the animals on the elevated maze. They seemed more susceptible to disturbance by environmental factors when they were up in an exposed position than when in the alleys of the Warner-Warden maze.

Maze D. (Elevated Maze)

Variables 15, 16 17, 18, 19. The correlations are for odd *vs.* even trials on trials 2-7.

			Raw	Corrected
Var.	15	"A errors"	.50	.67
	16	"B errors"	.37	.54

17	"C errors"	.20	.33
18	Time to start	.85	.92
19	Time to run	.38	.55

Again all the reliabilities are low except "Time to start." In the case of this maze, the low reliabilities may be due in part to the fact that the maze was very easy. It is interesting to note that the changed pattern of the elevated maze was learned very readily, while the changed pattern of the alley maze presented a great deal of difficulty. The floor plans were not exactly the same for the alley and elevated mazes and the results may be due entirely to this difference in floor plan. But the possibility is suggested that different sensory cues may be used in the elevated maze. Commins (2) has also observed the readiness with which a second elevated maze pattern is learned.

JENKINS CIRCULAR PROBLEM BOX

Variables 20, 21, 22, 23. The correlations are for odd *vs.* even days (5 trials per day) for trials 31-80.

		Raw	Corrected
Var. 20	Quadrants entered	.57	.73
21	Perfect trials	.26	.41
22	Time to start from entrance box	.89	.94
23	Time to run	.82	.90

The score for perfect trials, as arbitrarily defined by the experimenter, seems to have little value. Some animals developed a very successful response to the problem which never satisfied the arbitrary definition of a perfect trial, while many perfect trials were apparently achieved by chance. Quadrants entered gives a fairly consistent measure of a certain fraction of the animal's activity in the problem box, though many phases of his activity do not enter into this score. The time scores give the highest reliabilities, and again "Time to start" seems to be a very reliable measure. Under the circumstances of this experiment, "Time to run" seems to be the best measure of learning the problem.

The high reliability of these measures of the time that elapses before starting in on some performance, after having been put in the apparatus, seems very interesting. We shall see later that the three measures of time to start on different performances correlate quite highly. There seems to be an interesting and not widely advertised phase of the individual animal's make-up which enters in here.

Latch Problem Box

Variable 24. In this problem the animals were run three trials a day, the trials being separated by an interval of from two to four hours. The reliability of the score was obtained by correlating odd *vs.* even trials for trials 3-12. For the time taken to get to the food, the reliability was:

Raw—.77 Corrected—.87

Conditioned Response

Variables 25, 26, 27, 28. In these tests the animals were run ten trials at a time twice a day—in the morning and again in the afternoon. The reliabilities were computed by correlating odd *vs.* even sets of ten trials.

This amounted to correlating the score on the morning trials with the score on the afternoon trials. Reliabilities were obtained as follows:

		Raw	Corrected
Var. 25	Cross to buzzer	.76	.87
26	Cross between buzzers	.82	.90
27	Cross to light	.82	.90
28	Cross between lights	.80	.89

Both the frequency of crossing to the stimulus and the readiness of the crossing response seem to be quite stable features of the animal's behavior. A consideration of the intercorrelations, which we shall give later, suggests that frequency of crossing to the stimulus may be in large measure a function of the readiness of the crossing response.

Columbia Obstruction Apparatus

(Hunger Drive)

Variables 29, 30, 31. This test was run for one continuous period of ten minutes. The reliability was computed by correlating odd *vs.* even minutes. This reliability is the most questionable of any that we have obtained, because it seems hardly conceivable that many of the chance errors affecting the score on one minute would not affect the score on the adjacent minutes. However, the procedure is strictly analogous with that used in correlating odd *vs.* even items in a human test, and we shall use it here, remembering that the obtained reliabilities are almost certainly too high. The obtained reliabilities follow:

		Raw	Corrected
Var. 29	Approaches	.58	.73
30	Contacts	.72	.84
31	Crossings	?	?

In the case of crossings (Var. 31), less than a quarter of the rats crossed the grid even once, because the shock used was too severe. This being the case, a reliability coefficient seemed meaningless, and so was not computed.

The reliabilities here are not very high, and are probably partly spurious, so probably we should not attach much significance to the results on this test. It must be remembered that the shock and procedure which we used were not standard for this apparatus.

Feeding on Preliminaries

Variable 32. The reliability was computed by correlating the amount of time spent in eating on odd *vs.* even days, as there were scores for two days on each piece of apparatus. The reliability was:

Raw .65 Corrected .79

IV

INTERCORRELATION OF TEST SCORES

We have seen to what extent the tests are reliable measures. Now we are interested in finding out how these measures are related to one another. For this purpose we need the correlations between the different variables. The intercorrelations were computed by the Columbia Statistical Bureau. The Bureau makes a practice of computing all correlations to four decimal places, but, inasmuch as the correlations were based on only sixty-four cases and the sigmas of the correlations were of the order of 0.1, the last two places have been discarded as meaningless. The table of intercorrelations for the thirty-two variables is given, to two decimal places, in Table 4. The raw correlations are given on the upper right-hand side, the reliabilities along the diagonal, and the corrected correlations on the lower left-hand side.

