3

A Factor Analysis of the Performance of Dogs on Certain Learning Tests[1]

ANNE ANASTASI, J. L. FULLER, J. P. SCOTT & J. R. SCHMITT
Fordham University and Roscoe B. Jackson Memorial Laboratory

(Text-figures 1 & 2)

FACTOR analysis is a statistical technique for simplifying and clarifying the description of individual differences by reducing the number of necessary variables or dimensions. Such an analysis begins with the intercorrelations among a set of variables, such as the scores obtained by a group of individuals on a series of tests. The object of the analysis is to find the smallest number of factors or dimensions which can account for the obtained correlations among the test scores. Individual differences may then be described in terms of this relatively small number of factors, rather than in terms of all the original tests. For subsequent testing purposes, an effort is generally made to choose or develop single tests which provide the best measure of each of the factors identified in the analysis. Detailed discussions of the techniques of factor analysis and of its mathematical foundations have been given by Thurstone (1947), Holzinger & Harman (1941), Thomson (1951) and Cattell (1952). A very lucid elementary introduction to factorial techniques can be found in the recently published book by Fruchter (1954).

Although originally developed in connection with the study of human abilities, factor analysis has wide applicability. It has been employed in such diverse areas as the investigation of bodily physique and constitutional types, the classification of psychoses and neuroses, the identification of emotional and motivational traits, the study of interrelationships among allergy reactions, the exploration of aesthetic and humor preferences, the delineation of the cultural patterns of different nations and the analysis of the voting records of legislators and Supreme Court judges. For general surveys of the applications of factorial methods and for critical evaluations of results, reference may be made to Thurstone (1948), Fruchter (1954, Ch. 10), Anastasi (1948) and Anatasi & Foley (1949, Ch. 15). The special implications of factor analysis for test development are considered in Anastasi (1954, Ch. 14).

Factorial analyses of infrahuman behavior have been relatively few. A major reason for the infrequent use of this technique in animal studies stems from the difficulty of meeting certain important methodological requirements. Among such requirements, special mention should be made of the need for high test reliability, a sufficient number of variables to permit adequate determination and definition of each factor, and a large enough group of subjects so that chance errors of sampling will not loom too large in the correlation coefficients. Owing to their failure to meet one or more of these conditions, even the best available factorial investigations of infrahuman behavior must be regarded as preliminary and exploratory. And it should be added that such a characterization must also be applied to the study which will be reported in the present paper.

The pertinent animal studies published prior to 1950 have been summarized by Royce (1950a). About a dozen investigations conducted before 1935 reported correlations between two or more measures of learning. All were concerned with rats, with the exception of one study in which chicks were employed (Dunlap, 1933). The correlations were uniformly very low, except those between closely similar tasks, such as different mazes. There was no evidence of a general learning factor

[1] The raw data for this study were obtained at the Hamilton Station of the Roscoe B. Jackson Memorial Laboratory, Bar Harbor, Maine, while the statistical analysis was conducted at Fordham University, New York City. The cost of IBM computations was covered partly by the Roscoe B. Jackson Memorial Laboratory and partly by the New York Zoological Society. Assistance in making many of the arrangements necessary to conduct this research was rendered by Dr. John V. Quaranta, formerly Research Associate in Animal Behavior, New York Zoological Society.

(Dunlap, 1933; McCulloch, 1935). To be sure, no common learning factor has been found in the case of human subjects either, the abilities or group factors identified in the human studies being organized along different lines. Thus a person who excels in spatial learning, for example, may be quite deficient in verbal or numerical learning. The early animal studies, however, showed little evidence of any sort of group factors beyond a few of very narrow scope. A high degree of specificity seemed to characterize the behavior measured in these studies.

The first systematic investigation of animal behavior by means of current procedures of factor analysis is to be found in a study of rat behavior by R. L. Thorndike (1935). A total of 32 scores was obtained from seven experimental set-ups, including mazes, problem boxes, conditioned response apparatus, activity wheel and an obstruction box for measuring the relative strength of different drives. The subjects were 64 albino rats. Factorial analyses indicated the presence of three factors, which were described as docility, transfer and a conditioned response factor.

Van Steenberg (1939) subsequently re-analyzed Thorndike's data and rotated the centroid axes for simple structure in accordance with the procedures developed by Thurstone. Such a rotation is now common practice in factorial studies, its object being to obtain a more clear-cut and easily interpretable configuration of factors. Van Steenberg's analysis yielded ten factors, five of which could, according to the author, be interpreted with some confidence. These factors were identified as follows: ability to profit from visual cues (common to elevated mazes), adaptability to new situations, speed of movement, ability to learn a right-left alternation and visual insight or perception of the total stimulus pattern. Of the remaining five factors, three were very narrow factors specific to one kind of apparatus; one admittedly defied psychological interpretation; and one was regarded as a residual factor. It should be added that the descriptions of the first five factors themselves fall somewhat short of desirable clarity. Nor does the extraction of ten factors from intercorrelations obtained on only 64 rats appear quite warranted.

In a later study, Vaughn (1937) applied centroid analysis and rotation of axes to the intercorrelations among a set of 34 measures obtained from 75 rats. An even wider variety of behavior was covered than had been the case in Thorndike's study, although most of the tests were again concerned primarily with learning. The apparatus included a wildness tunnel, an activity cage, a straightaway, a perseverance box, several types of mazes, a problem box and a test designed to measure reasoning. Eight factors were isolated, four of which were tentatively identified as follows: speed, wildness-timidity, associative or insight learning, and transfer.

Other ways in which factor analysis may be applied to the investigation of animal behavior are illustrated by the work of Wherry (1939, 1940, 1941) and Searle (1949). In Wherry's analyses, intercorrelations were found, not among the scores obtained by each animal, but among the numbers of errors made by the entire group in different segments of the learning situation. Thus each blind alley in a given maze was considered as an "individual," and the total number of entrances made during a given trial or stage of learning was taken as the "score" for that learning period. Intercorrelations of "scores" obtained in different periods were found and submitted to a centroid analysis, with subsequent rotation of axes. By this procedure, Wherry sought to investigate changes in the factorial composition of behavior at different stages of learning. When applied to published data from mazes and other types of learning situations, this procedure yielded remarkably consistent results. Factors described as forward-going, food-pointing and goal-gradient predominated in the initial, middle and final stages of learning, respectively.

Searle (1947, 1949) applied obverse[2] factor analysis to rat learning data. In this method, correlations are found between individuals rather than between tests or other variables. The procedure can be visualized if we think of the columns and rows of a table of scores as having been interchanged prior to the computation of intercorrelations. Each correlation thus obtained indicates the degree of similarity of the score patterns or profiles of two individuals. When such correlations are submitted to a factor analysis, the resulting factors represent clusters or "types" of individuals characterized by similar score profiles.

