THE RELIABILITY OF THE MAZE AS A METHOD FOR TESTING LEARNING ABILITY.

by

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THE RELIABILITY OF THE MAZE AS A METHOD FOR TESTING LEARNING ABILITY.

INTRODUCTION.

An experiment to study the reliability of the maze as a test of learning ability was begun January 4, 1917, by Donald G. Paterson, instructor in the department of psychology in the University of Kansas. The exigency of war caused him to bring his experimental work to a close with the problem unsolved in June, 1917. He later indicated that he did not desire to continue this study and made his records available to anyone who should care to complete it. The present experimental work covered a period from October 1, 1919 until June 21, 1920.

The problem was suggested to me by Professor Walter S. Hunter to whom I am very grateful both for the problem itself and for his patience in criticising the experimental procedure and the preparation of this thesis. I also desire to express my thanks to Mr. Paterson for his generosity and for the twenty-nine records which I found suitable for my use.

The purpose of this experiment was to make a thorough study of the maze as a test of learning ability. The importance of such an investigation is obvious. Of all the apparatus used in comparative psychology the maze has been adapted to the solution of by far the greatest number of problems. Its reliability as an adequate measure has apparently been accepted without question. Such problems as the effect of age, drugs, decreased brain weight, etc. upon learning ability certainly rest upon a very unsound scientific foundation until the reliability of the test is established. In fact every problem whose explanation has been given in reference to the maze, loses some of its significance upon this consideration.

The white rat has commonly been the subject in experiments referred to above, because of his small size and well known ability to thread his way without error through a maze in a relatively short time. Any conclusions drawn from the data reported in this paper are applicable only to the white rat, but the implicationsof such conclusions will affect all experiments in which this animal acted as subject.

In the final analysis, then, the problem resolves itself into the examination of a situation, namely, the rat in the maze. The reliability of this situation, as a source of data from which to draw conclusions, has been approached through a study of the consistency of the rat's behavior in the maze. It is assumed, that if under the same conditions the results vary essentially from time to time in this test, the method cannot be considered reliable.

A careful study of the data discloses the extensive nature of the problem of reliability. The lack of time during the present year forbids a thorough investigation of the many angles of this fundamental question. All that can be done here, therefore, is to attempt a solution of some of the more obvious phases, and to point the way to the more subtle and theoretical implications involved.

This paper is divided into four sections. The problems treated in the first two sections, "An Adequate Criterion of Learning in the Maze" and "The Relative Value of Different Learning Curves", respectively, are not new, but have already interested several inves-

tigators. They are included here because the data are at hand, and because they have a direct bearing on the treatment of the calculations with regard to the central problem of the paper, namely, the reliability of the maze, which comprises Section III.

An historical division has been omitted because no studies have been made of the problem of the reliability of the apparatus used in Animal Behavior. Certain references, however, which have a direct bearing upon the other problems presented and thus indirectly upon the question of reliability will be inserted in the sections devoted to those topics.

SUBJECTS.

The subjects used in this experiment were 104 white rats (29 of these were the rats used by Paterson), raised from the laboratory stock. The rats were divided into three groups upon the basis of the method by which they were used.

GROUP I.

Litter	Numbers	Sex		
1	1-9	5M	4F	These rats were 30 days old when they were started in training and 88 days old when they finished.
	29 Paterson rats.			

GROUP II.

Litter	Numbers	Sex		
1	10-18		9F	These rats were 30 days old at the beginning of training. They finished at irregular intervals but the oldest was 63 days at the close of training.
2	19-25	5M	2F	
3	39-42	1M	3F	
4	46-52	3M	4F	
5	53-56		4F	
6	57-59		3F	
7	60-62	1M	2F	

GROUP III.

1	26-30	5M		These rats were 30 days old at the beginning of training. They were 124 days old at the close of training.
2	31-35	2M	3F	
3	36-38	1M	2F	
4	63-66		4F	
5	67-75	1M	8F	

The experimenter took complete care of the rats during the course of the experiment. The customary bread and milk was the principal food, but their diet was sometimes varied with sunflower seeds, carrots, and other green vegetables. The health of all the rats, in general, was excellent. Only 7 rats,

numbers 10, 12, 17, 18, 39, 40, and 41 died before the experiment was finished. The living cages were kept thoroughly cleaned and fresh drinking water was placed in them daily.

APPARATUS

The apparatus used was the Watson circular maze with the camera lucida attachment. This was the same piece of apparatus used by Paterson in securing the records used in the present paper. The end stops were placed in the alleys so that the error made in running past the door was equal to the error of retracing on the true path back to the end stop. The length of the true path was 219 inches which was reduced to one-ninth that length by the camera lucida. A twenty-five foot straightaway with a food box at one end was used in preliminary and intermittent training, as indicated in the section on method. A chartometer was used for measuring the tracings of the distance traveled by the rat. A ground-plan of the maze, showing the true path, is presented in Fig. I.

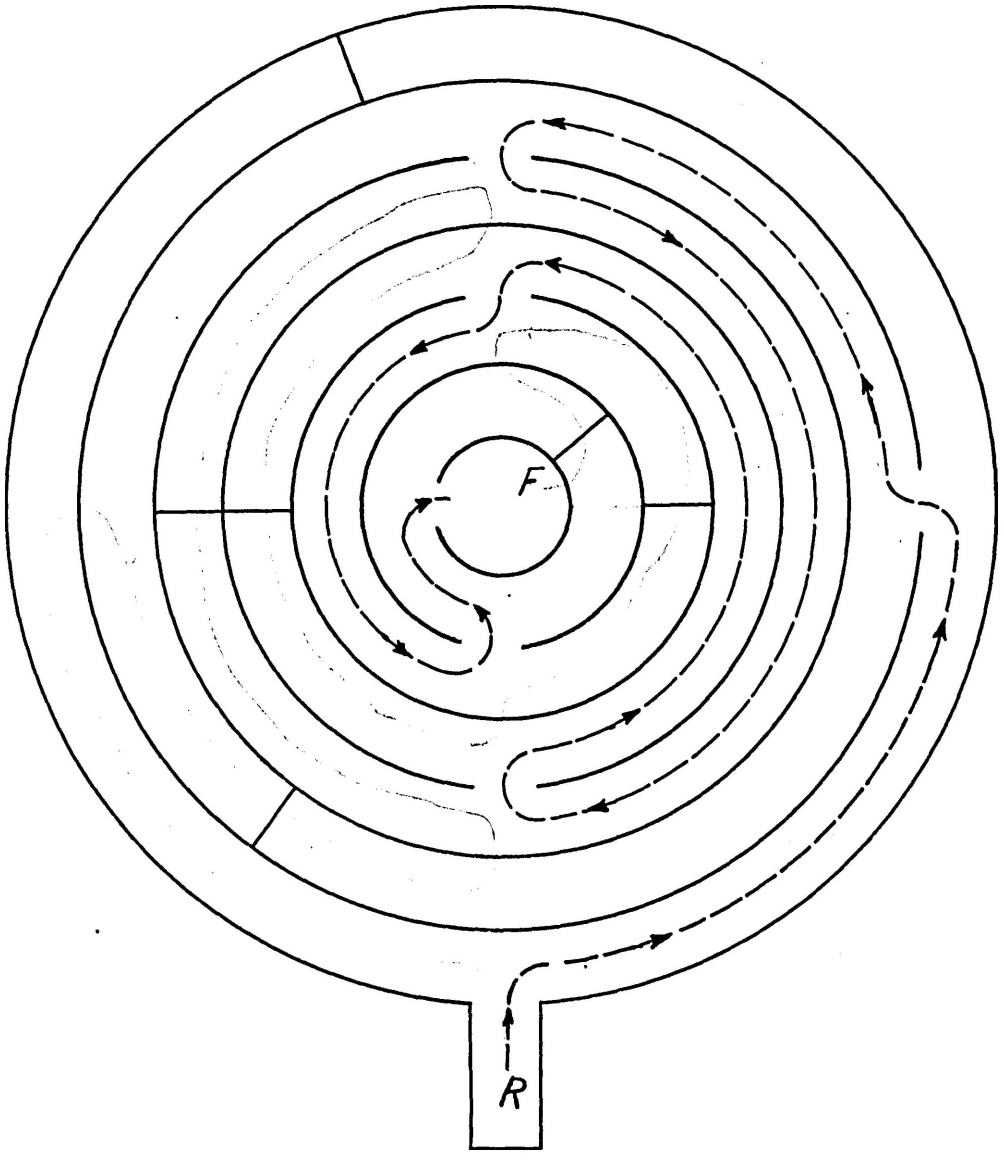

Fig. II.

Ground plan of Maze showing true path.

R is release box.

F is feed box.

METHOD

The problem was approached from three different angles and the method varied slightly to meet the need of each. The Paterson records were first carefully studied and an attempt was made in the first division of the experimental work to approximate as nearly as possible the method used in securing them. This method was as follows :

The rats of group I were taken on the day they were a month old and run down the straightaway for one trial per day for five consecutive days. Previous to this time the rats had been handled and fed on a chair for several days. The animals were perfectly tame and at no time during the experiment was there any difficulty because of the timidity of the subjects, except for an infrequent fright in the case of an individual due to some unusual event. The first day in the straightway the rats found the food box only after many random movements. They were allowed to eat for a short time and then returned to their cage. After the first day the rats improved rapidly and went, as a rule, immediately to the food box,

remaining there until removed from the straightaway.

On the sixth day each rat was placed in the maze for one trial, and likewise for the five succeeding days so that six trials were completed. On the seventh day the rats were no longer placed in the maze, but were again run down the straightaway one trial daily. This was continued for sixty days in order to keep the animals tame and give them exercise. The rats were again placed in the maze on the sixty-first day and given one trial per day for six days, thus completing a second series of six trials in the maze. These rats, from the divisions of their training, are referred to as the 6-60-6 rats.

The general method used with these rats, as with the Paterson rats, was to allow them to remain in the maze for a maximum of fifteen minutes, unless they arrived at the food box in a shorter time. If they had not reached the center of the apparatus at the close of this fifteen minute period, they were taken out and the attempt counted on a trial. However, after further study of the data, so gathered, I found it impossible to evaluate the records in

which all the trials were not complete. Since, also in any attempt to standardize a learning test the diversity of the sampling is of great importance, it was unsatisfactory to shorten the poorer records thereby getting a more or less selected group. Therefore, all of the Paterson records and those of my own which contained any uncompleted trials were excluded, and during the further progress of the experiment the animal was left in the maze until it found its way to the food box, when a complete trial could be counted. The rats were allowed to find their way through the maze without help of any kind from the experimenter who merely recorded the data.

Three types of records were taken. Gross time was registered with a stop watch to one-half of a second. The time was counted from the release of the rat at the entrance box until it entered the food box at the center of the maze. Static time was measured on a cumulative watch. The experimenter attempted to count all time as static in which the rat was not actually making progress. The distance traveled by the rat was recorded with the camera lucida attachment

and measured with the chartometer. The distance records were not, however, transferred into actual distance because no change would result in the relative standing of the animals and the smaller numbers were more convenient in calculations.