In giving these correlations, it has been decided in an arbitrary and common-sense manner what shall be a "good" score for each variable. For example, in all the maze-error scores a good score is a low score, while for the revolving wheel a good score is a high score. Consequently, a positive correlation between the revolving-wheel and a maze-error score indicates that the animal who runs many turns in the revolving wheel tends to make few errors in the maze. The following have been chosen as "good" scores:

Revolving wheel—	large number of turns;
Mazes—	few errors or short time;

TABLE 4
Intercorrelations of 32 Variables*

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	98	27	25	25	36	13	07	12	19	26	25	25	25	25	03	06	—01	24
2	30	81	79	88	82	39	45	42	29	53	32	57	46	57	52	39	36	28
3	31	100+	69	87	81	36	46	42	33	56	40	61	46	56	16	37	35	26
4	24	100+	100+	88	84	26	47	38	28	56	54	61	48	58	14	32	29	24
5	40	100	100+	97	84	29	39	36	41	48	39	61	59	69	09	26	20	40
6	15	49	50	52	35	77	74	85	74	20	04	22	11	10	54	35	32	31
7	08	54	63	56	47	94	79	91	79	18	—04	22	18	09	26	37	33	33
8	13	52	56	45	44	100+	100+	87	82	13	—03	23	13	07	19	32	29	23
9	20	54	41	31	47	100+	93	95	97	12	—01	22	27	17	15	16	21	60
10	39	86	99	87	77	32	30	20	19	47	50	72	45	58	40	26	30	18
11	35	49	66	50	59	07	—07	—05	—01	100	53	68	53	68	40	26	05	21
12	33	91	100+	93	100+	35	36	36	33	100+	100+	49	58	81	23	18	20	21
13	28	55	61	56	71	14	22	15	31	72	80	91	87	74	12	08	05	54
14	37	92	98	91	100+	17	15	11	27	100+	100+	100+	100+	47	17	07	10	40
15	04	44	23	18	12	48	35	26	20	71	30	40	16	30	67	38	55	29
16	08	56	60	47	38	54	57	49	23	52	03	35	11	14	63	54	85	10
17	—02	69	72	53	57	62	64	55	38	75	11	50	10	24	100+	100+	33	22
18	25	35	32	27	46	36	39	27	65	27	29	31	62	60	37	15	40	02
19	29	65	67	56	51	61	52	46	35	71	79	69	49	73	90	92	100+	48
20	—29	17	05	04	00	35	17	19	08	—04	—10	—29	—17	—29	29	27	35	04
21	—35	—04	—15	—16	—22	45	27	37	17	—08	—04	—36	—50	—59	37	—16	07	—20
22	36	49	40	34	59	46	33	40	59	32	37	52	47	59	33	33	56	65
23	22	52	37	32	51	58	40	48	54	24	12	23	25	28	37	36	59	52
24	08	16	33	16	18	52	32	25	30	13	03	10	15	14	29	64	30	44
25	57	24	16	12	06	30	11	18	—05	37	32	16	11	04	14	19	12	00
26	35	32	28	17	23	18	00	11	—07	19	15	14	—01	10	—01	18	17	—14
27	21	02	01	—04	—11	17	—04	05	—09	29	31	07	—11	10	09	26	27	—07
28	40	20	29	16	18	39	27	26	16	23	17	22	—07	08	05	19	15	11
29	—38	08	—02	03	12	36	53	55	32	—13	—20	04	25	06	02	10	09	11
30	—02	20	58	17	20	14	18	17	—02	14	00	21	12	19	23	15	32	—16
31	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
32	45	49	37	44	41	24	19	09	22	53	44	56	41	63	43	21	25	46

*Decimals have been omitted.

TABLE 4 (*Continued*)

	19	20	21	22	23	24	25	26	27	28	29	30	31	32
1	21	—24	—22	34	21	08	34	33	19	37	—07	—02	—15	33
2	43	13	—02	43	44	14	20	27	01	17	06	17	11	40
3	41	04	—07	32	29	25	13	22	01	23	—01	29	16	28
4	39	03	—10	31	29	14	10	16	—04	14	02	15	11	36
5	35	00	—13	52	45	15	05	20	—09	15	10	17	10	34
6	40	27	24	40	48	26	25	15	14	33	27	12	19	19
7	34	13	15	29	33	26	09	00	—03	19	25	14	20	15
8	31	15	22	35	41	21	15	09	03	22	27	14	18	07
9	25	06	11	55	49	26	—04	—06	—08	15	26	—02	15	18
10	36	—02	—04	22	16	08	24	12	19	15	—08	09	16	32
11	43	—07	—02	26	08	02	22	11	22	12	—13	00	07	29
12	36	—17	—16	35	16	06	10	09	05	14	03	13	10	55
13	33	—14	—30	41	21	13	10	00	—10	—06	20	10	11	33
14	37	—17	—26	39	18	09	02	07	—07	05	03	12	09	38
15	54	20	20	26	28	22	11	—01	07	04	01	17	18	31
16	50	17	—08	23	25	44	13	13	18	13	06	10	14	14
17	52	17	03	32	32	48	07	09	15	08	04	17	18	13
18	54	03	—12	63	47	39	00	—13	—06	10	09	—14	09	39
19	*55*	17	01	42	38	33	12	11	—02	10	11	08	16	42
20	26	*73*	51	02	39	07	22	13	25	19	06	05	13	—13
21	02	94	*41*	—05	24	—07	29	13	26	17	—02	04	11	—21
22	58	02	—08	*94*	83	21	05	15	00	19	16	08	14	46
23	53	48	39	90	*90*	27	17	27	10	29	23	16	22	31
24	47	09	—11	23	30	*87*	05	—04	10	11	03	14	22	20
25	18	28	48	05	19	05	*57*	54	77	71	—05	11	01	12
26	15	15	21	17	30	—05	61	*90*	45	64	27	26	04	07
27	—03	31	43	00	11	12	58	50	*90*	64	—08	00	—06	—02
28	14	24	28	21	33	13	81	72	72	*89*	14	16	—01	19
29	17	08	—03	19	29	04	—06	34	—10	17	*73*	49	45	13
30	12	06	07	09	19	17	12	29	00	18	63	*84*	53	07
31	—	—	—	—	—	—	—	—	—	—	—	—	—	21
32	63	—18	—37	53	37	24	14	08	—02	23	17	08	—	*79*

Problem boxes—	short time, few quadrants entered, and many perfect trials;
CR—	many crossings of the fence;

Obstruction apparatus—many approaches, contacts, or crossings.