Factorial techniques have likewise been applied to the analysis of emotional and motivational data obtained in animal studies. But the results in this area are even more tentative than those in the field of learning. Geier, Levin & Tolman (1941) factor-analyzed 29 measures of the behavior of 57 rats in two experimental set-ups. Both learning and emotionality indices

[2] Also known as "Q-technique" and sometimes incorrectly described as "inverted factor analysis." In the terminology of matrix algebra, such an analysis involves, not the inverse, but the transpose of the original score matrix.

were represented in this study. An investigation concerned only with the factorial composition of emotionality indices was conducted on 40 rats by Billingslea (1942). Using a procedure similar to that of Wherry, described above, Rethlingshafer (1941) compared the factorial composition of different stages of learning under conditions of varying motivational strength. Previously published data on rats were utilized for this purpose.

More recently, Royce (1950b, 1951) applied the centroid method of factor analysis to the intercorrelations among 32 physiological, psychological and social measures of emotionality obtained from 53 dogs. Rotation of the centroid axes yielded an oblique simple structure. Of the ten factors thus identified, six were tentatively interpreted as follows: psychophysiological timidity, behavioral timidity, heart reactivity to social stimulation, aggressiveness, activity level and audiogenic reactivity. Many of the animals utilized in the Royce investigation have been included in the sample employed in the present study.

Procedure

The present study represents an exploratory factorial analysis of the performance of dogs in a variety of learning situations. The data were gathered by members of the research staff of the Division of Behavior Studies, Roscoe B. Jackson Memorial Laboratory, Bar Harbor, Maine, as part of a long-range project on genetics and social behavior in dogs. A brief account of the over-all research plan can be found in a report by Scott & Fuller (1951). For descriptions of the physical environment and of the procedures followed in the care and rearing of the dogs, the reader is referred to the *Manual of Dog Testing Techniques,* edited by Scott & Fuller (1950, pp. 4-9).

Subjects. — Seventy-three dogs of pedigreed stock were included in the present sample. All had been reared under uniform laboratory conditions and had been put through a standardized system of handling, training and testing. Detailed genetic records on each animal are available at the Jackson Laboratory.

Table 1 shows the breed and sex distribution of the subjects. It will be noted that the group comprised 16 Basenjis, 4 Beagles, 18 Cocker Spaniels, 5 Shetland Sheep Dogs, 7 Wire-haired Fox Terriers and 23 Basenji-Cocker Spaniel crosses. There was a total of 34 males and 39 females. The animals employed represent all those for whom complete data were available on the variables under consideration.

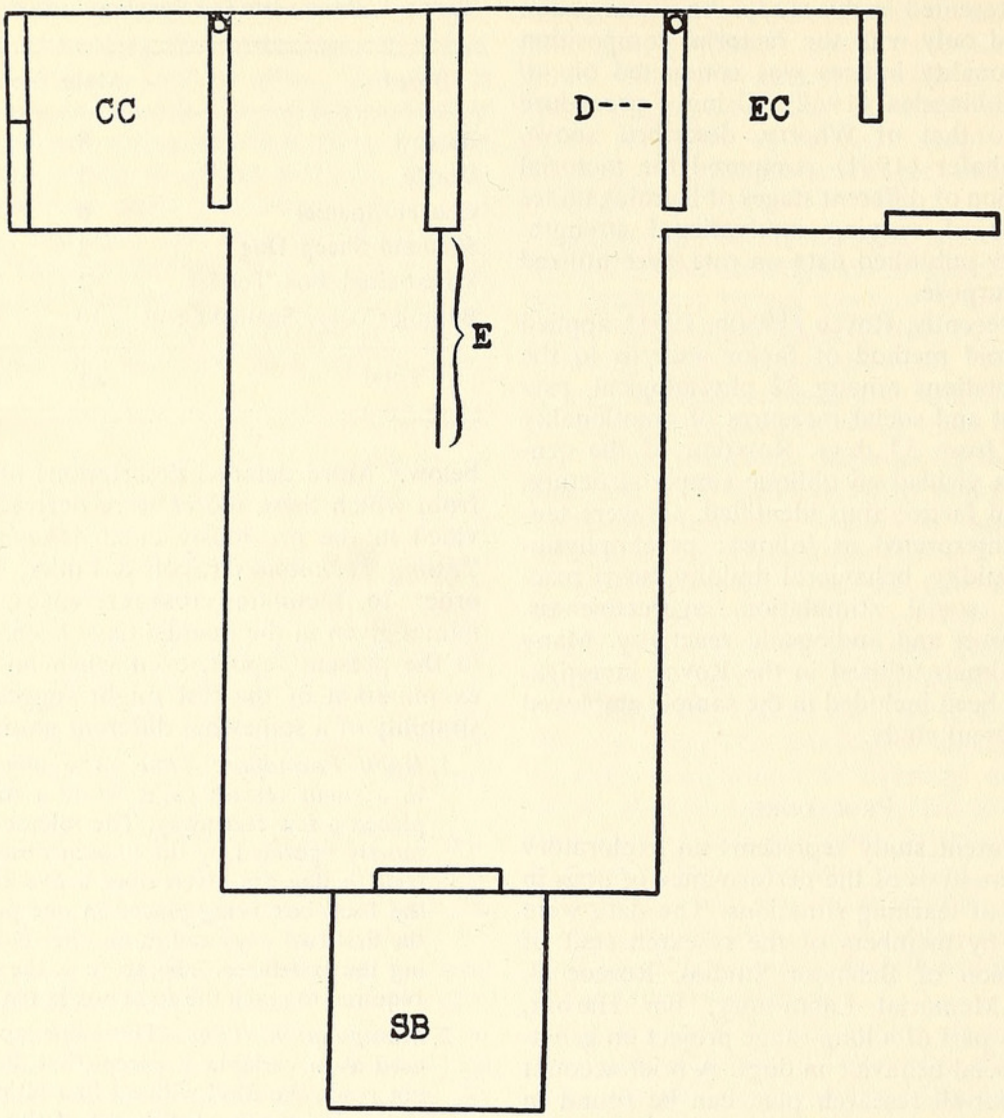
Tests.—The present analysis is based on the scores obtained in the 17 variables described below.[3] More detailed descriptions of the tests from which these scores were derived are provided in the previously cited *Manual of Dog Testing Techniques* (Scott & Fuller, 1950). In order to facilitate cross-references, the test names given in the manual have been employed in the present report, even when an objective examination of the test might suggest the desirability of a somewhat different name.