The second part of the experiment consisted in training the animals for total learning as a control series. The method employed with Group II was exactly as described above for Group I with the exception that after the preliminary five trials down the straightaway, the rats were still run one trial per day in the maze until learning was complete. The criterion of mastery was three successive perfect trials. A trial was considered perfect in which no excess distance was traversed. Time as a criterion did not enter into the determination of a perfect trial.

The completion of the 6-60-6 group (I) disclosed the fact that the maze did not present a new problem to the rat on the first trial after the sixty day interval, so the method was varied somewhat with the third group of rats. These animals were taken as the others on the day on which they were a month old, but were run down the straightaway for one trial for four-

teen consecutive days. This change from five to fourteen days in the straightaway was made in order to insure that the timidity of the rats should be entirely eliminated. This extra precaution was taken because, since the rats were to be given only three trials in the maze, any disturbances which might result from an imperfect elimination of this factor would be greater in proportion for the three trials than for the six. The first of the series of three trials was given on the fifteenth day, and one trial per day on the two succeeding days. These rats were then kept without training of any kind for 46 days. It was thought that the long training down the straightaway might have influenced the second set of six trials with the 6-60-6 rats. Since the maze and the straightaway are somewhat similar situations the transfer of the effects of training for sixty days might be rather large. This reduction of training in the straightaway would also make the two series of trials in the maze more comparable. During the period of non-training the rats were kept tame by being handled and fed on a chair. On the forty-

seventh day the rats were again put in the straightaway for one trial and likewise on the thirteen succeeding days. After the second set of fourteen trials in the straightaway, they were run on the three following days for one trial each in the maze. These records are designated as 3-60-3 records.

In all cases bread and milk was used in the center of the maze, and the rat was allowed to eat there for a few seconds but was not allowed to retrace his path. Upon being removed from the maze the rat was fed a certain portion on a chair but no food was placed in the cages.

CRITERION
AN ADEQUATE OF LEARNING IN EXPERIMENTS WITH THE MAZE.

As has been indicated in the section on method, two groups of rats were given only partial learning in the maze. In order to evaluate these records, it was necessary to determine what relationship this partial learning has to total learning. Incidentally I have also secured data on the general questions of an adequate criterion for maze learning. This has been a problem for psychology ever since the maze has been used in learning experiments. Since it is generally conceded that the learning of the maze is not complete until its pathways can be threaded without error, one or more errorless trials has customarily been used as the sign of completed learning.

Hubbert used six successive perfect runs as an adequate criterion in her work on the relation of time and distance in learning[1]. In a later experiment, however, to determine the effects of age upon habit formation, she reduced this criterion to three

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1. Hubbert, Helen B. Time versus Distance in Learning.. Jr. An. Behav. 1914, vol 4 page 60.

successive perfect trials[2], and others have also used this standard, for after a rat has completed three perfect trials, it rarely fails to succeed on the second three. Three perfect trials are sufficient to eliminate the possibility of a rat's succeeding by chance alone, for it is not within the limits of probability that an animal should have the good fortune to make every turn correctly on three successive days. Chance might operate to keep him from entering one or two blind alleys, after the maze is partially learned, and thus enable him to make one perfect trial. Using three perfect trials in succession eliminates such a contingency.

Lashley[3], working with the data of 94 white rats, trained to determine the effects of drugs on learning, compared the standing of these rats, (divided into ten groups, according to the drug administered), when tested by the criterion of one per-

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2. The effects of Age upon Habit Formation Behav. Mon. 1915, vol 2, No. 6.

3. Lashley, K.S. The Criterion of Learning in Experiments with the Maze. Jr. An. Behav. 1917, vol.7, pp. 66-70.

fect trial and by the more difficult criterion of three successive perfect trials. He concluded that "there is no advantage, for the reliability of results, in prolonged training where the problem is that of the statistical comparison of different groups of animals by a single standard of achievement."

Lashley's results, as he himself states, are not strictly comparable because of the different drugs administered to different groups, differences in the ages of the rats, the possible effect of seasonal differences, etc. These factors would appear to lower the correlation; but whether they decrease it or increase it they render uncertain any conclusions which might be drawn from it.

With the twenty-four rats, whose records are used for the calculations in the present section, an attempt was made, to control all the extraneous factors which Lashley left uncontrolled and which might influenced the correlation coefficient. The rats were exactly the same age at the time of training. They were all fed alike and, objectively at least, their living conditions were normal. Theywere trained in

approximately the same season of the year; the train-period lasted from October 24, 1919 to March 30, 1920. The rats were, of course, given no drugs of any kind.

Correlations were made to determine whether or not the standing of the individual rats in time, trial, and distance records, using three perfect trials as the criterion of learning, were related to their standings when a less difficult standard was used. Lashley based hisconclusions on a single correlation between the number of trials preceding the first errorless run with the number preceding "perfect learning" for all the animals. His conclusions were as follows: "The former varied from 10 to 75 with the mean at 23.8 ± .977, the latter from 10 to 150 with the mean at 47.3 ± .299; the correlation in the variations of the two is 0.632± 0.061. The coefficient of regression of the variations in trials preceding the first errorless run over those preceding "perfect learning" is 1.304, that of variations in "perfect learning" over first trial is .306." Lashley's computations are repeated here (Table I) and in addition correlations using time and distance have been made. (Tables II-IV)

The Spearman Foot-rule, $R = 1 - \frac{6\Sigma g}{n^2-1}$, was the formula used by me in making the correlations. This formula is concerned with the relative standing of a single individual in two different series of measurements. Using this data a number of Pearson coefficients were also calculated and compared with the results obtained by using the rank method with the same data and translated into the values for the Pearson coefficient according to the table in Rugg.[4] In every case the results were exactly the same which indicates that this data falls into a rectangular distribution, making it valid, therefore, to use the formula of conversion, $r = 2 \cos.\frac{\pi}{3}(1-R) - 1$. The results of the Spearman formula are converted into the Pearson coefficient. The probable errors are computed, separately for each method of correlation, according to the formula applying to that method. For the rank method P.E. $= \cdot\frac{43}{\sqrt{N}}$; for the Pearson formula P.E. $= .6745\ \frac{1-r^2}{\sqrt{N}}$. The results of these calculations are shown in the following tables.

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4. Rugg, H.O. Statistical Measurements, p 405. Riverside Text in Education, Houghbon-Mifflin-Chicago.

Table I.

TRIALS.

		R	r
Total trials including 3 successive perfect trials.	Total trials including 1 perfect trial	P.E. = .081 .578	.81 ± .045
"	Total trials including 2 perfect trials in succession	.754	.935 ± .0169
"	Total trials including 2 perfect trials regardless of position	.734	.923 ± .0203

Table II.

DISTANCE.

Total distance including 3 successive perfect trials.	Total distance including 1 perfect trial	.755	.935 ± .0169
"	Total distance including 2 successive perfect trials	.88	.984 ± .0042
"	Total distance including 2 perfect trials regardless of position	.765	.939 ± .0168

Table II (cont.)

		R P.E.=.081	r
Total distance including 3 successive perfect trials.	Total distance for first six trials	.578	.81 ± .045
"	Total distance for first three trials	.40	.618 ± .083
"	Total distance for first two trials	.296	.482 ± .043
"	Total distance including three perfect trials regardless of position.	.954	.997 ± .0022
"	Total distance for third trial	.40	.618 ± .0834
"	Total distance for second trial	.07	.124 ± .1252
"	Total distance for first trial	.291	.472 ± .1048

Table III.

GROSS TIME.

Total gross time including 3 successive perfect trials.	Total gross time including 1 perfect trial	.927	.994 ± .00214

Table III (con't)

		R P.E.=.081	r
Total gross time including 3 successive perfect trials	Total gross time including two perfect trials in succession	.959	.998 ± .0012
"	Total gross time first six trials	.781	.947 ± .013
"	Total gross time first three trials	.729	.921 ± .0204
"	Total gross time for first trial	.197	.336 ± .119
"	Total gross time for first two trials	.61	.836 ± .041
"	Total gross time for two perfect trials not successive	.948	.996 ± .00214
"	Total gross time for second trial	.55	.782 ± .0501
"	Total gross time for three perfect trials not successive	.967	.998 ± .0021
"	Total gross time for third trial	.599	.827 ± .0426

Table IV.
NET TIME.

		R P.E. = .081	r
Total net time including three successive perfect trials	Total net time including 1 perfect trial	.918	.992 ± .00215
"	Total net time including 2 perfect trials in succession	.937	.995 ± .00122
"	Total net time first six trials	.792	.952 ± .0126
"	Total net time first 3 trials	.70	.902 ± .031
"	Total net time first trial	.207	.352 ± .1182
"	Total net time first 2 trials	.593	.819 ± .044
"	Total time including 2 perfect trials regardless of position	.948	.997 ± .00121
"	Total net time including 3 perfect trials regardless of position	.949	.998 ± .0012

Table IV (cont.)

		R P.E.=.081	r
Total net time including 3 successive perfect trials	Total net time for second trial	.42	.642 ± .0792
"	Total net time for third trial	.48	.711 ± .0677

The correlation coefficient obtained by correlating the total number of trials required for perfect learning with the total number of trials including the first perfect trial as shown in Table I is .81 ±.045 (twenty times the P.E.),so it may be concluded that if the number of trials is to be used as the basis for a judgment of a rat's or a group of rats' standing with regard to other rats or groups of rats in ability to learn the maze, it is valid to use the number of trials preceding one perfect trial rather than the number preceding three successive perfect trials to indicate its standing. The coefficient of regression of the number of trials including the first perfect trial over those including total learning is 1.13 which means that in a group of animals the total

number of trials required for perfect learning may be computed by multiplying the number of trials including one perfect trial by 1.13.

Total time and total distance may be used as criteria of the animal's ability to learn the maze as well as the number of trials. Correlations have been made with these measures, therefore, to determine at what point in the learning process a sufficient indication is made of the rat's final standing. It will be seen by reference to Tables III, IV, and V that two successive perfect trials , two perfect trials regardless of position, and one perfect trial, when time and distance are used, are almost as good as three perfect trials in succession, the correlations being .984 ± .004, .939 ± .016, .935± .016, respectively for distance, and .998 ± .001, .996 ± .002, and .994 ± .002, respectively, for gross time. In the next section, a comparison will be made between trials, distance, and time, as to their relative value as measures of the rat's maze ability.