Let us now examine the table of correlations. In the first place, most of the different measures from the same test (different types of errors, time, etc.) are closely correlated, especially for the mazes. The raw correlations are quite high, and when these are corrected for the unreliability of the tests, many of them become greater than unity. For the Warner-Warden mazes the median raw correlation between different types of scores is about .82, and the median corrected correlation over 1.00. For the elevated mazes the same figures are .54 and .96. Apparently these scores are all measuring much the same thing. Later we shall consider a condensed array of correlations, where several of these scores have been combined into single scores.

When we consider the correlations between different tests, we observe that the great majority of them are positive and that most of them are quite small. Less than 15 per cent of the correlations are negative, and no one of these is significantly different from zero. The mean of the raw correlations is .18 and that of the corrected correlations is .27. This result agrees quite closely with a mean raw correlation of .205 found by Dunlap (5) from his tests on chicks.

The table of correlations shows us quite distinctly that the mazes are more closely related to one another than they are to the other tests, or than the other tests, in general, are to each other. The average raw correlation between different mazes is about .30, and the average raw correlation between two tests which are not both mazes is about .17. When we use corrected correlations the difference shows up in a more striking way. In this case the two figures are .46 and .19. Mazes have something in common which spreads to a much lesser extent to the other tests used. This was also found to be the case in the work of Commins, McNemar and Stone (3), and of Tomilin and Stone (33). The average intercorrelation of our mazes is somewhat less than they report.

The relationship of activity (Var. 1) and "Feeding on preliminaries" (Var. 32) to the rest of the tests is rather interesting. There is some indication that the rat who is more active and who eats more readily in a new situation learns the maze better, has lower time scores on the problem box, and crosses the fence more readily in the CR apparatus. The same relationship between activity and maze score was reported by Shirley (22), while Rundquist (20) found a negligible relationship.

Variables 13, 18, and 22 are of considerable interest. Each of these measures the time that the animal took to start going in some apparatus. That this trait is fairly consistent from one test to another is indicated by the correlations of .54, .41, and .63 (corrected—.60, .47, .68) between these variables. These measures of time to start correlate with the other maze and problem-box time and error scores, but not as highly as the time and error scores correlate among themselves.

A table of intercorrelations among 32 variables is rather hard to analyze. There is so much detail that it tends to hide any general trends. It therefore seemed desirable to reduce the number of variables. We have seen that the three types of error scores for each maze were measuring much the same thing, so they might well be combined into a single score. We therefore combined the "A," "B," and "C" errors for each maze into a single variable.

In combining the variables it was necessary to adopt some system of weighting. The simplest technique would have been to weight each variable equally, but this would have given undue weight to a variable in which the scores scattered widely. The next simplest thing would have been to weight each variable in inverse proportion to its standard deviation. This would probably have proved perfectly satisfactory, and would have given results that differed only very slightly from those which we obtained by a somewhat different technique.

We shall illustrate the technique which we adopted by an example. Consider variables 2, 3, and 4. The intercorrelations between these variables are $r_{23} = .79$, $r_{24} = .88$, $r_{34} = .87$. We form the table:

	.88	.79	.88	
	.79	*.87*	.87	
	.88	.87	*.88*	
Σr	2.55	2.53	2.63	$\Sigma\Sigma r = 7.71$
				$\frac{1}{\Sigma\Sigma r} = .1298$
k_1	.92	.91	.95	$\frac{1}{\sqrt{\Sigma\Sigma r}} = .36$

and fit a first factor to the array of correlations by Thurstone's center of gravity method of factor analysis (29). We obtain the factor loadings .92, .91, and .95 for the three variables. The scores on the variables are first reduced to standard scores (divided by their standard deviations), and then given weights equal to these first factor loadings.

The intercorrelations between this new composite variable and the other variables are found from the correlations of the separate component variables by the formula for the correlation of sums. [See Kelly (14, p. 197).] In this particular case, the formula takes the form

$$r_{(Ax+By+Cz,\ w)} = \frac{A.r_{xw}+B.r_{yw}+C.r_{zw}}{\sqrt{A^2+B^2+C^2+2AB.r_{xy}+2AC.r_{xz}+2BC.r_{yz}}}$$

where A, B, and C are the weights (i.e., the factor loadings) of the variables *x*, *y*, and *z*.

In this way, we combined the three error scores for each maze pattern into a single score. We also discarded several variables which were of low or unknown reliability, namely, variables 14, 19, 21, and 31. The correlations among the remaining 20 variables are given in Table 5.