Table 1. Breed and Sex Distribution of Subjects

Breed	Male	Female	Total
Basenji	8	8	16
Beagle	3	1	4
Cocker Spaniel	8	10	18
Shetland Sheep Dog	3	2	5
Wire-haired Fox Terrier	2	5	7
Basenji-Cocker Spaniel Cross	10	13	23
Total	34	39	73

1. *Habit Formation: Time.*—The dog is placed in a small release cage, while a food box is placed a few feet away. The release box is remotely operated by the unseen observer. Two trials a day are given over a five-day period, the food box being placed in one position for the first two days and in another position during the last three. The score is the total time required to reach the food box in ten trials.
2. *Manipulation: Time.*—The same apparatus is used as in variable 1, except that the dog cannot reach the food without first biting, nosing, or pawing the food dish out of the food box. Two trials a day are given for two days. The score is the total time required to obtain the food in four trials.
3. *Manipulation (String-pulling): Time.* — The same apparatus is again used as in variables 1 and 2, except that the food dish is placed well back in the food box and must be pulled out by a string which is attached to the rim of the dish. The score is the total time required to obtain the food in two trials.
4. *Maze (Second Barrier Test): Errors.*—The apparatus for this test consists of a six-unit T-maze with a food dish at the exit. Since the barriers are made of poultry netting, the solution to each part of the maze is visible, but not that of the whole. Following a two-day orientation period, each dog is put through one trial

[3] Other variables were considered and discarded because of lack of experimental independence of scores. The measures omitted for this reason include a cover-lifting test and three scores obtained in a discrimination and delayed-response apparatus. In all these tests, subjects who had failed an earlier related test were not subsequently tested, but were automatically recorded as failures in the new test.



TEXT-FIG. 1. Discrimination apparatus. SB–Starting Box. EC–Escape Corridor. CC–Closed Corridor. D–Door banged as cue. E–Partition which is swung either right or left in variable 5 (Motivation) so as to completely obstruct one corridor.

a day for ten days. An error is recorded whenever an animal stops or reverses direction. The score is the total number of errors in the last nine of the ten trials.

5. *Motivation* (*Discrimination Apparatus*): *Time.* —This test was designed to measure the motivational strength of each animal, as indicated by his running time in escaping from an enclosed area and in reaching food. The discrimination apparatus (cf. Text-fig. 1) is utilized as the enclosed area. This apparatus has a starting box and two escape corridors. In the motivation test, one escape corridor is completely closed off so that the dog has only one possible route. To provide a visual and auditory cue, the experimenter bangs the inner door of the correct escape corridor four or five times, just as he releases the dog from the starting box. After escaping from the apparatus, the dog is allowed to run freely in the room and is fed by the experimenter near the starting box. The order of presentation of escape corridors (RLRRLRLLRL) is designed to avoid the formation of position habits or of a simple alternation habit. The score is the median time required to escape in ten trials.

6. *Cue Response* (*Discrimination Apparatus*): *Trials.*—Cue response training is started on the day following completion of the motivation test. The apparatus is arranged so that the center partition extends directly forward, as shown in Text-fig. 1, rather than being swung right or left as in the motivation test. The dog must therefore choose one side or the other before he can see which outer door is open. Entrance into the wrong corridor counts as an error. The cue is given as in the motivation test by swinging the inner corridor door four or five times and releasing the dog from the starting box immediately thereafter. The outer door of the uncued corridor is closed so that the dog can never escape from the wrong corridor. A

uniform random sequence of right and left escape corridors is again used. The score is the number of trials required to reach either of two pre-established criteria of learning in which the proportion or sequence of correct choices exceeds chance at the .01 level of significance.

7. *Cue Response (Discrimination Apparatus): Time.*—This variable is the same as variable 6, except in the scoring. In the present variable, the score is the median time required for the last 19 correct trials of cue response training.

8. *Leash Control (In): Trials.*—The dog is removed from the outside pen before the leash is put on him. He is then led on leash over a short course of outdoor pathways and brought into the building, where he is fed a small amount of fish. The training is continued for ten days. The dog's performance is rated by assigning differential weights to errors of varying degrees of seriousness, including balking, pulling, dragging, fighting the leash, "sun-fishing," crossing in front of or jumping at the trainer and various kinds of vocalizations such as whining, yelping or howling. The score is the number of trials required to reach a performance rating of 2 or less.

9. *Leash Control (Stairs): Trials.*—During the last eight days of leash control training, the dog is also taken through the building and up the stairs to one of the lofts, where he is fed. The course includes a flight of stairs interrupted by a landing. A rating scale similar to that of variable 8 is used to score the subject's performance while climbing up and down the stairs. The score is the number of trials required to reach a performance rating of 2 or less on this portion of the course.

10. *Leash Control (In): Initial Errors.*—This variable is the same as variable 8, except in the scoring. The score is the error rating obtained on the first day of training in leash control.

11. *Leash Control (Stairs): Initial Errors.*—This variable is the same as variable 9, except in the scoring. The score is the error rating obtained on the first day of training in stair climbing.

12. *Motor Skills: Time.*—This test was designed to measure the dog's general physical skill, especially in relation to climbing, jumping and balancing. Two boxes, each one foot high, are stacked and a two-by-five-foot ramp leads to the top box where a food dish is placed. The dog is released about six feet from the apparatus and is timed from his release to the moment when he reaches the food. The score is the total time on three trials.