If it is possible, to use either time or distance as the reliable measure of the rat's ability in

the maze, the relative standing of the animal is largely determined long before a perfect trial is made as indicated by the other correlations found in Tables III, IV, and V. Two trials are adequate if time is to be the criterion used. In the case of net time the correlation between "perfect learning" and total time for two trials is .819 ± .044. This correlation value for gross time is .836 ± .041. If the criteria of learning is to be the amount of distance traversed it seems necessary to run the rats for six trials, which gives a correlation of .81 ± .045 with total distance, a coefficient equivalent in size to the time correlations for the first two trials. Total distance for the first two trials with total distance gives a very poor indication, since the correlation is only .482 ± .104. No single trial in the first three trials for either time or distance is sufficient by itself.

It is valid, therefore, to conclude that where an experimenter wishes to draw general conclusions from his data and to have a reliable indication of the rat's standing in both time and dis-

tance that it is sufficient to run the rat in the maze one trial per day for six days. His results would then not be different in kind from those secured if he used three perfect trials as the criterion of learning. If he is using a fairly large number of animals and finds a given difference between two groups as measured by the average amount of time or distance required to complete six trials, then he may calculate the difference in the amount of time or distance required for learning, (including three perfect trials in succession), by means of the coefficient of regression. This coefficient for gross time required for six trials over that required for perfect learning is 1.09, for net time it is 1.18 and for distance 1.43.

If six trials had been used to determine the standings of the rats in the present experiment, it would have resulted in saving 10,780 seconds in the actual running time of the rats besides the time required to feed and care for them. If the rats had been run to one perfect trial, only 1,707 seconds of running time would have been saved. Thus, there would

be a large amount of time saved, if the experimenter could use only six trials instead of running the rats to "perfect learning". At the present time it is almost impossible for one person to perform experiments which require a large number of rats within a reasonable length of time. In all experiments in which such extraneous as differences in age, sex, brain weight, etc. are already present at the beginning of the experiment it is reliable to use the shorter criterion which will result in the saving of considerable time. If, however, extraneous factors such as drugs are introduced after the experiment has commenced, it may be necessary to run the rats to perfect learning if no effects are found within the six day period because the drugs might not as yet had time to produce their effect. If the effects are obtained in the six trials no further training would be necessary. Since, in this experiment no such factors were introduced, the results which are found for the rats in partial learning will apply equally well to total learning records. However, there are three possible criteria which may be used as the measure of the learn-

ing. It is, therefore, necessary to determine which is the most reliable as a criterion of the rat's ability. This is done is Section II.

SECTION II.

THE RELATIVE VALUE OF DIFFERENT CURVES OF LEARNING.

Whether time, distance, errors, or numbers of trials shall be considered the best criterion of learning ability has been commented upon by various investigators and made the subject of two specific investigations. Yerkes, in compiling his data on the behavior of the dancing mouse in the maze, dispensed with the time records because he considers that the elimination of errors is the final test of learning. While time includes this elimination, it also includes such activities of the animal as washing its face, nosing around, etc., which should not be termed errors, for they have no direct connection with learning. He says, "whenever it is possible (and the experimenter can always plan his tests so that it shall be possible), the number of errors should be given first importance and the time of the test second place".[5]

Watson,[6] on the other hand, in his discussion

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5. Yerkes, R.M. The Dancing Mouse. New York, 1907, pp. 217-18.
6. Watson, J.B. Behavior, An Introduction to Comparative Psychology. pp. 243 and 244.

of motor habits in general, says "time is the best single criterion of motor habits", and "distance traversed, where it can be measured accurately is probably the next best criterion." He states later, however, that the "mastery of the problem regardless of the time cannot be said to have been attained until there is no excess distance," which would seem to imply that for Watson also the elimination of excess distance is the final test of learning.

Hicks[7] used the records of seventeen white rats trained in the Hampton Court maze with a "total of 591 trials," for the study of this specific problem. She recorded the learning progress in two ways, first, by taking the total amount of time consumed (eliminating the nosing around period at the entrance box) in running from the entrance to the food box, and, second, by counting the errors. Errors were defined as follows:

"1st. Errors shall include all total and partial returns as well as entrances into the blind alleys.

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7. Hicks, V.C. The Relative Values of Different Curves of Learning. Jr. An. Behav. 1911, vol. I, No. 2.

2nd. A runway, viz., the distance between two corners, was taken as the unit of error."

After a careful study of this data she came to the following conclusions: First, time is the best single criterion for an adequate representation of all the features of the learning process, because time represents all four of the following factors and distance but one:

1st. Elimination of errors.

2nd. The inhibition or elimination of the natural tendencies of timidity and curiosity in new situations.

3rd. The association between the food and the maze.

4th. Increased speed of running.

Second, the distance and error criteria are fundamentally alike, for both represent the factor of distance elimination. Third, a combination curve constructed from the time and error data is probably the most satisfactory if the errors can be properly evaluated.

Hubbert[8] concluded from the records of twenty-

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8. Hubbert, Helen. Time versus Distance in Learning. Jr. An. Behav. 1914, vol 4, p 60.

seven white rats used in a Watson circular maze with the camera lucida attachment that: first, it is possible to chart the path of the animal through the maze and to measure accurately the total distance covered in that run; and second, time and distance curves are so similar in character that it is impossible to state which is the better criterion of learning. She says "as to which type of record is best, time or distance, it seems wise to await a more complete study of the question before deciding."

In order to further the solution of this problem, and to form a basis upon which to discuss the reliability of the maze as a method for testing learning ability it is necessary that the data presented here be analyzed with this problem in mind. The type of record taken is the same as that used by other investigators with the exception that static time is also measured. This method takes separate account of all stops and other irrelevant activities of the animal which are contained in gross time and which have brought criticism of the validity of the gross time curve. It would appear that with static

time eliminated, net time and distance should have a very close relationship in the form of the curves constructed from them.

The various curves constructed from my data have been analyzed by the usual methods of observing the rises and falls in the curves and in addition correlations have been made to determine the relationships between the different criteria. By examining these relationships, it is possible to say that if there is a high correlation then the two criteria involved are measuring the same thing or two different things which vary together. If the correlation is insignificant , it shows that the two are not measuring the same factors. If they are not measuring the same factors, it must be determined which is measuring the progress of the learning and the total amount of effort required to complete it most accurately and satisfactorily.

Trials have been most generally used in measuring the total amount of effort required to learn the problem. From a logical standpoint alone, it would seem extremely questionable whether or not the

trials adequately serve this purpose because of the difficulty in evaluating them. During the progress of the first trials, some rats proceed almost to the center of the maze and then return to the entrance only to repeat this procedure several times in succession, while another rat will, upon his approach to the center, accidentally stumble into the food box. It seems undesirable, therefore, without further consideration to give these two trials the same value.

I have observed that a rat which takes a very long time and runs a considerable distance in getting through the maze on the first trial will practically always be relatively fast in comparison with other rats on the second day, while a rat which makes an average run on the first day will also make an average run on the second day. A study of the data bears out this observation as will be seen in the following table:

Table V.

Rat	Distance				Net time			
	1st day	Rank	2nd day	Rank	1st day	Rank	2nd day	Rank
13	307	9	48	2	251	5	71	3
19	207	6	48	2	490	8	40	1
22	199	5	48	2	426	7	64	2
46	468	11	114	7	1193	12	187	8
55	405	10	72	4	511	9	130	6
56	247	8	75	5	677	11	141	7
59	240	7	76	6	602	10	126	5
60	519	12	195	8	1323	13	367	9
16	168	4	401	10				
50	37	1	444	12	101	2	1071	13
54	104	2	332	9	156	3	877	11
57	107	3	414	11	279	6	916	12
62					62	1	109	4
24					187	4	456	10

A valid explanation of the fact shown in this table, is that a trial which requires a long time or distance record to complete is equivalent to several trials which require a much shorter time or distance. This fact is shown more conclusively by the correla-

tion values in the following tables, where the standings in time and distance are compared with the standings in trials.

TABLE VI

TRIALS VERSUS GROSS TIME

		R	r
	P.E.-	.081	
Total trials including three perfect trials	Gross time for first trial	.038	.056 ± .134
"	Gross time for second trial	.09	.14 ± .124
"	Gross time for first two trials	.11	.17 ± .13
"	Gross time for first three trials	.069	.11 ± .133
"	Gross time for first six trials	.027	.05 ± .14
"	Gross time including first perfect trial	.046	.065 ± .138
"	Gross time including three perfect trials	.067	.089 ± .133
Total trial including first perfect trial	Gross time for first trial	.032	.05 ± .135
"	Gross time for second trial	.009	.01 ± .134

Table VI(cont.)

Total trial including first perfect trial	Gross time for first two trials	.157	.235 ± .128
"	Gross time for first three trials	.157	.235 ± .128
"	Gross time for first six trials	.116	.18 ± .132
"	Gross time including first perfect trial	.001	
"	Gross time including three perfect trials	.03	.05 ± .135

Table VII

TRIALS VERSUS NET TIME

		R	r P.E. =.081
Total trials including three perfect trials	Net time for first trial	.012	.02 ± .135
"	Net time for second trial	.132	.227 ± .128
"	Net time for first two trials	.155	.267 ± .124
"	Net time for first three trials	.033	.058 ± .134
"	Net time for first six trials	.023	.038

Table VII (cont.)

TRIALS VERSUS NET TIME

		R P.E. = .081	r
Total trials including three perfect trials	Net time including first perfect trial	.143	.245 ± .126
"	Net time including three perfect trials	.173	.294 ± .123
Total trials including one perfect trial	Net time for first trial	.0192	.03 ± .135
"	Net time for second trial	.04	.071 ± .134
"	Net time for first two trials	.109	.185 ± .133
"	Net time for first three trials	.14	.242 ± .126
"	Net time for first six trials	.085	.146 ± .123
"	Net time including first perfect trial	.082	.143 ± .124
"	Net time including three perfect trials	.03	.054 ± .135

Table VIII

TRIALS VERSUS DISTANCE

		R P.E. = .081	r
Total trials including three perfect trials	Distance for first trial	.08	.141 ± .122
"	Distance for second trial	.11	.192 ± .132
"	Distance for first two trials	.16	.275 ± .136
"	Distance for first three trials	.18	.307 ± .135
"	Distance for first six trials	.03	.054 ± .134
"	Distance including first perfect trial	.235	.389 ± .114
"	Distance including three perfect trials	.385	.56 ± .093
"	Distance for first trial	.087	.148 ± .123
"	Distance for second trial	.098	.166 ± .131
"	Distance for first two trials	.105	.181 ± .133

Table VIII (cont.)

TRIALS VERSUS DISTANCE

		R	r
		P.E. =.081	
Total trials including three perfect trials	Distance for first three trials	.09	.158 ± .121
"	Distance for first six trials	.05	.089 ± .133
"	Distance including first perfect trial	.246	.405 ± .112
"	Distance including three perfect trials	.265.	.434 ± .11

It is thus found that the correlations between total time and distance, with trials are practically insignificant. Total trials versus gross time gives r a value of .089 ± .133, and total trials versus net time a coefficient which equals .294 ± .123. This value is somewhat greater for trials versus distance, namely, .56 ± .092. This evidence is sufficient to indicate that these two criteria are not measuring the same factors, although it is not evidence to show that either is superior to the other. However, since trials, as has already been pointed out, do not admit

of a proper evaluation, it seems better to rely upon time or distance.