Again we see that most of the correlations are positive, and that the negative ones are quite small. The correlations between mazes are all positive, with a median raw correlation of .36. The correlation between time and error scores for the same maze are quite high—.87 and .83 for the Warner-Warden mazes, and lower for the less reliable elevated mazes. The cor-

TABLE 5

INTERCORRELATIONS: 20 VARIABLES

Variables	1	2 etc.	5	6 etc.	9	10 etc.	13	15 etc.	18	20	22	23	24	25	26	27	28	29	30	32
1		.26	.36	.11	.19	.28	.25	.03	.24	—.24	.34	.21	.08	.34	.33	.19	.37	—.07	—.02	.38
2 etc.			.87	.45	.32	.61	.49	.37	.27	.07	.37	.36	.18	.15	.23	—.01	.19	.02	.21	.56
5				.36	.41	.57	.59	.22	.40	.00	.52	.45	.15	.05	.20	—.09	.15	.09	.17	.34
6 etc.					.83	.16	.15	.38	.30	.19	.36	.43	.26	.17	.08	.05	.26	.28	.14	.14
9						.13	.27	.21	.60	.06	.55	.48	.26	—.04	—.06	—.08	.15	.26	—.02	.18
10 etc.							.60	.27	.23	—.10	.52	.15	.06	.21	.12	.17	.15	—.06	.09	.37
13								.10	.54	—.13	.41	.21	.13	.10	.08	—.10	—.06	.20	.10	.33
15 etc.									.24	.21	.32	.33	.45	.12	.09	.16	.10	.05	.17	.22
18										.03	.63	.47	.39	.00	—.13	—.06	.10	.09	—.14	.39
20											.02	.39	.07	.22	.12	.25	.19	.06	.05	—.13
22												.82	.21	.05	.15	.00	.19	.16	.08	.45
23													.27	.17	.27	.10	.29	.24	.16	.31
24														.05	—.04	.10	.11	.03	.14	.19
25															.54	.77	.71	—.05	.11	.12
26																.45	.64	.27	.26	.07
27																	.64	—.08	.00	—.02
28																		.14	.16	.19
29																			.49	.13
30																				.07
32																				

relations between the different CR variables are quite high—median .64. Most of the other correlations are quite low.

We have further combined the variables, in a more or less arbitrary manner—reducing the number to 13. Variables 2 etc. and 6 etc. have been combined into a single alley-maze error score, variables 5 and 9 into a single alley-maze time score, variables 10 etc. and 15 etc. into a single elevated-maze error score, and variables 13 and 18 into a single elevated-maze time score. Variables 25 and 27 have been combined into a single jump-the-fence-to-stimulus score, and 26 and 28 into a single jump-the-fence-between-stimuli score. Variables 29 and 30 form a single hunger-drive score. The same method of weighting was used as before, but as only pairs of variables were combined, this amounted to giving equal weights to the correlations of each variable. The correlations among the remaining 13 variables are given in Table 6.

TABLE 6

INTERCORRELATIONS: 13 VARIABLES

Var.	1	2,6	5,9	10,15	13,18	20	22	23	24	25,27	26,28	29,30	32
1		.22	.33	.20	.28	—.24	.34	.21	.08	.28	.38	—.05	.38
2,6			.77	.56	.41	.15	.43	.46	.26	.11	.25	.22	.30
5,9				.43	.63	.04	.64	.55	.25	—.05	.14	.17	.31
10,15					.42	.07	.40	.31	.32	.22	.16	.09	.37
13,18						—.06	.59	.39	.30	—.02	—.03	.08	.41
20							.02	.39	.07	.25	.17	.06	—.13
22								.82	.21	.02	.19	.14	.45
23									.27	.14	.31	.23	.31
24										.08	.04	.10	.19
25,27											.68	—.01	.05
26,28												.26	.14
29,30													.12
32													

Examination of this table shows correlations between the various maze scores ranging from .41 to .77, with a median at about .50. The maze scores seem to be related fairly closely to the two Jenkins problem box time scores—the correlations range from .31 to .64 with a median at about .44. Slightly lower correlations appear between the mazes and the latch problem box (.25 to .32), the revolving wheel (.20 to .33), and the preliminary feeding (.30 to .41). The time scores for the Jenkins problem box are related to activity (.34 and .21) and to feeding on preliminaries (.45 and .31). Another interesting relationship is that between activity and CR scores (.28 and .38).

V

ANALYSIS OF INTERCORRELATIONS

The examination of the intercorrelations has so far been qualitative and subjective. Now let us see what we get when we apply current methods of factor analysis to the array of correlations. Of the various possible techniques, we have used Thurstone's center of gravity method (29). Practice has shown that the results from this method approximate quite closely those obtained by Thurstone's (28) and Hotelling's (8) more laborious techniques. We have checked on this for our 13-variable array of correlations by computing the first two factors by Hotelling's method also and comparing them with the results of the simpler method. These results will be compared later. It is sufficient to say that with our sixty-four cases the greatly increased labor of the other techniques did not seem worth while for the 32- and 20- variable arrays.

A factor pattern was first fitted to the original array of correlations between *all 32* variables. The factor loadings for the first three factors are given in Table 7.