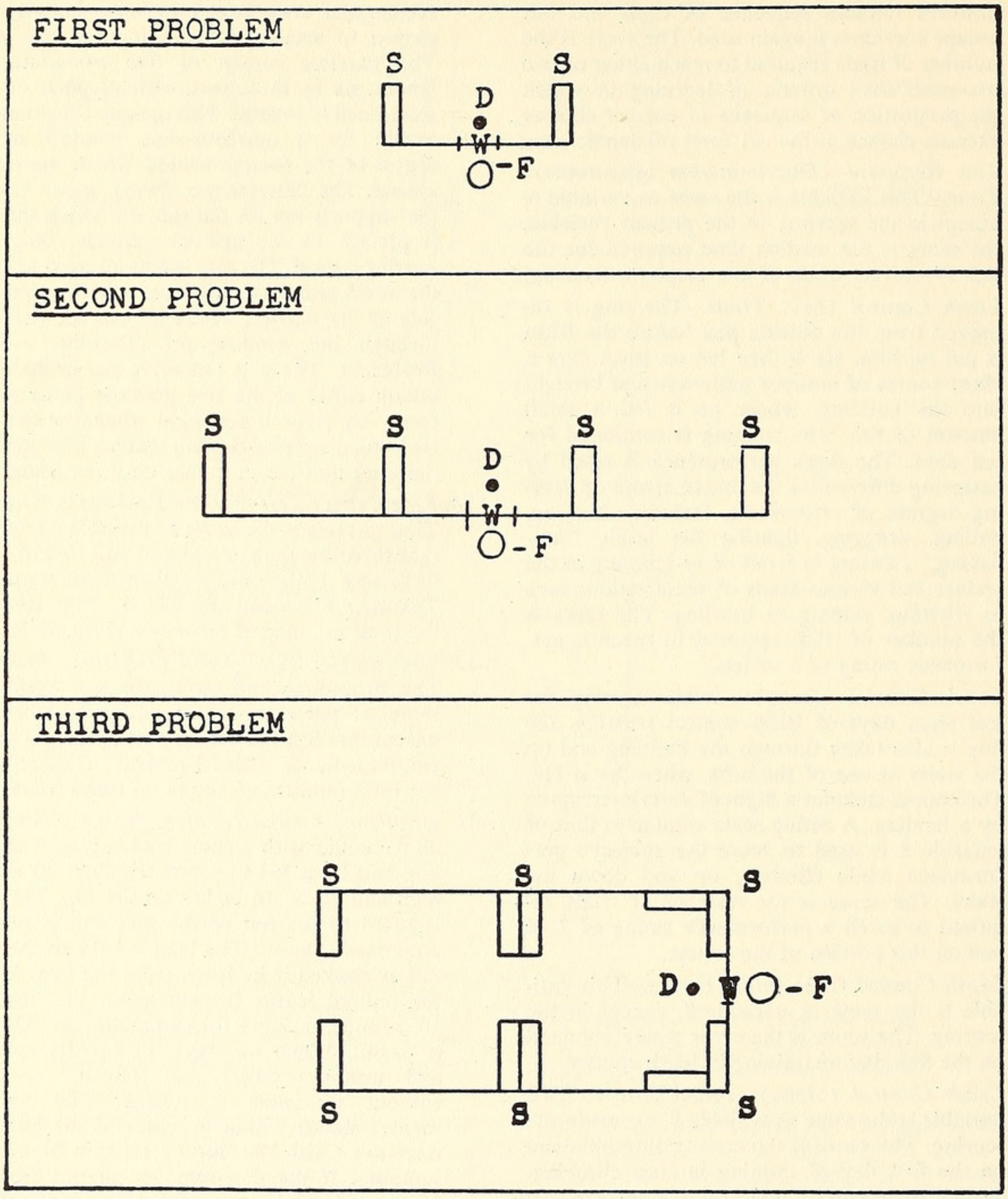
13. *First Barrier Test (First Problem): Errors.*—This test is of the "Umweg" type and was designed to test performance in a situation which is totally new to the dog. It may also test generalization or transfer of training from a simple situation to a more complex one of the same type, as represented by variables 14 and 15. The test is conducted within a large rectangular area, two days being initially employed to accustom the animal to this area. The barriers consist of five wood-and-wire fences, six by three feet, with supports on one side. Each is covered with opaque brown paper, except for a one-foot-wide window in the center of the barrier behind which the dog is placed. The barriers are always set up so that the supports are on the side on which the dog is placed. In the present variable, only one barrier is used. The dog is first allowed to smell the food and is then placed on the opposite side of the barrier, where he can see the food through the window (cf. Text-fig. 2—First Problem). The dog can solve the problem by taking either of the two possible paths to the food. An error is recorded whenever the animal stops or reverses direction. The score is the total number of errors on three trials.

14. *First Barrier Test (Second Problem): Errors.*—This variable is the same as variable 13, except that three barriers are placed end to end so as to form a longer straight-line obstruction (cf. Text-fig. 2—Second Problem). The score is the total number of errors on three trials.

15. *First Barrier Test (Third Problem): Errors.*—The procedure and apparatus are again the same as those described under variable 13, except that five barriers are set up in a U shape (cf. Text-fig. 2—Third Problem). The score is the total number of errors on three trials.

16. *Obedience (Adjusted Stay Score): Time.*—A choke collar with a short lead is placed on the dog and he is led to a box which is 20 inches high and 20 × 16 inches on the top. The dog is lifted to the top of the box and given the command, "Stay." The lead is held so that the dog is choked if he leaps from the box. When the animal learns to remain on the box for 30 seconds, training for responding to "Down" is begun. When he stays up for 30 seconds and jumps promptly at "Down," training without a collar is started. The experimenter stands within 6 inches of the box but does not touch the dog or restrain him from jumping. If the dog remains on the box for 30 seconds and jumps promptly at "Down," the distance of the experimenter is increased on the next trial. The control distances are: 6", 18", 36", 72", 144", and out of sight behind a screen placed 14 feet from the box (BHS). A total of three days is devoted to the above training. On the fourth or test day, the dogs are tested in the following sequence of control distances: 6", 18", 72", 144", BHS, 6", 18", 72", 144", BHS. The score employed in this variable is the "adjusted stay score," i.e., the total time during which the dog remains on the box in the ten 30-second test trials (max. = 300 sec.), minus a 10-second penalty for each failure to jump within 10 seconds of the command "Down."

17. *Obedience: Jumps during Training.*—This variable is similar to variable 16, the score being



Text-fig. 2. First barrier test. S–Supports for barriers. F–Food dish. D–Dog. W–Window in barrier.

the number of spontaneous jumps with collar on, or at the minimum distance of 6 inches without the collar, during the *training period.* Each such jump constitutes an error.

Results

Conversion of Scores.–Prior to the computation of intercorrelations, the scores on all variables except two (variables 3 and 6) were converted to single-digit, normalized standard scores.[4] The converted scale ranges from 0 to 9, with a mean of 4.5 and a standard deviation of 2. It will be recalled that the raw scores on all variables except 16, the adjusted stay scores on the obedience tests, were expressed so that the higher the score the poorer the performance. In the converted scores, however, 9 represents the best performance and 0 the poorest in all variables.

Some of the converted distributions retained a certain amount of skewness or other irregularities. Such variations result from the occurrence of an excessive number of identical scores either at the upper or lower end, or at some

[4] A list of raw scores, as well as details of the score conversion and other computational procedures, can be found in Schmitt (1954).

other part of the range. Since all such identical scores were assigned the same converted score, the frequency of a given converted score sometimes exceeded that required by the normal curve transformation. Nevertheless, the converted distributions of 15 variables were deemed to be sufficiently close to a normal curve for use in the computation of Pearson correlation coefficients. In the case of the remaining two variables, however, the marked skewness resulting from the large number of failures led to the decision to dichotomize the variables. This was done for variable 3, string pulling, and variable 6, trials to learn cue response.

Intercorrelations.—The intercorrelations among the 17 variables were computed by IBM procedures at the Test Division of The Psychological Corporation, New York City. All are Pearson correlations, except that between variables 3 and 6, which is tetrachoric, and those between variables 3 or 6 and the remaining variables, which are biserial. The complete set of 136 correlations is reproduced in Table 2. The correlations range from +.71 to −.43, including 82 positive and 54 negative coefficients. For a sample of 73 cases, the minimum correlations significant at the .05 and .01 levels are ±.232 and ±.302, respectively. Reference to Table 2 shows that 44 coefficients reach or exceed the .05 level of significance; and of these, 27 reach or exceed the .01 level. By chance, between 6 and 7 of the 136 correlations would be expected to reach the .05 level, and only 1 or 2 of these should reach the .01 level.