Further evidence against accepting total trials as a reliable criterion may be found in the fact that the inequalities in evaluations (above commented upon) cannot be said to be removed by the irregularities of the time and distance neutralizing each other in such a way that the total amount of time or distance required will be proportional to the total number of trials. An inspection of individual records shows that in some cases, a rat which takes a smaller number of trials requires more time and distance than one which takes more trials, and rats requiring the same number of trials take a varying amount of time and distance. For example, rats numbers 20 and 55 required 367 and 1067 seconds, and 352 and 659 inches, respectively, but both completed the learning in 11 trials. In contrast to rat 20, rat number 49 finished the learning in 7 trials but in 1014 seconds, i.e., in four less trials but with an increase of 647 seconds. The distance records of these rats may likewise be contrasted, rat number 20 requiring 352 inches,

and rat 49 , 776 inches. Many similar examples might be taken from the total learning records. Rat 16 and 45, for instance, exceeded rat number 20 in both time and distance, though each learned the maze in 9 trials while rat 20 took 11. Trials, then, seem to indicate practically nothing as to the relative standing of the rats as far as the amount of effort required to learn the maze is concerned. This makes it impossible to generalize from the results of an experiment in which the rats are run a number of trials per day to those of an experiment in which the rats are run only one trial per day. Because if it is difficult to evaluate from one trial to another when they are given in approximately equal situations, it would be much more difficult to evaluate the second or third trial given on the same day. Thus conclusions from experiments on distributed efforts, Etc., are unreliable to an uncertain degree if based upon the number of trials required for completed learning.

Trials then have been excluded as a reliable measure of the learning in the maze for the reasons which have been advanced, namely,

1. Individual trials do not admit of a theoretically logical evaluation.

2. The data shows that a rat learns more in a long trial as measured by time or distance units than in a short trial.

3. This difficulty is not obviated by assuming that long and short trials cancel each other in such a way that the total trials of each rat will be proportional to its total time or distance.

4. Correlations show that trials are not measuring the same factors as time or distance.

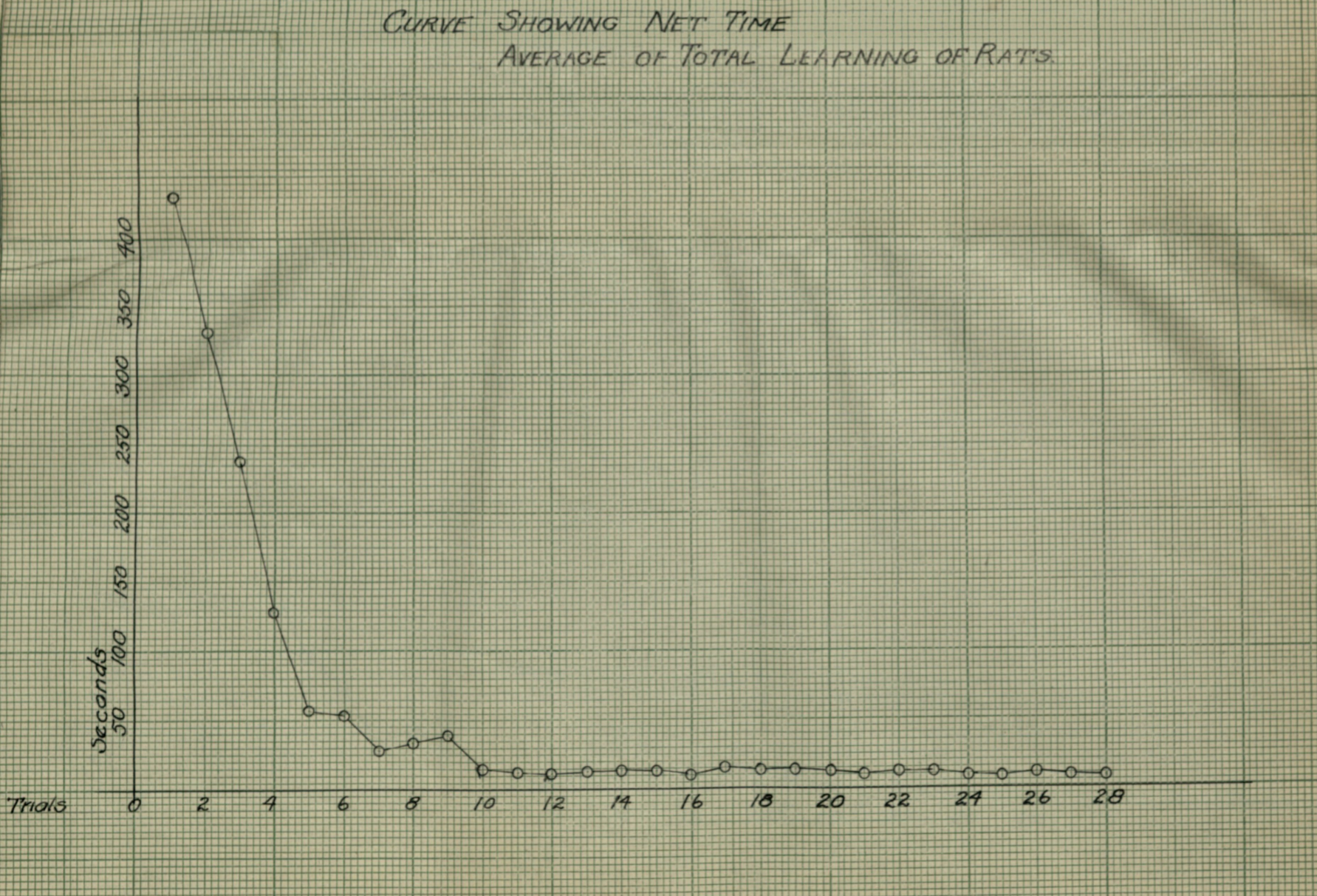
This leaves time and distance to be considered as to their adequacy as measures of ability in maze learning. All discussion of errors is omitted because the elimination of errors is included in the distance records. Counting errors has always been criticised because of the impossibility of making all the errors equal in length, i.e., the traversing of the whole length of the blind alley is counted no greater error than merely turning into it. Hicks has attempted to overcome this difficulty by decreasing the unit of error to one-half or one-fourth of

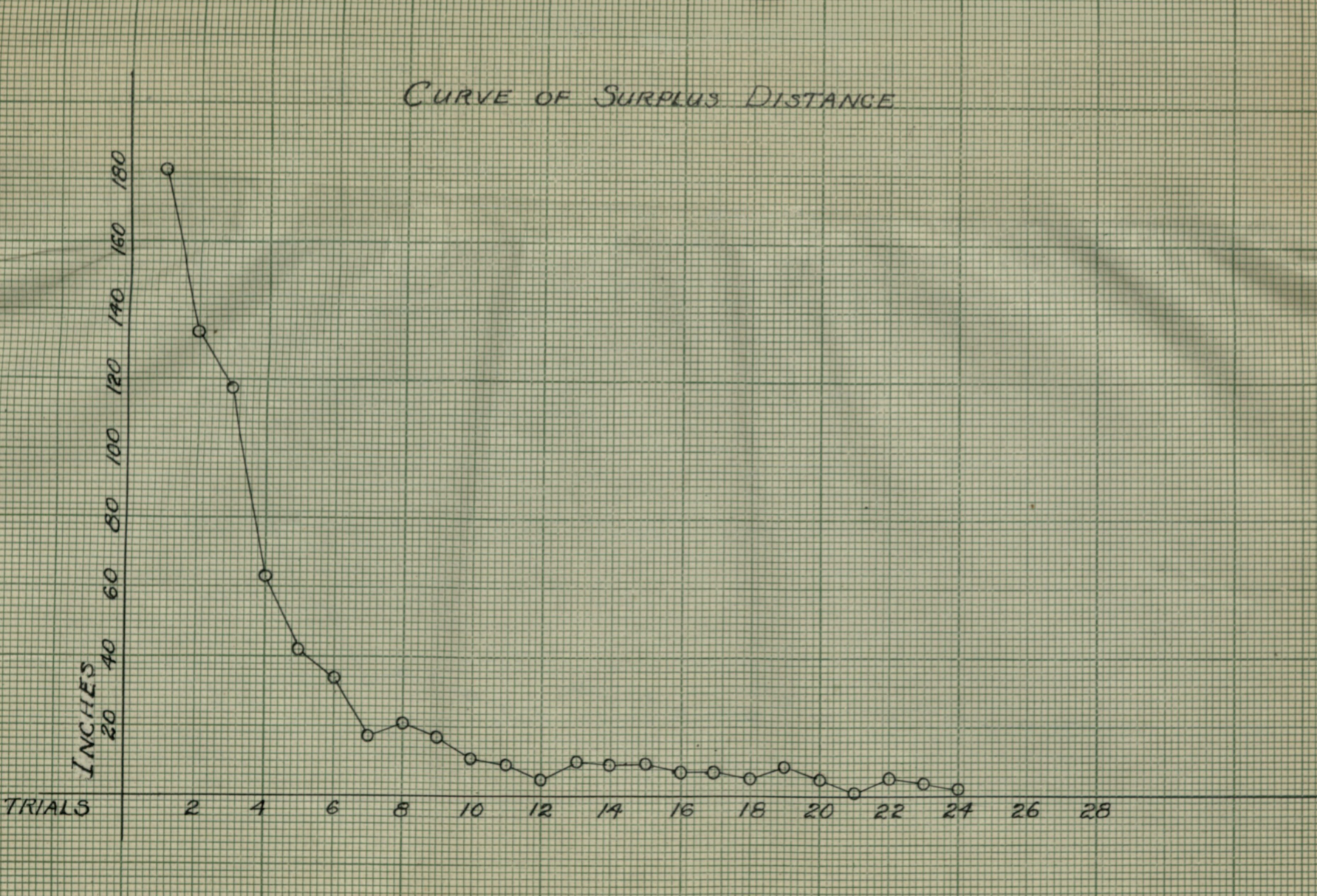
the blind alley. In this way the equality of the error approaches unity as the unit of error is decreased. Surplus distance, therefore, is the most perfect indication of errors.