In order to obtain some idea of how many factors are needed to give an adequate fit to the array of correlations, the residuals after removing each factor have been tabulated. If we assume that the true correlation between any two variables is zero, then with our sixty-four cases the standard deviation of this correlation is .125. Working on the assumption that no true correlation remains among the variables after removing one factor, we determine how many of the obtained

TABLE 7

FACTOR LOADINGS OF 32 VARIABLES

Variable	Factor 1	Factor 2	Factor 3
1	.338	.233	—.254
2	.759	.299	.037
3	.730	.308	.061
4	.682	.404	.090
5	.713	.452	.136
6	.656	—.400	.192
7	.611	—.289	.394
8	.608	—.359	.337
9	.563	—.150	.408
10	.579	.350	—.345
11	.432	.486	—.352
12	.606	.517	—.120
13	.515	.532	.101
14	.557	.658	—.039
15	.452	—.096	.043
16	.504	—.226	.222
17	.525	—.252	.271
18	.494	.191	.254
19	.623	.068	.106
20	.199	—.441	—.059
21	.086	—.484	—.201
22	.641	.130	.176
23	.650	—.168	.112
24	.369	—.141	.221
25	.397	—.289	—.769
26	.350	—.216	—.462
27	.251	—.359	—.693
28	.442	—.318	—.563
29	.243	—.270	.233
30	.292	—.232	.100
31	.310	—.215	.193
32	.464	.272	.017
$\frac{\Sigma k^2}{n}$	.272	.112	.088

residuals lie within 1 sigma (.125), 2 sigma (.250), etc., of the assumed true value of zero. This distribution of residuals is then compared with the distribution to be expected by chance. If the distribution of residuals approximates what should be expected by chance, we have some justification in feeling that we have fitted a sufficient number of factors to the table of correlations.

For the 32-variable table of correlations the results were as follows:

	First residuals %	Second residuals %	Third residuals %	Normal probability %
Within 1 sigma	59.4	73.1	78.4	68.3
2	88.5	93.6	97.8	95.4
3	96.0	98.0	99.6	99.7
4	98.8	99.6	100.0	100.0
5	99.8	100.0		

From this table we can see that the three factors reduce the residual correlation between variables to about what would be expected to arise by chance alone. There may be some doubt as to whether the third factor is needed.

Now let us examine these three factors in order to try to get some understanding of what they might be. In the first place, the first factor has a positive weight in every test, though some of the weights are very low. This shows that every test tends to be correlated positively with the other tests. We must be cautious, however, in interpreting this as a general factor among all the tests; the slight tendency for all the tests to be correlated may have arisen through some slight heterogeneity of conditions among the different groups of animals and nothing more. This first factor is most prominent in the maze scores and in the time scores of the Jenkins problem box. Perhaps it should be considered maze-running ability, rather contaminated with activity, tameness, and possibly hunger.

The second factor seems to be a temporal factor, in that most of the tests that occurred early in the experimental routine have positive weights and those that occurred late in the training have negative weights. Since it discriminates the earlier from the later tests, we might name it a transfer factor.

The third factor seems to discriminate the CR tests from the rest of the tests. They have large negative weights, while most of the rest of the weights are rather small negative or positive ones. The four CR scores were obtained in the same apparatus, at the same part of the schedule, with only slightly different conditions.

TABLE 8
FACTOR LOADINGS OF 20 VARIABLES

Variable	Factor 1	Factor 2	Factor 3
1	.414	.101	.233
2, 3, 4	.684	—.136	.490
5	.690	—.293	.439
6, 7, 8	.612	—.227	—.282
9	.570	—.468	—.342
10, 11, 12	.508	.005	.598
13	.491	—.311	.390
15, 16, 17	.459	—.031	.024
18	.539	—.405	—.033
20	.177	.152	—.361
22	.698	—.332	—.056
23	.716	—.167	—.319
24	.366	—.113	—.080
25	.468	.756	—.040
26	.435	.508	—.090
27	.331	.801	—.135
28	.556	.595	—.220
29	.284	—.243	—.379
30	.278	—.043	—.112
32	.469	—.126	.254
$\frac{\Sigma k^2}{n}$	.259	.136	.086

The apparatus was very different from any of the other pieces used. The motivation was escape-from-shock instead of hunger. Under these conditions it is not surprising that the four CR scores have factors in common which do not extend to the rest of the tests.

Now let us see what we get when we fit the same type of factor pattern to the 20-variable array of correlations. The factor loadings for three factors appear in Table 8.

As in the case of the 32-variable array, we compare the residuals with the correlations to be expected by chance:

	First residuals %	Second residuals %	Third residuals %	Normal probability %
Within 1 sigma	53.7	73.5	81.1	68.3
2	84.7	94.1	97.4	95.4
3	96.3	99.0	100.0	99.7
4	99.5	100.0		100.0

Here again, three factors seem to be adequate, with the third of doubtful importance.

The factors seem to be open to about the same interpretation in this case as in the case of the 32 variables, except that the second and third factors have been interchanged. In this case, the second factor is the CR factor and the third factor the transfer factor, if we choose to adopt this interpretation of them.

The number of variables was further reduced to thirteen. In fitting a factor pattern to these, only two factors were fitted. As we shall see presently from a consideration of the residuals, two factors seemed ample for this set of correlations. The factor loadings appear in Table 9.

TABLE 9
FACTOR LOADINGS OF 13 VARIABLES

Variable	Factor 1	Factor 2
1	.412	.061
2 etc., 6 etc.	.727	—.158
5, 9	.736	—.353
10 etc., 15 etc.	.606	—.161
13, 18	.597	—.444
20	.174	.179
22	.752	—.323
23	.773	—.025
24	.368	—.135
25, 27	.362	.707
26, 28	.501	.773
29, 30	.249	.047
32	.497	—.164
$\frac{\Sigma k^2}{n}$	.307	.127

In this case we have the residuals for only the first two factors:

	First residuals %	Second residuals %	Normal probability %
Within 1 sigma	65.4	85.9	68.3
2	93.6	97.5	95.4
3	98.8	100.0	99.7

In this case the first factor seems to be the factor of what is general to the various tests, highly weighted for the maze scores and for the time scores on the Jenkins problem box. The second factor gives a large positive weight to the CR scores, and negative weights to most of the rest of the scores. The scores having the largest negative weights are time scores. It is not surprising that we find no considerable transfer factor with this group of variables, as we have combined the first and second patterns of the mazes and of the CR test into single scores.