Factor Analysis.—The intercorrelations were analyzed by Thurstone's complete centroid method (Thurstone, 1947, Ch. 8). The criterion employed for determining how many factors to extract was that developed by McNemar (1942). According to this criterion, the *sth* factor is significant if the estimated SD of the partial correlations remaining after the extraction of s factors exceeds the standard error of a zero correlation. The SD of the partial correlations (σ_s) is estimated by the following formula: $\sigma_s = \frac{{}_s\sigma_\rho}{1 - M_{h_s^2}}$, in which ${}_s\sigma_\rho$ is the SD of the *sth* factor residuals and $M_{h_s^2}$ is the mean communality of s factors. With 73 cases, the standard error of a zero correlation is .1179. This value is slightly less than that of σ_{IV} (.1257). but exceeds that of σ_V (.1168). Factorization was therefore discontinued after the extraction of the 5th factor.

In Table 3 will be found the centroid factor matrix, showing the weight of each of the five factors in each of the 17 variables, as well as the communality, or proportion of common factor variance, in each variable. The centroid axes were next rotated graphically in such a way as to maximize the number of zero factor loadings (simple structure), while retaining the orthogonal relationship among the axes. The rotated factor matrix is reproduced in Table 4.

It will be noted that the mean communality is .46. Factor II contributes the largest proportion of common variance, .12. Factors I and IV each contribute .10; and Factor V accounts for .09. The smallest contribution, .05, is made by Factor III. The uniqueness of the variables, including unknown proportions of specificity and error variance, accounts for as much as 64 per cent of the total variance of the battery.

Interpretation of Factors.—In order to arrive at a provisional psychological interpretation of each of the five rotated factors, all variables having loadings of ±.40 or higher on that factor were examined. Such a factor loading accounts for 16% or more of the variance of the particular variable.

Reference to Table 4 shows that the variables which meet the above criterion with regard to *Factor I* are the following:

13. First Barrier Test (First Problem): Errors	.47
11. Leash Control (Stairs): Initial Errors	.47
9. Leash Control (Stairs): Trials	.46
16. Obedience (Adjusted Stay Score): Time	−.44
17. Obedience: Jumps during Training	−.53

The type of behavior involved in all these tests suggests that Factor I may be related to *activity* and *impulsiveness.* In the first barrier problem, the more active or impulsive animal is less likely to hesitate or reverse direction in going to the food dish. It might be added that the second and third barrier problems (variables 14 and 15) also show appreciable positive loadings on Factor I, but of decreasing magnitude (.39 and .31). These two problems would also favor the more impulsive animal, since hesitations and reversals again constitute the only errors. Lower loadings would be expected, however, than on the first problem, which represents the animal's initial contact with a relatively strange situation. Moreover, because of their greater complexity, the second and third problems may depend more heavily upon cognitive factors than upon mere impulsiveness or general activity level.

In the two measures of stair climbing (variables 9 and 11), the more active animal is less likely to manifest such behavior as balking and dragging, both of which are scored as errors.

TABLE 2. INTERCORRELATIONS AMONG THE SEVENTEEN VARIABLES
(N = 73)

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1																
2	.3303															
3	.3902*	.4696*														
4	.0460	−.1692	−.1898*													
5	−.0284	.1025	−.1539*	−.1381												
6	.1949*	.1949*	.0700†	−.4338*	.5173*											
7	−.0392	.0757	−.0624*	−.0294	.7070	.4902*										
8	−.3525	−.1610	−.2692*	−.0684	.4492	.0302*	.2724									
9	.1433	.1327	.0102*	.0410	.0892	.2716*	.1344	.0242								
10	−.1273	−.0261	−.0892*	−.1190	.4002	.1678*	.2641	.3859	−.0241							
11	.0075	−.0510	.1112*	−.1822	.2680	.2943*	.2383	.3073	.2443	.3079						
12	.3101	.2026	.0792*	−.0087	.0387	−.0035*	.0345	−.0778	−.0462	.0651	.1001					
13	.2990	.0886	.3705*	−.2212	−.0578	.1461*	.0208	−.3031	.2726	.0325	.1793	.2023				
14	.3860	.0966	.1477*	.0437	−.3880	.0394*	−.2719	−.2195	.2254	−.1025	.1202	.0546	.4058			
15	.2239	.0406	.1487*	−.1704	−.2200	.1713*	−.3075	−.3537	.0679	−.1757	.1395	.1595	.2811	.4291		
16	−.0393	.0075	−.0151*	−.0094	.1618	.1390*	.1668	.1981	−.2648	.1630	−.1155	−.1185	−.1508	−.2296	−.2900	
17	−.1528	−.0829	−.0631*	.2475	.1975	−.1400*	.1859	.2995	−.2785	.3034	.0108	−.1704	−.3424	−.3948	−.3641	.4866

All correlations are Pearson Product-Moment Coefficients unless otherwise indicated.
* Biserial correlation.
† Tetrachoric correlation.

TABLE 3. CENTROID FACTOR MATRIX

Variable	Factor I	Factor II	Factor III	Factor IV	Factor V	h^2
1. Habit Formation: Time	.5116	.2032	−.3358	.3516	.1556	.5636
2. Manipulation: Time	.3383	.3634	−.3985	−.1795	−.1319	.4549
3. Manipulation (String pulling): Time	.4722	.2973	−.4206	−.2253	.0706	.5440
4. Maze (Second Barrier Test): Errors	−.2371	−.3162	−.1768	.1848	.3375	.3355
5. Motivation (Discrim. Appar.): Time	−.3519	.7085	.2551	.1168	−.2046	.7464
6. Cue Response (Discrim. Appar.): Trials	.1709	.6063	.3021	.1391	−.4237	.6869
7. Cue Response (Discrim. Appar.): Time	−.2978	.6478	.1535	.1362	−.1217	.5653
8. Leash Control (In): Trials	−.5104	.3040	.2917	−.2519	.1920	.5383
9. Leash Control (Stairs): Trials	.2853	.1631	.3100	−.1146	.1405	.2370
10. Leash Control (In): Initial Errors	−.2687	.4404	.1671	.0547	.2501	.3596
11. Leash Control (Stairs): Initial Errors	.0940	.4113	.3916	−.0576	.3299	.4435
12. Motor Skills: Time	.2439	.1531	−.1104	.1340	.0764	.1189
13. First Barrier Test (First Problem): Errors	.5578	.2211	.1079	.1337	.2011	.4300
14. First Barrier Test (Second Problem): Errors	.5917	−.1248	.1292	.1608	.2805	.4869
15. First Barrier Test (Third Problem): Errors	.6032	−.1463	.1804	.2085	−.0697	.4661
16. Obedience (Adjusted Stay Score): Time	−.4147	.2231	−.2711	.1944	−.0679	.3376
17. Obedience: Jumps during Training	−.6356	.1675	−.3209	.0961	.1735	.5744

On the other hand, the negative weights of the two obedience measures are understandable, since an active, impulsive dog is more likely to jump down and finds it more difficult to remain motionless for the required period. It may also be suggested, as a further elaboration or description of Factor I, that this factor indicates confidence in a strange situation and lack of timidity. It is noteworthy in this connection that all three variables which have high positive loadings on this factor are based on tests administered outside the animal's normal living environment.