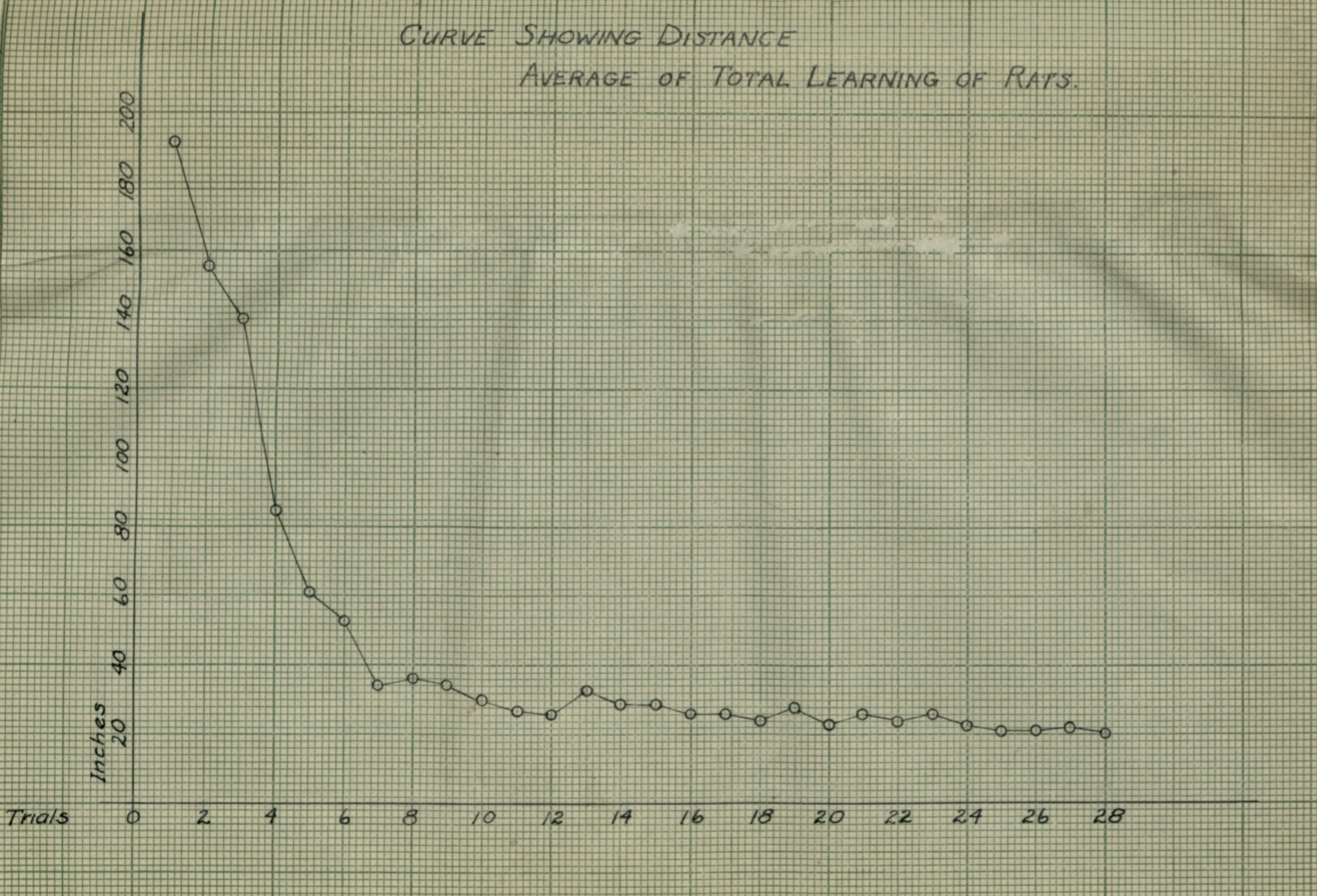
Graphic representations of surplus distance, distance, gross time, and net time are made from the records of 24 rats by placing trials on the x-axis and the average amount of the various measures for each trial on the y-axis. These curves are shown on the following pages in figures II, III, IV, V and VI.

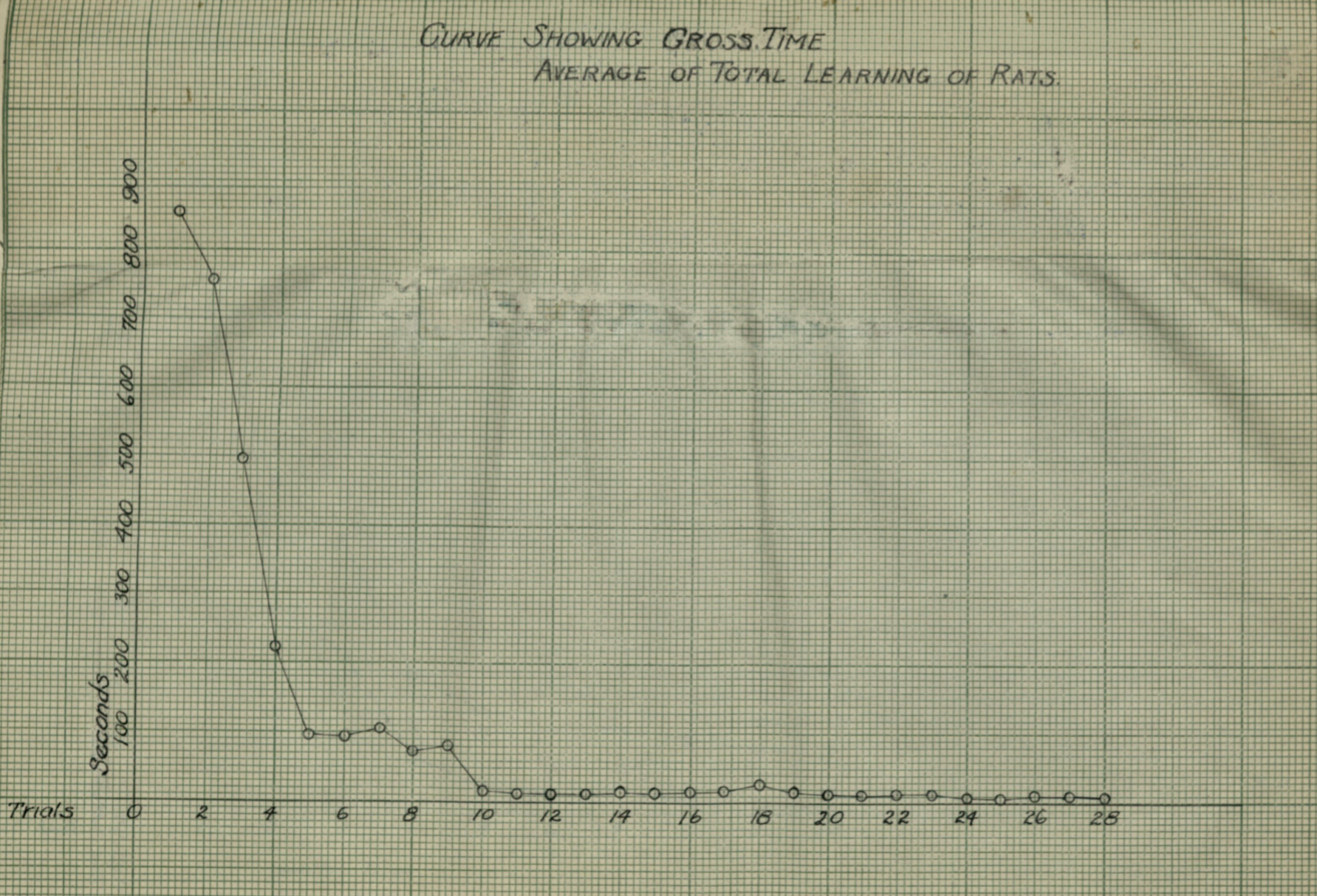
Reference to the curves will show that the distance and the surplus curves are exactly the same, with the exception that one is plotted on a lower level. This is to be expected since in order to make the surplus distance curve it was only necessary to subtract the distance of the true path from each trial.

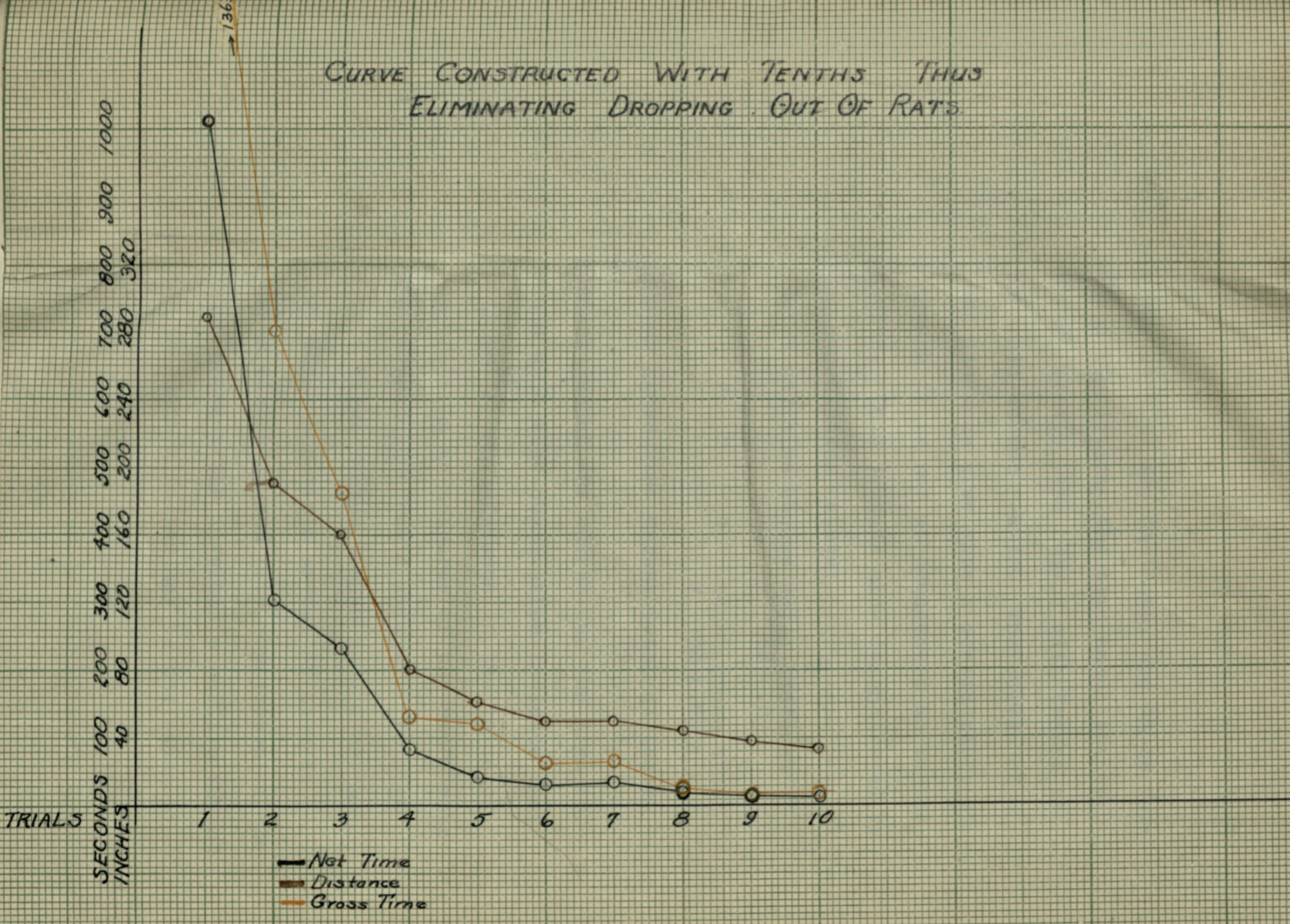
All the curves are very similar and a glance at them would indicate that it would be just as safe to take one as the other as the criterion of progress of a group of rats. The similarity is especially