At this point let us compare the factor pattern obtained for the 13-variable array by the Thurstone center-of-gravity method with the one obtained by Hotelling's method. The factor loadings for the two methods are given in Table 10.

TABLE 10

FACTOR LOADINGS OF 13 VARIABLES

Variable	Factor 1 Thurstone	Factor 1 Hotelling	Factor 2 Thurstone	Factor 2 Hotelling
1	.41	.49	.06	.21
2 etc., 6 etc.	.73	.74	—.16	.01
5, 9	.74	.80	—.35	—.26
10 etc., 15 etc.	.61	.60	—.16	—.01
13, 18	.60	.69	—.44	—.39
20	.17	.12	.18	.32
22	.75	.81	—.32	—.18
23	.77	.75	—.02	.07
24	.37	.41	—.13	—.08
25, 27	.36	.23	.71	.83
26, 28	.50	.39	.77	.80
29, 30	.25	.26	.05	.12
32	.50	.55	—.16	—.12

We see that the loadings differ somewhat in detail, but that the general pattern is about the same in both cases. This is seen if we arrange the variables in order of size of the loadings for a particular factor and compute a rank-difference correlation between the orders obtained by the two methods. The correlation is found to be over .95 for each factor. The loadings by Hotelling's method all tend to be shifted somewhat, but in most cases the shift is in the same direction for each variable. Using this method does not seem to change or add to our essential results.

Perhaps a graphic presentation of the factors will show up certain relationships which the numerical results do not readily show. Where three factors have been fitted, a tri-dimensional figure would be required to show up the relationships. The factors can be shown in bi-dimensional form by taking them in pairs. We have done this for the case of 32 variables. In the 20-variable and 13-variable factor patterns, we have

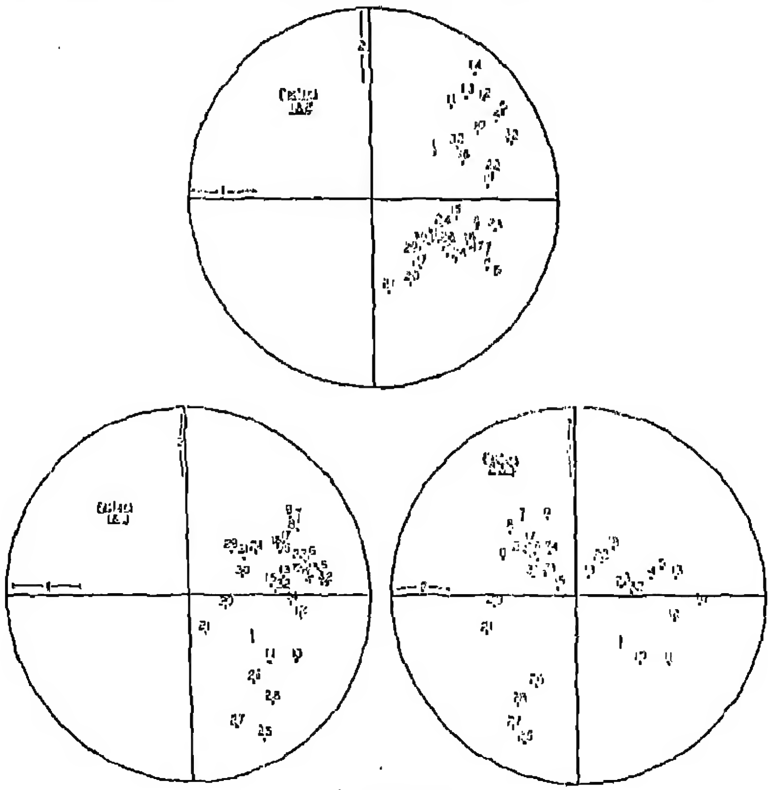

FIGURE 2

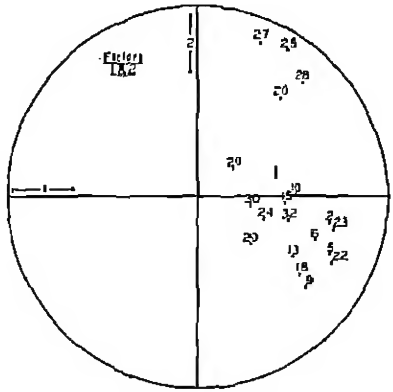

FIGURE 3

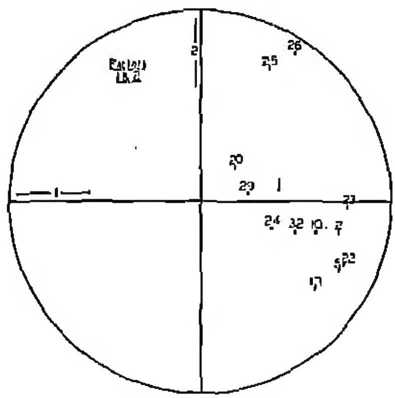

FIGURE 4

graphed only the first two factors. In the graphs, each variable is represented by a point. The identifying number of the variable is above the point, whereever possible.

When we examine the graph of the first two factors for the 32 variables, we notice first of all that the different measures taken on the same piece of apparatus tend to cluster together. We find all the different scores for maze A, or for the CR apparatus, or for the Columbia obstruction apparatus in the same general locality. We can also see that the earlier tests tend to be in the upper half of the cluster. Finally, most of the right-hand half of the cluster is composed of maze and problem-box scores.