Turning our attention to *Factor II,* we find loadings of .40 or more on the following variables:

8. Leash Control (In): Trials	.57
10. Leash Control (In): Initial Errors	.56
17. Obedience: Jumps during Training	.54
5. Motivation (Discrimination Apparatus): Time	.54
7. Cue Response (Discrimination Apparatus): Time	.53
11. Leash Control (Stairs): Initial Errors	.40
15. First Barrier Test (Third Problem): Errors	−.45

This factor appears to involve *docility* or *responsiveness to a human trainer.* Its two highest positive weights occur in those measures of leash control in which the animal is led over an outdoor course. A loading of .40 is likewise found in initial errors made when being led up the stairs on leash. Subsequent stair-climbing performance, however, shows no significant loading with this factor, probably because such performance soon becomes primarily a matter of motor skill or activity rather than responsiveness to the trainer. Similarly, the measure based upon performance during obedience training (variable 17) has a loading of .54 on this factor. A lower loading of .32, which may also be significant, is found in the performance measure obtained after completion of obedience training (variable 16).

The motivation and cue response (time) measures both involve speed of escaping from the discrimination apparatus. It will be noted that the pattern of weights on all five factors is closely similar for these two variables. With reference to the present factor, it should be recalled that in both tests the animal receives food from the experimenter, whom he must approach specially for this purpose, since the experimenter does not stand near the exit of the apparatus. Relation to the human trainer thus appears to play a more important role in these tests than in those in which the animal obtains food impersonally from a dish.

In this connection it is also interesting to observe the negative weight on the third barrier problem. The first two barrier problems likewise have negative weights on this factor, although the weight is negligible for the first problem. It

TABLE 4. ROTATED ORTHOGONAL FACTOR MATRIX

Variable	Factor					h^2
	I	II	III	IV	V	
1. Habit Formation: Time	.10	−.04	.00	.73	.00	.56
2. Manipulation: Time	.20	.00	.41	.37	−.32	.45
3. Manipulation (String pulling): Time	.31	.00	.46	.46	−.13	.54
4. Maze (Second Barrier Test): Errors	−.34	.09	.00	.03	.47	.35
5. Motivation (Discrim. Appar.): Time	.01	.54	−.27	−.13	−.60	.74
6. Cue Response (Discrim. Appar.): Trials	.26	.09	−.31	.08	−.71	.68
7. Cue Response (Discrim. Appar.): Time	−.02	.53	−.20	−.04	−.50	.57
8. Leash Control (In): Trials	.05	.57	−.02	−.46	−.04	.54
9. Leash Control (Stairs): Trials	.46	.03	−.12	.00	.01	.23
10. Leash Control (In): Initial Errors	.07	.56	−.15	−.06	−.08	.35
11. Leash Control (Stairs): Initial Errors	.47	.40	−.23	−.02	.00	.43
12. Motor Skills: Time	.11	.02	−.01	.32	−.03	.12
13. First Barrier Test (First Problem): Errors	.47	−.03	−.17	.42	.02	.43
14. First Barrier Test (Second Problem): Errors	.39	−.24	−.20	.37	.29	.47
15. First Barrier Test (Third Problem): Errors	.31	−.45	−.28	.30	.04	.47
16. Obedience (Adjusted Stay Score): Time	−.44	.32	.06	.04	−.19	.34
17. Obedience: Jumps during Training	−.53	.54	.16	−.06	.03	.60
$\frac{\Sigma a^2}{n}$	.10	.12	.05	.10	.09	.46

will be recalled that in all three barrier problems, the animal must walk away from the food in order to circumvent the barrier. In the second problem he must walk farther than in the first; and in the third, which presents a U-shaped barrier, he must turn completely around and walk in the direction opposite to that of the food. Moreover, in all these problems, the experimenter sits by the food dish and is visible through the window in the screen. An animal which is unduly dependent upon the human trainer might thus be handicapped in these problems—and particularly on the third—since the correct solution requires that he begin by walking away from the visible experimenter. The less docile and more "socially independent" animal, on the other hand, tends to respond to the physical elements of the situation, with little or no regard for the position of the experimenter.

The only variables which meet our criterion for the interpretation of *Factor III* are:

3. Manipulation (String pulling): Time	.46
2. Manipulation: Time	.41

The factor may thus be named *manipulation*, in the sense of pawing, nosing, biting or pulling with the teeth. The measures listed above are the only variables which require such activities. To be sure, this factor is underdetermined, insofar as it has weights of .40 or more in only two variables. At the same time, the proposed interpretation of this factor is supported by the consistent pattern of low negative weights in variables involving the discrimination apparatus, leash control and the barrier problems. In all these tasks, any biting, nosing or pawing behavior would delay the animal, distract him from the correct solution, or might in some cases be counted directly as an error, as when the animal bites or fights the leash.

On *Factor IV*, the following variables have loadings of .40 or more:

1. Habit Formation: Time	.73
3. Manipulation (String pulling): Time	.46
13. First Barrier Test (First Problem): Errors	.42
8. Leash Control (In): Trials	−.46

Since all tests with high positive loadings on this factor require the use of vision in locating objects or in perceiving the relationships among objects, the factor may be identified as *visual observation*. In the habit formation test, the location of the food dish is changed from trial to trial, so that the animal must be guided by visual cues in order to reach the incentive. In the string-pulling test, the discovery of the string and its proper utilization to secure the food depend upon visual observation. It will be noted that the other manipulation test (variable 2) also has an appreciable positive weight of .37 on this factor. Similarly, all three problems of the first barrier test require the correct visual perception of the spatial relations between barrier and goal. The first of these problems has a weight of .43 on this factor. The second and third have weights of .37 and .30, respectively. Although the three successive problems are of increasing difficulty, it is possible that the benefit to be derived from visual observation is greatest in the initial problem, when the animal must first discover the Umweg type of solution to be followed.

It should also be noted that the motor skills test has a loading of .32 on this factor. Although this is not a high weight, it is the highest loading of this test with any factor, all other loadings being virtually negligible. In this test, too, the dog must correctly observe the relation of ramp to food dish. And he must inhibit any tendency to try to reach the food by jumping directly from the ground to the stacked boxes, rather than by climbing the ramp. In this respect the motor skills test might be said to require that the animal visually recognize an Umweg-type solution.