Curve Showing Net Time
Average of Total Learning of Rat's.
Seconds
50
100
150
200
250
300
350
400
Trials
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28


CURVE OF SURPLUS DISTANCE
INCHES
20
40
60
80
100
120
140
160
180
TRIALS
2
4
6
8
10
12
14
16
18
20
22
24
26
28


Curve Showing Distance
Average of Total Learning of Rats.
Inches
20
40
60
80
100
120
140
160
180
200
Trials
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28


CURVE SHOWING GROSS TIME
AVERAGE OF TOTAL LEARNING OF RATS.
Seconds
100
200
300
400
500
600
700
800
900
Trials
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28


CURVE CONSTRUCTED WITH TENTHS THUS
ELIMINATING DROPPING OUT OF RATS
136
1000
900
800 320
700 280
600 240
500 200
400 160
300 120
200 80
100 40
SECONDS
INCHES
TRIALS
1
2
3
4
5
6
7
8
9
10
Net Time
Distance
Gross Time

great between net time and distance, and it is further emphasized by dividing the time and distance into tenths and plotting the curves with tenths as the arbitrary unit on the x-axis. The curves of gross time and distance also show a considerable similarity, although it is not as pronounced as in the case of net time. This fact is also demonstrated by the following correlation values:

1. Total net time versus total distance
   r .88 ± .03

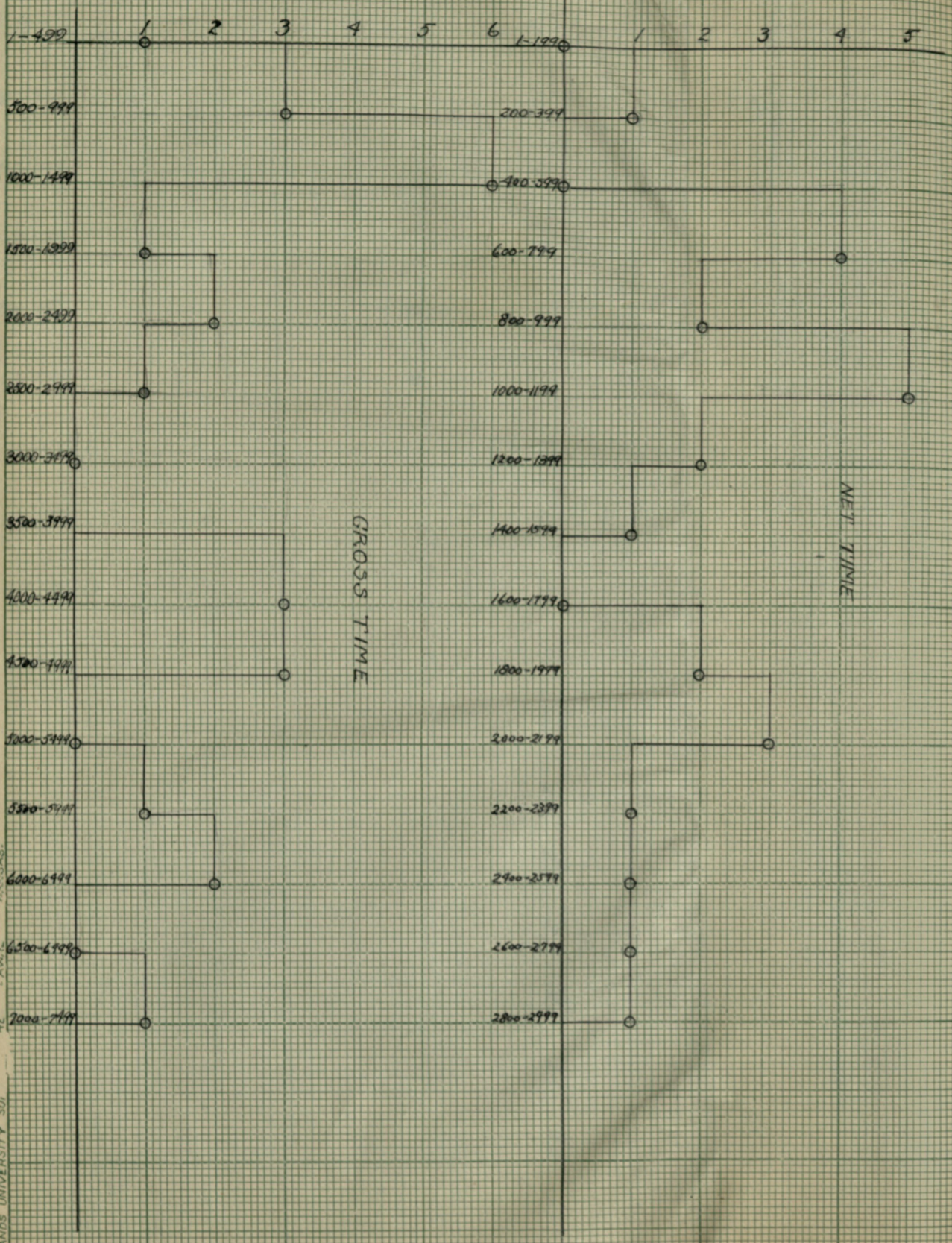
2. " " " " total gross time
   r .96 ± .01

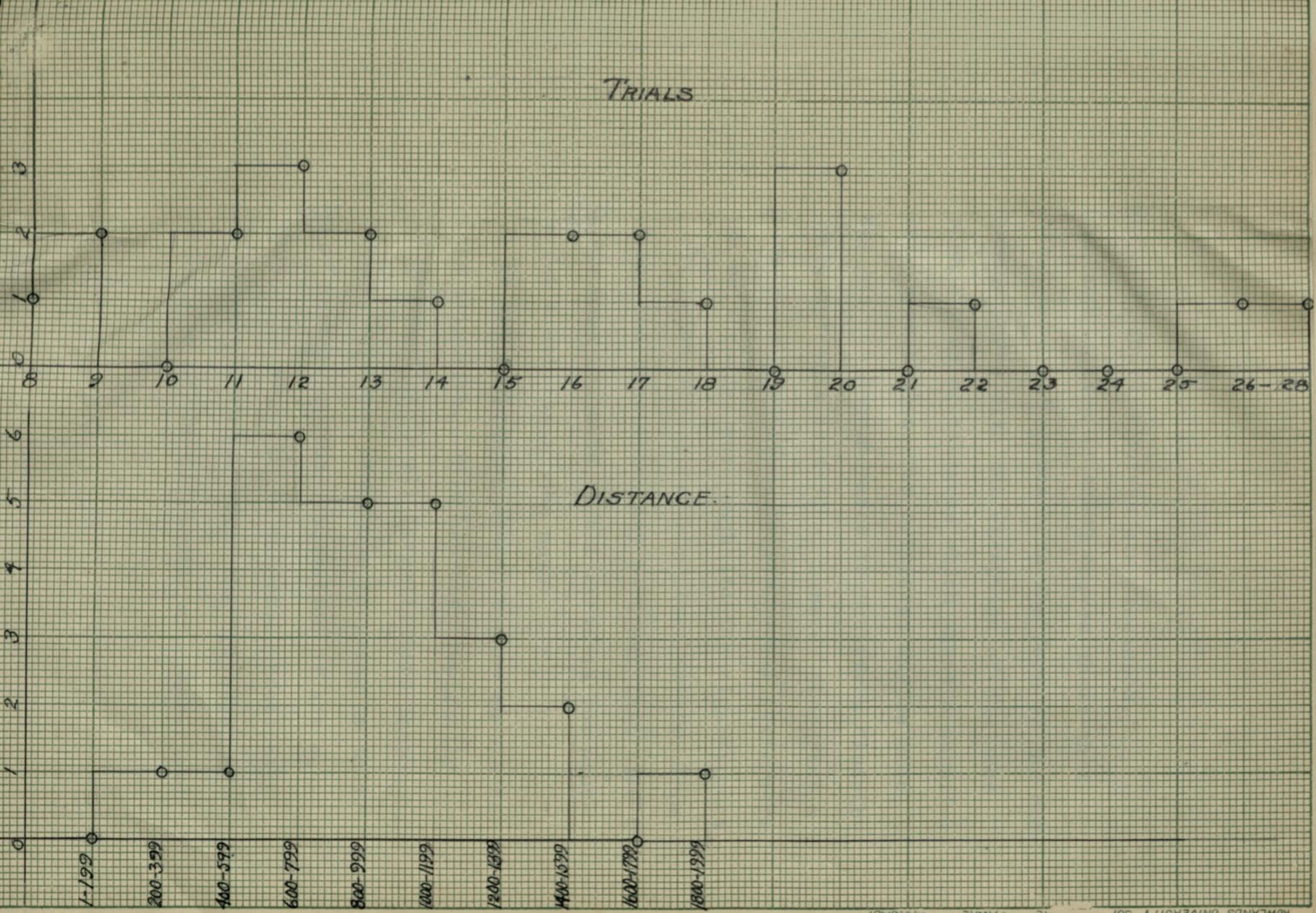
3. Total gross time versus total distance
   r .74 ± .061

Similarities of the curves and the high correlations would upon mere observation indicate that there is practically no difference in the value of these various criteria as measures of the rat's maze ability. The correlations would naturally be high since there is a large factor common to all of them. That is, it requires a certain amount of time to traverse a given distance, and time, by reason of the rat's activity, necessarily involves a certain amount of distance. The common factor may be the cause of

the high correlation, to the exclusion of the special factors involved, that is, to those which are casually connected to maze learning. The value of the various criteria is determined by these factors and an attempt will be made to determine which one is rendered more valuable because it takes account of such factors.

Since all the curves are similar, and inasmuch as there are no essential differentiating features between those which may not be significant, I have attacked the problem from another angle. The results of all tests which have been devised to measure learning ability or intelligence have been required to fall on a normal distribution curve because it has been assumed that these characteristics are distributed normally as are physical phenomena. In other words, it is assumed that if the results of the test do not fall on a normal frequency curve, that they are incapable of placing the individuals tested in the classes to which they belong. In order to determine, which, if any of the criteria, in question, (gross time, net time, and distance) will perform this


1-499
500-999
1000-1499
1500-1999
2000-2499
2500-2999
3000-3499
3500-3999
4000-4499
4500-4999
5000-5499
5500-5999
6000-6499
6500-6999
7000-7499
1
2
3
4
5
6
1-199
200-399
400-599
600-799
800-999
1000-1199
1200-1399
1400-1599
1600-1799
1800-1999
2000-2199
2200-2399
2400-2599
2600-2799
2800-2999
1
2
3
4
5
GROSS TIME
NET TIME



function, distribution curves are presented.