The striking characteristic of the clustering for factors one and three is the separation of the CR tests from the rest of the cluster.

The graph for factors one and two of the 20-variable array of correlations is very similar to that for factors one and three of the 32-variable problem just considered. The CR scores are isolated from the rest of the scores. It is interesting to note that the five scores furthest removed from the CR scores are time scores. In this case, the second factor appears to distinguish between rapid running of a maze or problem box and frequent crossings of the fence in the CR apparatus.

The 13-variable graph resembles that for 20 variables and shows the same trends.

We may make one more approach to the analysis of the intercorrelations by finding to what extent factors common to two different mazes and those common to two different problem boxes, for instance, are common between the mazes and problem boxes. We use the more general case of Spearman's attenuation formula, which takes the form

Community of a and b with x and y =

$$\frac{\sqrt[4]{r_{ax} \cdot r_{bx} \cdot r_{ay} \cdot r_{by}}}{\sqrt{r_{ab} \cdot r_{xy}}}$$

Comparing the two alley mazes with the two elevated mazes, we find a community of .98 for errors and .94 for time. Comparing scores on two different mazes with time scores on two different problem boxes, we get communities ranging from .70 to 1.00+, with a median at .91. On the other hand, when we take two maze or problem-box scores and get the community with two CR scores, the communities are very low. Four comparisons made at random give communities of .36, .11, .00, and .27. Likewise, when we consider the community between the two hunger-drive scores and a pair of maze, problem-box, or CR scores, we get sample results of .43, .27, .25, and .36.

This analysis suggests that the different mazes and problem boxes have very nearly the same factors in common, but that most of the factors common to the CR scores or to the hunger drive scores are common to those scores alone.

VI

DISCUSSION

Our results have shown a general tendency for different abilities in the same rat to be correlated. The relationship between different mazes is considerable—the median corrected correlation between scores on the different mazes that we used being about .45. But the relationships between the other tests are generally slight. The general tendency for correlation is confirmed in the work of Dunlap (5), and the higher relationship among mazes is in accord with the work of Commins, McNemar and Stone (3), and of Tomilin and Stone (33).

When we fitted factor patterns to our array of intercorrelations, using three factors, the first factor was weighted positively for each variable, and seemed to be composed of what was common to all the variables, especially what was common to the mazes and problem boxes. Another factor seemed to be a factor of transfer, or improved adjustment to the situation. The third factor seemed to be concerned chiefly with the CR tests.

The experimenter feels, from his observation of the rats at work, that a very important element in most of the time scores, and even in the error scores at the beginning of the test, was the "tameness" of the animals. It was obvious that some rats "knew" the maze long before they started to make perfect trials. The scores of the poor rats were probably poor largely because they were nervous in the maze and slightly conditioned against the food box. The scores of the good rats were probably more nearly measures of their ability to learn the maze. Thus, the maze-learning score would not be a homogeneous function, but would measure "intelligence" for good rats and "tameness" for the poor ones.

Under these circumstances, it seems possible that the first factor is this combination of "intelligence" and "tameness" which goes to explain the scores. We might call it "docility." The "transfer" factor might be thought of as a change in the relative importance of tameness in the scores of certain rats. It might represent the decreasing importance of tameness and the increasing importance of ability in the later scores.

The CR factor seems to be concerned largely with these tests, and is probably due in large part to the common apparatus and procedure and to the contiguity in time of these tests. The high correlation between the scores on jumping the fence to the stimulus and jumping the fence between stimulations suggests that our training has merely increased the readiness of the response, instead of attaching it to a particular stimulus. What we have called "conditioned-response" scores may be measures of irritability or sensitivity to shock rather than of learning. In this connection, we observe an appreciable correlation between these scores and activity as measured by the revolving wheel.

In conclusion, it must be remembered that any number of factor patterns can be fitted to a set of correlations such as these, and that many of them will give about as satisfactory fits. Even if we admit these particular factors as the best ones, there may still be considerable latitude in interpreting them. We must realize that the factors as they stand do not coincide with unitary biological traits, and at best only approximate such traits. We must look upon any names that we apply to individual factors purely as convenient tags, to be viewed with considerable distrust.

VII

SUMMARY AND CONCLUSIONS

1. Records were obtained for sixty-four albino rats on a wide variety of tests, including mazes, problem boxes, revolving-wheel activity cage, conditioned-response tests, and a measure of hunger drive.

2. The reliabilities of the various scores were determined, in most cases, from the scores on odd and even days corrected by the Brown-Spearman formula. With the exception of the scores for running the elevated mazes, most of these corrected reliabilities were fairly high (.70 to .95).

3. The intercorrelations of the different tests were computed. These were found to be positive in about 85 per cent of the cases. Most of the correlations between different tests were quite low, except for the correlations between different mazes. The median correlation between mazes was about .45 or .50 while the correlations between tests which were not both mazes had a median value of about .20.

4. A factor pattern was fitted to the intercorrelations by Thurstone's center-of-gravity method. More than one factor seemed necessary in order to get a satisfactory fit. The following factors were tentatively identified: (1) docility—maze-learning, intelligence, tameness; (2) transfer—distinguishing early from later tests; (3) a factor specific to the different CR scores.