The negative weight of Factor IV in the single measure of leash control (variable 8) suggests the possibility that the more visually observant animal is more likely to be distracted and hence drag, pull, or make similar errors. Visual distractions of interest to the dog would probably occur more often in the outdoor course followed in variable 8 than in stair-climbing (variables 9 and 11). Similarly, such distractions would not be likely to operate on the first day of leash training (variable 10), since the animal's attention would then be more completely absorbed by the novelty of the leash itself.

The variables to be considered in the interpretation of *Factor V* include:

4. Maze (Second Barrier Test): Errors	.47
7. Cue Response (Discrimination Apparatus): Time	–.50
5. Motivation (Discrimination Apparatus): Time	–.60
6. Cue Response (Discrimination Apparatus): Trials	–.71

The animal which performs well on the maze is probably one who has good positional memory for the correct turns. Conversely, the tendency to take the same path on successive trials is a handicap on all three variables based on the discrimination apparatus, since the correct escape route is varied in random order from trial to trial. It would thus seem that Factor V represents *persistence of positional habits.*

Breed Differences.—It should be borne in mind that some of the factors which have been identified may correspond to characteristic differences among the breeds included in the present sample. Previously published studies on many of the same dogs employed in the current investigation provide evidence of significant physiological differences among these breeds (Fuller, 1951). Observations of the general behavior of the dogs have likewise suggested breed differences in such traits as timidity, attraction to human handlers and activity level (Scott & Charles, 1953). Analyses of breed differences have also been carried out on four of the tests included in the present study, viz., Maze (Scott & Charles, 1953), Motivation (Fuller, 1953), Cue Response (Fuller & Scott, 1954) and Leash Control (Fuller & Scott, 1954). In all of these variables, one or more significant differences between breeds were found.

The number of cases available for these analyses was small, especially in certain breeds. In the current study, some of these numbers were further reduced by the necessity of retaining only animals with complete records on all 17 variables. Nevertheless, it may be of interest to examine the results on breed differences in the present group. The relevant data are summarized in Tables 5 and 6, covering continuous and dichotomized variables, respectively. In Table 5, the results are reported in the form of median scaled scores for each breed. It will be recalled that the unit employed in these scaled scores is .5SD. Table 6 gives the median raw score, as well as the number of cases passing and the number failing each test.

Reference to Tables 5 and 6 suggests that the **Basenjis** tend to excel in tasks requiring independent action and visual observation of relations, such as habit formation, manipulation, string pulling, the three barrier problems and the maze. They are especially deficient in tasks which depend upon responsiveness to the human handler, such as leash control and obedience training. And they also do poorly on the discrimination apparatus tests. It is interesting to note that the inferiority of the Basenjis on some of these tests is so pronounced that there is no overlapping with the distributions of high-ranking breeds. This is true of Basenji-versus-Beagle in the motivation test (variable 5), and of Basenji-versus-Wire-haired Fox Terrier in leash control (variable 8). Thus in these two variables the best

TABLE 5. MEDIAN SCALED SCORES FOR EACH BREED: CONTINUOUS VARIABLES*

Variable	Bas.	Bea.	CS	SS	WHT	Bas. X CS
1. Habit Formation: Time	5	4	4	2	4	5
2. Manipulation: Time	6	4.5	4	5	5	4
4. Maze (Second Barrier Test): Errors	5	6	5	3	2	4
5. Motivation (Discrim. Appar.): Time	3	7	5	5	6	4
7. Cue Response (Discrim. Appar.): Time	3	7.5	5	4	5	4
8. Leash Control (In): Trials	2	6	5	6	5	4
9. Leash Control (Stairs): Trials	5	7	2.5	5	5	4
10. Leash Control (In): Initial Errors	4	5.5	6	2	6	4
11. Leash Control (Stairs): Initial Errors	4	6.5	4	4	6	6
12. Motor Skills: Time	4	4	5	3	3	6
13. First Barrier Test (First Problem): Errors	5	6.5	3	4	6	5
14. First Barrier Test (Second Problem): Errors	7	3.5	4	2	5	5
15. First Barrier Test (Third Problem): Errors	5.5	4.5	3	5	4	5
16. Obedience (Adjusted Stay Score): Time	3	4.5	5	6	5	4
17. Obedience: Jumps during Training	4	5	6.5	2	4	4
Number of Cases	16	4	18	5	7	23

* High scores signify better performance. All scores are scaled to an over-all M of 4.5 and σ of 2.

Basenji score falls at least .5SD below the poorest Beagle or Terrier score, respectively.

Since there were only 4 Beagles in the group, it is especially hazardous to make any statements about their performance. The exceptionally high achievement level of these dogs on several of the tests, however, is very striking. This is particularly evident in the three discrimination apparatus tests and in leash control. The Cocker Spaniels excel in obedience training and leash control, but not in stair climbing, which yields their poorest score. They are also poor in cue response (trials), which requires the establishment of an association between visuo-auditory cue and open exit; but they do relatively well on the other two discrimination apparatus tests. In string pulling, they exhibit the poorest performance in the group; and they are also below average in the manipulation test. Any conclusions about the Shetland Sheep

TABLE 6. ANALYSIS OF BREED DIFFERENCES IN DICHOTOMIZED VARIABLES

Variable	Bas.	Bea.	CS	SS	WHT	Bas. X CS
3. Manipulation (String Pulling)						
No. failing	2	1	9	2	3	4
No. passing	14	3	9	3	4	19
Median* time in seconds	124	276	477†	199	430	262
6. Cue Response (Discrim. Appar.): Trials						
No. failing	5	0	7	1	0	5
No. passing	11	4	11	4	7	18
Median* No. of Trials	113	27	116	30	48	84
Number of Cases	16	4	18	5	7	23

* The failures were included in the computations of these medians. The higher the raw scores, the poorer the performance.

† This median falls midway between a bona fide score and a failure, which was automatically recorded as 480.

Dogs must be very tentative because of the small number of cases. The outstanding finding regarding this breed seems to be its relatively poor performance on many variables.

The **Wire-haired Fox Terriers** achieve their best scores on tests which seem to call for confidence in strange situations. These are illustrated by the motivation test (which represents the animal's first contact with the discrimination apparatus), initial errors in both leash control and stair climbing, and the first barrier problem. They also do well in other tests involving the discrimination apparatus. On the other hand, they do particularly poorly on the maze, where it is reported that they become over-excited and make many errors (Scott & Charles, 1953). Little can be concluded regarding the **Basenji-Cocker Spaniel** crosses beyond the fact that they are close to the total group mean on most measures.

A sharper delineation of breed differences in behavior characteristics might be obtained through the application of obverse factor analysis or Q-technique. For this purpose, it would be desirable to have scores on a more extensive set of variables, or at least more part-scores resulting from further breakdowns of the present variables. Eventually it would be advisable to carry out factor analyses similar to that reported in the present study on each breed separately. This would, of course, require a much larger sampling of each breed than is now available.