An examination of these curves shows that none of them make any approach to the form of the normal frequency curve with the exception of distance with the exception of distance which shows a surprisingly close resemblance. The criticism may be made that there are not enough cases to justify a distribution curve, but this criticism, however justifiable it would be if no approaches to the normal curve were found, can only render more emphatic the significance of the curve which does give this distribution. From this evidence the conclusion may be drawn that distance is the most reliable of all criteria for measuring the rat's ability in the maze.

It is not surprising that distance should be the adequate criterion. This has been implicitly recognized by practically all investigators inasmuch, as they have been almost unanimous in using as their criterion of perfection the elimination of all surplus distance. It would be in any case practically impossible to make a minimal time the criterion of perfection because of the difficulty of establishing

a fair norm for all the rats to attain. If the maze presents any problem at all, it is the problem of learning to follow the true path which requires that the rat make the run in a minimal distance. Since distance, then, includes all the factors which are involved in learning the maze, it is not necessary to take time at all and the results in reliability will be discussed principally with reference to distance criteria, the results from time being used for purposes of comparison.

While total distance is the reliable criterion of the rat's ability in the maze, it is yet to be determined whether or not the maze is a reliable test of the rat's learning ability. This problem is discussed in Section III.

SECTION III

THE RELIABILITY OF THE MAZE AS A TEST OF LEARNING ABILITY.

Since there is no precedent in Animal Behavior for the study of the reliability of the tests used, it has been difficult to decide what methods should be employed in the solution of this problem. In order to provide an orientation, it was thought advisable to take those which have been found suitable for the study of the reliability of tests applied to the measuring of human intelligence.

Two general methods have been used by various investigators for this purpose. They are, first, to correlate the results of the even trials with those of the odd trials in cases in which the test is administered several ti mes in succession or in which each trial brings the subject closer to a perfect performance; second, to correlate the results obtained by giving the tests at two different times between which some interval of time has elapsed.

These methods are briefly outlined by Whipple[9]

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9. Whipple, G.M. Manual of Mental and Physical Tests. p.52

as follows: Let "A_1 the first series of observations of trait A. Let A_2 the second series of observations of the trait A. The correlation thus measured between the results of two different applications of the same test upon the same persons has been used, particularly by recent English investigators, like Spearman, Burt, Wyatt, et al., as a coefficient of reliability. The principle is simple enough. If the outcome of a test is not disturbed by chance or by constant errors, the ranks of the several S's should be the same at each trial. Constant errors must, of course, be avoided by other precautions. If, however, chance or errors are too obtrusively present, this fact will be revealed by a low correlation between A_1 and A_2. In practice a test whose coefficient of reliability is less than .60 or .70 is in need of rectification - improvement of conditions, larger number of observations - or should be discarded. It should be understood that A_1 and A_2 need not be independent series of tests given by different E's at different sittings but may be made up from data obtained at a

single sitting, though, as a rule, two sets of data are secured and the correlation is calculated between the first half of the first performance added to the last half of the second performance and the last half of the first performance added to the first half of the second performance.

"It would be wrong, to constitute A_1 of the first six sets and A_2 of the second six sets, because the latter half-dozen would be affected by a constant factor -that of practice- to an extent different from the first half-dozen. It would be better to constitute A_1 from the odd and A_2 from the even numbered tests. "

The coefficients of reliability determined by these methods for various tests are shown in the following table:

Table IX

COEFFICIENTS OF RELIABILITY

Name of test	Investigator	Coefficient
Ebbinghaus Completion Test	Simpson	.92
	Spearman and Krueger	.76

Table IX (cont.)

COEFFICIENTS OF RELIABILITY

Name of test	Investigator	Coefficient
2. Hard Opposites	Simpson	.97
3. Memory of Words	Simpson	.97
	Spearman and Krueger	.92
4. Easy Opposites	Simpson	.93
5. Cancellation of A's	"	.72
6. Memory of Passages	"	.90
	Winch	.65
7. Adding	Simpson	.91
	Spearman and Krueger	.76
	Burt	.50
	Brown: Speed	.68
	Accuracy	.30
8. Geometrical Forms	Simpson	.90
9. Learning Pairs	"	.93
10. Scroll	"	.76
11. Recognizing Forms	"	.40
12. Completing Words	"	.92

Table IX (cont.)

COEFFICIENTS OF RELIABILITY

Name of test	Investigator	Coefficient
	Brown	.70
	Burt	.68
	Burt and Moore	.58
	Wyatt	.89
13. Drawing Lengths	Simpson	.72
14. Estimating Lengths	"	.48
15. Mirrow Drawing	Burt and Moore	.52
16. Immediate Memory	Burt	.70
17. Invention of Stories	Whipple	.50
18. Word Building	Wyatt	.88
19. Analogies	Burt	.71

It will be noted that some of the tests listed in the above table do not give a coefficient of reliability which is sufficient according to Whipple.

Some of the investigators, Winch, Brown, and others, whose results are listed in the above table have correlated odd and even trials; others have made their calculations by correlating the results obtained by different sittings. Both of these met-

hods are applied in the present study to the reliability of the maze.

Three sets of data are used ; 24 total learning records, 29 6-60-6 records, and 26 3-60-3 records. The total learning records could only be used with the method of correlating odd and even trials. In the other two sets, however, (in which the rats were run for 3 or 6 days and then allowed to rest 60 days when they were again returned to the maze for a corresponding number of trials), the total times for the two learning periods are correlated as well as the odd and even trials of these two periods.

The results of the application of the odd versus even method to the records are shown in the following tables:

Table X

CORRELATIONS OF ODD VERSUS EVEN TRIALS
TOTAL LEARNING DATA

		P.E.	R .081	r
Net time	Odd vs. Even trials		.19	.323 ± .12
" "	Odd vs. Even tenths		.548	.772 ± .054
" "	Odd vs. Even trials minus 1st. and 2nd. Trials		.32	.514 ± .099

Table X (cont.)
CORRELATIONS OF ODD VERSUS EVEN TRIALS
TOTAL LEARNING DATA

		R P.E. = .081	r
Gross time	Odd vs. Even trials	.37	.58 ± .089
" "	Odd vs. Even tenths	.558	.782 ± .054
" "	Odd vs. Even trials minus 1st. and 2nd. trials	.406	.618 ± .083
Distance	Odd vs. Even trials	.291	.472 ± .114
"	Odd vs. Even tenths	.558	.782 ± .054
"	Odd vs. Even trials minus 1st. and 2nd. trials	.50	.732 ± .063

Table XI

CORRELATIONS OF ODD VERSUS EVEN TRIALS
6-60-6 Data

	R P.E. = .079	r
DISTANCE		
1st. six trials; odd vs. even trials	.10	.176 ± .19
2nd. six trials : odd vs. even trials	.315	.50 ± .11
1st. six trials ; odd trials vs. 2nd six trials : odd trials	.221	.369 ± .118

Table XI (cont.)

CORRELATIONS OF ODD VERSUS EVEN TRIALS
6-60-6 Data

	R	r
P.E.	.079	
1st. six trials : even trials vs. 2nd. six trials: even trials	.09	.158 ± .19
NET TIME		
1st. six trials: odd vs. even trials	.025	.036 ± .134
2nd. six trials: odd vs. even trials	.397	.60 ± .082
1st. six trials: odd trials vs. 2nd. six trials: odd trials	.207	.338 ± .119
1st six trials: even trials vs. 2nd. six trials: even trials	.078	.125 ± .192
GROSS TIME		
1st. six trials: odd vs. even trials	.039	.071 ± .134
2nd. six trials: odd vs. even trials	.428	.642 ± .081
1st. six trials: odd trials vs. 2nd. six trials: odd trials	.139	.226 ± .16
1st. six trials: even trials vs. 2nd. six trials: even trials	.018	.036 ± .134

It will be noted in Table IX for total learning that none of the correlations using odd and even trials in the way described by Whipple, are significant by his standard. The highest correlation (.58 ± .089) is obtained from gross time, its coefficient being larger than that for net time by .26 and larger than that for distance by .11. If, however, the first trial is subtracted from the odss and the second trial from the evens, in order to eliminate the trials in which the chance factors admittedly have most influence, distance has the highest correlation. This was to be expected from the fact that distance was shown in the last section to be probably the best criterion of maze learning. When the great chance factors of the first two trials are eliminated, then distance is less subject to those factors which tend to destroy the consistency of the odd and even trials in the correlation where the time values are used.

Distance, with the chance errors of the first and second trial eliminated, shows a correlation of .732 ± .063 which gives the maze a good degree of re-

liability, as measured by Whipple's standard, when the criterion used is distance. However, the elimination of certain other factors beside the chance errors of the first and second trials, may still further increase this correlation. One of these factors is that of periods of increased or decreased efficiency on the part of the rat. If these periods should not distribute themselves evenly throughout the odd and even trials, they would, of course, tend to decrease the coefficient of correlation. In order to eliminate, as far as possible, any influence which such periods might have, the three criteria were each divided into tenths as suggested by Vincent. This division was made on the basis of trials. Thus if the rat ran 27 trials the time or distance for the first two trials plus .7 of that for the third trial would constitute the first tenth; the remaining .3 of the third trial plus the 4th. and 5th. trials plus .4 of the sixth trial would constitute the second tenth, and so on. The coefficient obtained by the correlating of the odd and even tenths is .782 ± .054 for distance. It is the same for gross time but .01 for net time.

The correlation of odd and even tenths is therefore reliable(judged by the standard set by Whipple), as is also the coefficient .732 ± .063, given above, between odd and even total distances omitting the first two trials. This correlation means that the total time of the rat has been divided approximately into halves, so that the rat which has the highest total time will have the highest time in both odd and even trials when they are summed separately. The remaining rats will rank themselves in approximately the same manner. If the choice of measures of the rat's ability lies between the sum of the odd and the sum of the even trials then on the basis of this correlation it can be asserted that one is as good as the other for this purpose, if the large chance factors of the first two trials are eliminated.

The assumption that the elimination of the chance factor raised the correlation between the odd and even trials is given greater credence by the results of the 6-60-6 data. The only coefficients which are significant in this set are those between the odd

and even trials of the second six trials. The trials with the great chance factore occur in the first set of six trials. The coefficient for odd and even trials of the second six trials are .50 ± .11, .60 ± .082, and .642 ± .081 for distance, net time, and gross time, respectively.

The correlations, then between odd and even trials if the first two trials are omitted would indicate that the maze does not have a high degree of reliability. Even when the perfectly obvious chance factors are eliminated, the chance errors still present do not neutralize each other sufficiently to raise the consistency of the odd and even trials very high. It would be expected that the correlation between odd and even trials should be almost perfect, since it should, for any particular rat, require the same amounts of time to complete two sets of an equal number of trials each. A correlation of .60 or .70 therefore cannot be considered high.