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L'ORGANISATION DU COMPORTEMENT CHEZ LE RAT BLANC

(Résumé)

On a testé soixante-quatre rats blancs, âgés de soixante jours, dans dix divers appareils. On a testé les animaux sur deux formes du labyrinthe à unités multiples de Warner-Warden, deux formes d'un labyrinthe élevé, deux types de boîte à problème, deux tests de réponse conditionnelle, l'appareil d'obstruction de Columbia avec une impulsion de faim de vingt-quatre heures, et la cage d'activité à roue tournante. Quelques-uns des tests ont donné plusieurs différents types de résultats, de sorte que l'on a obtenu des dix tests trente-deux résultats de temps, d'erreur, et de distance.

Dans la plupart des cas on a déterminé les constances des divers résultats au moyen des résultats les jours pairs et impairs corrigés par la formule de Brown-Spearman. A l'exception des résultats du parcours du labyrinthe élevé, la plupart de ces constances corrigées ont été assez élevées,

c'est-à-dire, de 0,70 à 0,95. Les résultats des tests n'ont pas été influencés d'une façon marquée par les variations quotidiennes du rendement.

On a computé les intercorrélations des divers tests. Celles-ci se sont montrées positives dans environ 85 pour cent des cas, et nulle des corrélations négatives n'a été constamment différente de nulle. La plupart des corrélations entre les divers tests ont été assez peu élevées, à l'exception des corrélations entre les divers labyrinthes. La corrélation médiane corrigée entre les labyrinthes a été d'environ 0,45 ou 0,50, tandis que les corrélations corrigées entre les tests qui n'ont pas été tous deux des labyrinthes ont eu une valeur médiane d'environ 0,20.

On a ajusté une forme de trois facteurs aux corrélations entre les trente-deux variables, et aussi à une série réduite de corrélations entre vingt variables, au moyen de la méthode du centre de gravité de Thurstone. Le premier facteur a eu un poids positif pour chacune des variables, et a semblé surtout associé aux labyrinthes et aux boîtes à problème. Le deuxième facteur a donné des poids positifs aux premiers tests et des poids négatifs aux subséquents. Le troisième facteur a donné de grands poids négatifs aux tests de réponse conditionnelle et de petits poids négatifs ou positifs à tous les autres. Les trois facteurs ont été provisionnellement identifiés comme (1) la capacité en train d'être testée—l'apprentissage du labyrinthe, "l'intelligence," "la docilité," (2) un facteur de "transfert," discriminant entre les premiers tests et les subséquents, et (3) un facteur qui a eu surtout rapport, paraît-il, aux tests de réponse conditionnelle.

THORNDIKE

DIE ORGANISATION DES VERHALTENS DER ALBINORATTE

(Referat)

Vierundsechzig Albinoratten im Alter von sechzig Tagen wurden in zehn verschiedenen Apparaten untersucht. Die Tiere wurden bei zwei Mustern des Warner-Warder vielfachen Einheitslabyrinths, zwei Mustern des erhobenen Labyrinths, zwei Arten des Problemkastens, zwei bedingten Antwortstests, dem Columbia Hindernisapparat nach vierundzwanzig Stunden Futterentziehung, und dem Drehradtätigkeitskäfig untersucht. Einige Versuche ergaben mehrere Typen von Ergebnissen. Auf dieser Weise wurden im ganzen zweiunddreissig Zeit- , Irrtum- , und Entfernungswerte von den zehn Versuchen gewonnen.

Die Zuverlässigkeiten der verschiedenen Resultate wurden bestimmt; in den meisten Fällen wurden Ergebnisse an geraden und ungeraden Tagen durch die Brown-Spearman Formel verbessert. Mit der Ausnahme der Ergebnisse für das erhobene Labyrinth waren die meisten dieser verbesserten Zuverlässigkeiten ziemlich hoch, d.h. 0,70 bis 0,95. Die Ergebnisse wurden durch tägliche Veränderungen der Leistung nicht ungebührlich beeinflusst.

Die Zwischenkorrelationen der verschiedenen Versuche wurden ausgerechnet. Es wurde festgestellt, dass diese in ungefähr 85 Prozent der Fälle positiv waren, und keine der negativen Korrelationen zuverlässig verschieden von Null war. Die meisten Korrelationen zwischen den verschiedenen Versuchen waren ganz niedrig, mit der Ausnahme der Korrelationen zwischen den verschiedenen Labyrinthen. Die verbesserte Durchschnittskorrelation zwischen den Labyrinthen war ungefähr 0,45 oder 0,50 während die verbesserte Korrelationen zwischen den Versuchen, die nicht von beiden Labyrinthen waren, einen Durchschnittswert von ungefähr 0,20 hatten.

Das Gebilde von drei Faktoren wurde den Korrelationen zwischen den zweiunddreissig Variablen passend gemacht, und auch einer verminderten Reihe von Korrelationen zwischen zwanzig Variablen vermittelst der Thurstone Schwerpunktmethode (center-of-gravity method). Der erste Faktor hatte ein positives Gewicht für jede der Variablen und schien besonders mit den Labyrinthen und Problemkasten in Beziehung zu stehen. Der zweite Faktor ergab positive Gewichte bei den früheren Versuchen und negative Gewichte bei den späteren. Der dritte Faktor ergab grosse negative Gewichte bei den bedingten Antwortsversuchen und kleine negative oder positive Gewichte bei den anderen. Die drei Faktoren wurden probend identifiziert als (1) die untersuchte Fähigkeit—das Labyrinthlernen, "Intelligenz," "Fügsamkeit," (2) ein Faktor der "Übertragung," das Unterscheiden zwischen den früheren und späteren Versuchen, und (3) ein Faktor, der sich scheinbar besonders auf die bedingten Antwortsversuche bezog.

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