Summary and Conclusions

The scores of 73 pedigreed dogs on 17 variables, most of which were designed as measures of learning, were submitted to a multiple factor analysis. The dogs included males and females of the following breeds: Basenji, Beagle, Cocker Spaniel, Shetland Sheep Dog, Wire-haired Fox Terrier and Basenji-Cocker Spaniel crosses. A centroid analysis of the intercorrelations among the 17 variables yielded five factors. Following orthogonal rotation of reference axes, the factors were interpreted as: activity and impulsiveness, docility or responsiveness to a human trainer, manipulation, visual observation, and persistence of positional habits. It is pointed out that one or more of these factors may reflect breed differences within the population investigated. An obverse factor analysis would further clarify breed differences. If data should eventually become available on sufficiently large numbers within each breed, separate factorial analyses for each breed would be desirable.

Some of the present findings indicate that tasks which may appear quite similar to the human experimenter often involve dissimilar factors for the animal. Moreover, the factorial composition of the same task may vary considerably at different stages of training, a fact which was suggested by the earlier results of Wherry (1939, 1940, 1941) on rats.

Another outstanding finding pertains to the predominance of bipolar factors. This, too, corroborates earlier factor analyses of animal behavior, and sharply contrasts with typical results on human abilities. In the present study, negative factor loadings are common and appear to be psychologically meaningful in terms of the proposed interpretation of the factors. Such a finding is probably related to the obvious intertwining of cognitive with emotional and motivational factors in animal behavior. On most of the learning tasks employed in the present study, the dogs' performance reflected emotional and motivational factors as much as, or more than, it reflected ability factors. As in the case of other factor analyses of animal behavior, the present findings thus suggest that the distinction between cognitive and noncognitive aspects of behavior is not so sharply drawn in animals as in humans (cf. Anastasi, 1948). To what extent such a trait differentiation is the product of cultural influences in the human has not been determined. It is hoped that it will eventually prove feasible to conduct longitudinal studies on animals, whose object will be to alter the subjects' trait organization by controlled experiences. Such an approach should provide the answers to many questions regarding the nature and organization of psychological traits.

Bibliography

Anastasi, Anne

1948. The Nature of Psychological "Traits." Psychol. Rev., 55: 127-138.

1954. Psychological Testing. N. Y.: Macmillan.

Anastasi, Anne, & J. P. Foley, Jr.

1949. Differential Psychology (2nd ed.). N. Y.: Macmillan.

Billingslea, F. Y.

1942. Intercorrelational Analysis of Certain Behavior Salients in the Rat. J. comp. Psychol., 34: 203-211.

Cattell, R. B.

1952. Factor Analysis: An Introduction and Manual for the Psychologist and Social Scientist. N. Y.: Harper.

Dunlap, J. W.

1933. The Organization of Learning and Other Traits in Chickens. Comp. Psychol. Monogr., 9, no. 4.

FRUCHTER, B.

1954. Introduction to Factor Analysis. N. Y.: Van Nostrand.

FULLER, J. L.

1951. Genetic Variability in Some Physiological Constants of Dogs. Amer. J. Physiol., 166: 20-24.

1953. Cross-Sectional and Longitudinal Studies of Adjustive Behavior in Dogs. Ann. N. Y. Acad. Sci., 56: 214-224.

FULLER, J. L., & J. P. SCOTT

1954. Heredity and Learning Ability in Infrahuman Mammals. Eugen. Quart., 1: 29-43.

GEIER, F. M., M. LEVIN & E. C. TOLMAN

1941. Individual Differences in Emotionality, Hypothesis Formation, Vicarious Trial and Error, and Visual Discrimination Learning in Rats. Comp. Psychol. Monogr., 17, no. 3.

HOLZINGER, K. J., & H. H. HARMAN

1941. Factor Analysis: A Synthesis of Factorial Methods. Chicago: Univer. Chicago Press.

MCCULLOCH, T. L.

1935. A Study of the Cognitive Abilities of the White Rat with Special Reference to Spearman's Theory of Two Factors. Duke Univer. Contrib. Psychol. Theory, 1, no. 2.

MCNEMAR, Q.

1942. On the Number of Factors. Psychometrika, 7: 9-18.

RETHLINGSHAFER, DOROTHY

1941. The Learning of a Visual Discrimination Problem Under Varying Motivating Conditions. J. comp. Psychol., 32: 583-591.

ROYCE, J. R.

1950a. The Factorial Analysis of Animal Behavior. Psychol. Bull., 47: 235-259.

1950b. A Factorial Study of Emotionality in the Dog. Amer. Psychologist, 5: 263. (Abstract)

1951. A Factorial Study of Emotionality in the Dog. Unpubl. doctor's dissert., Univer. Chicago.

SCHMITT, J. R.

1954. A Factor Analysis of Learning in the Dog. Unpubl. master's dissert., Fordham Univer.

SCOTT, J. P., & MARGARET S. CHARLES

1953. Some Problems of Heredity and Social Behavior. J. gen. Psychol., 48: 209-230.

SCOTT, J. P. & J. L. FULLER

1951. Research on Genetics and Social Behavior at the Roscoe B. Jackson Memorial Laboratory, 1946-1951—A Progress Report. J. Hered., 42: 191-197.

SCOTT, J. P. & J. L. FULLER, (EDS.)

1950. Manual of Dog Testing Techniques. Bar Harbor, Maine: Roscoe B. Jackson Memorial Laboratory. (Mimeographed)

SEARLE, L. V.

1947. Application of the "Inverted" Factor Analysis Technique to the Study of Hereditary Behavior Types in Rats. Amer. Psychologist, 2: 320.

1949. The Organization of Hereditary Maze-Brightness and Maze-Dullness. Genet. Psychol. Monogr., 39: 279-325.

THOMSON, G. H.

1951. The Factorial Analysis of Human Ability (5th ed.). Boston: Houghton Mifflin.

THORNDIKE, R. L.

1935. Organization of Behavior in the Albino Rat. Genet. Psychol. Monogr., 17: 1-70.

THURSTONE, L. L.

1947. Multiple Factor Analysis. Chicago: Univer. Chicago Press.

1948. Psychological Implications of Factor Analysis. Amer. Psychologist, 3: 402-408.

VAN STEENBERG, N. J.

1939. Factors in the Learning Behavior of the Albino Rat. Psychometrika, 4: 179-200.

VAUGHN, C. L.

1937. Factors in Rat Learning. An Analysis of the Intercorrelations between 34 Variables. Comp. Psychol. Monogr., 14, no. 3.

WHERRY, R. J.

1939. Factorial Analysis of Learning Dynamics in Animals. J. comp. Psychol., 28: 263-272.

1940. A Test by Factorial Analysis of Honzik's Exteroceptive Data. J. comp. Psychol., 29: 75-95.

1941. Determination of the Specific Components of Maze Ability for Tryon's Bright and Dull Rats by Means of Factorial Analysis. J. comp. Psychol., 32: 237-252.