Although, the maze is not very reliable as measured by the correlation of odd and even trials, there are still two other methods of investigating

reliability which are employed in the present paper, viz. (1) correlations between single adjacent trials and (2) correlations between two different performances on the same test. This method is more severe than that of the odd and even trial method because in making such correlations the chance errors are not given an opportunity to cancel themselves. It would be expected, therefore, that these coefficients should be comparatively low, although a significant correlation between such variables would be extremely important in proving the consistency of the maze as a test. These correlations are as follows.

Table XII

CORRELATIONS OF INDIVIDUAL TRIALS OF TOTAL LEARNING

	P.E.	R .081	r
1st. versus 2nd. trial	.23	.384	± .10
2nd. versus 3rd. trial	.10	.176	± .19
3rd. versus 4th. trial	.31	.50	± .11
4th. versus 5th. trial	.218	.367	± .118
5th. versus 6th. trial	.28	.458	± .116

These coefficients are uniformly small, even the largest between the third and fourth trials being insufficient to indicate reliability. This shows therefore that there is no consistency between the reactions of the rats to the maze on successive days as measured by us up to the 6th. day. This conclusion will, I believe, apply to any of the correlations between odd and even trials, for such correlations may range all the way from 0 to +1 or from 0 to -1 without in any way affecting the sum of total learning. It does not necessarily indicate, however, that the total distance (measuring the amount of effort required for complete learning), which the rat requires to learn the maze at one time is not consistent with the total distance he would require to learn the maze at another time. Inasmuch as the total distance is the criterion, which I consider the best by which to judge the rat, for the reasons given in Section II, the consistency of this measure is here investigated. This is done by the second method referred to above. The 6-60-6 records have been used for this purpose and correlations have been made between the total distance

in the first six trials and total distance in the second six trials given after a sixty day interval, when it was presumed the maze would present essentially a new problem. As the six trials are a good indication of the rat's standing in total learning ($r = .81$) then the correlation which applies to them will apply approximately well to total learning. Time correlations are included here along with the distance records for the purpose of comparison and because some investogators have used time as their criterion. Tables showing these correlations are presented here.

Table XIII

CORRELATION OF TOTALS OF 6-60-6 DATA

	R	r
P.E. = .079		
Total distance: 1st. six trials vs. 2nd. six trials	.178	.291 ± .13
Total distance: 1st. three trials vs. 3rd. three trials	.246	.399 ± .10
Total distance: 2nd. three trials vs. 4th. three trials	.19	.323 ± .119
Total gross time: 1st. six trials vs. 2nd. six trials	.153	.259 ± .15

Table XIII (cont.)

CORRELATION OF TOTALS OF
6-60-6 DATA

	R	r
	P.E. ±.079	
Total gross time: 1st. three trials vs. 3rd. three trials	.19	.323 ±.119
Total gross time: 2nd. three trials vs. 4th. three trials	.068	.107 ±.134
Total net time: 1st. six trials vs. 2nd. six trials	.228	.369 ±.11
Total net time: 1st. three trials vs. 3rd. three trials	.18	.307 ±.123
Total net time: 2nd. three trials vs. 4th. three trials	.008	.00 .

The correlation coefficient for the total amount of effort required in the first six trials as measured in distance units, and the total amount of effort used in the second six trials is .291 .13. The time correlations, also, give small negative coefficients and those in which the first half of the first six trials are correlated with the first half of the second six, are no better. When the first three trials of each set, in which chance errors are greatest, are eli minated and the second halves

of each test are correlated, the results tend toward the positive side but they are too small to indicate that the maze is at all consistent. As far as its reliability as a measure of learning ability is concerned, it apparently fails to meet the standard set for all intelligence tests, namely that it give approximately the same score for the same individual whenever it is used, provided other factors are equal. Because of the possibility of fluctuation in periods of efficiency, correlations between every trial of one set with every trial of the other set have been made, in order to see if there is any relation between any parts of the two tests. The results of these correlations are shown in the following tables.

Table XIV

SINGLE TRIAL CORRELATIONS
DISTANCE

2nd. six trials; 1st. six trials trials	1	2	3	4	5	6
1	.203	.13	.16	.22	.27	.05
2	.02	.01	.11	.02	.03	.08
3	.08	.1	.08	.06	.22	.15

These are R coefficients. P.E. .079

Table XIV (cont.)

SINGLE TRIAL CORRELATIONS
DISTANCE

2nd. six trials: 1st.six trials	1	2	3	4	5	6
4	.1	.02	.17	.23	.03	.01
5	.18	.12	.11	.02	.12	.18
6	.14	.04	.08	.322	.007	.04

These correlations are insignificant, also, so the conclusion must be drawn either that the maze is an inconsistent and unreliable apparatus for testing the rat's process of habit formation or an explanation must be sought in other factors. It may be urged that some effect upon the results might be due to the fact that the rats were two months older when they were given the second test. They were, however, of equal age and since they were only three months old when the second period of training was begun, it is not probable that this factor would have much influence upon the correlations. Especially is this true, since it would not be necessary for the rats to travel the same amount of distance during the second test

as during the first in order to give a good correlation. It would only be necessary for them to keep their relative standing practically unchanged.

Another factor, however, which entered to complicate the learning process when the rats were returned to the maze for the second set of trials and one which it would seem might well have affected the correlations was retention. When the rats were returned to the maze after the sixty day interval, it was apparent from the great decrease in total distance of the first trial that the maze was not presenting a new problem. It was possible, therefore, that retention was influencing the results.

An attempt was made to minimize this influence by running a third group of rats only three trials in each set instead of six, as described under the "Method"above (3-60-3 group). The table of correlations which follows shows the results obtained.

Table XV

SINGLE TRIAL CORRELATIONS
DISTANCE (3-60-3)

2nd. three trials: / 1st. three trials:	1	2	3
1	.03	.13	.01
2	.15	.08	.23
3	0	.24	.05

Table XVI

CORRELATION OF TOTALS OF
3-60-3 DATA

		R	r
	P.E.	.08	
Total distance:	1st. three trials vs. 2nd. three trials	.046	.075 ± .134
Total net time:	1st. three trials vs. 2nd. three trials	.073	.13 ± .191
Total net time:	1st. trial vs. 4th. trial	.054	.092 ± .133
Total net time:	3rd. trial vs. 6th. trial	.25	.14 ± .116
Total gross time:	1st. three trials vs. 2nd. three trials	.076	.131 ± .191
Total gross time:	1st. trial vs. 4th. trial	.086	.15 ± .18

Table XVI (cont.)

CORRELATION OF TOTALS OF
3-60-3 DATA

	R	r
P.E.	.08	
Total gross time: 3rd. trial vs. 6th. trial	.304	.487 ± .114

Far from improving the status of the maze as a reliable test, these correlations only tend to decrease the probability that it is an apparatus which will give consistent results with the rat. There is, apparently, no relationship between the rat's standing in the first three trials and his standing in the second three trials given after a sixty day interval. It should be mentioned however that in these correlations as well as in the others, retention may have had a greater or less effect.

The above results, while not final, are firmly united against the view that the maze is consistent and, therefore, increase greatly the importance of arriving at a definite solution of this problem. It will be difficult to establish the reliability of a test given to animals in the way that the reliability of tests applied to humans is established, be-

cause it is scarcely probable that measures will be devised which will be fine enough to grade the rats as to the efficiency of their adjustment to their own environment, and thus to measure their intelligence or learning ability in a practical situation. It should be possible, however, to establish the consistency of the tests which are given to the animals. Then, if it is fair to presume that these tests are measuring the factors whcih it is proposed to measure, we are justified in drawing conclusions from the results of our tests.

It is proposed, therefore, to offer some suggestions, based on the experience obtained in the present experiment, towards methods of definite and satisfactory nature for the solution of the problem of consistency. A method devised for this purpose must meet two requirements: first, it must be measuring the consistency of the results which are used as the basis of conclusions; second, it must be such that the results found are really due to the consistency or inconsistency of the apparatus itself. The present experiment has been concerned with the rat in the

maze but in the final analysis the inconsistency shown above may be the fault of either factor above.

The question involved is whether or not the rat reacts the same day after day and time after time to a situation in which there could be no large chance error due to the apparatus. The solution of this problem, though difficult, may be attacked in two different ways: first, by presenting the rat with a situation from time to time from which approximately all of the chance errors have been eliminated and correlating his reactions at one time with those of another time; second, to present the rat with different problems of equal possibilities for chance errors and of equal difficulty.

W.T.Heron, working in this laboratory (data yet unpublished) has correlated the rat's standings in the maze and the inclined plane problem box (which have been used in the solution of the same problems) and found no relation. The problem box alone showed no more reliability than did the maze.

In solving the problem of reliability we are compelled to cope with retention and age differences.

These difficulties might be overcome by correlating the average standings of a number of groups of animals instead of using the standings of individual rats. A control test for age may be introduced by running a group of rats for the first time in the maze which are equal in age to another group which are being rum for their second learning period. The results of this control group could then be compared with the results of the other rats for their first time in the maze. It is possible a retention is a constant and that its effect upon the correlations can be calculated in such a way that allowance may be made for it.

This problem, however, is very large in itself so it is impossible fo treat it adequately at the present time and it will be left for future discussion.

SUMMARY AND CONCLUSIONS

This study was begun with the feeling that there should be a critical evaluation of the tests used in Animal Behavior. The data, presented here, has strengthened this feeling, and stressed the importance of arriving at a final and satisfactory solution of the problem.

In treating the data two other problems, An Adequate Criterion of Learning in the Maze, and The Relative Value of Different Curves of Learning, were studied because of their intimate connection with the problem of reliability. Inasmuch as the rats were given only partial learning in the accumulation of data with regard to reliability, it was necessary to determine the relationship whcih this data would bear to that of total learning. It was found that the correlation between total distance for complete learning and total distance for the first six trials was .81 ± .43. It was concluded therefore, that, in general, distance for six trials would be just as effective by which to judge the rat's maze ability as would total distance. It was, then, necessary to

determine what measure was the most consistent in showing the progress of learning in the maze. Gross time, net time, trials, and distance were compared. Distance was found to be superior because of its greater freedom from error, less rapid elimination, and because it distributed on the normal frequency of the curve.

The methods used in the study of reliability in this experiment are those which have been used in solving the same problem for human tests. These methods are two in number and briefly described are as follows: first, to correlate the sum of the odd and even trials of the test which has been given at periodic intervals until the learning is perfected; second, to correlate the total results of two sets of consecutive trials at two separate times. The results of both methods show the maze to be inconsistent in so far as they were found applicable to the present study. The correlation by the odd versus even for total distance was .472 ± .114. The coefficient obtained by correlating the total distance of the six trials after an interval of 60 days was .291 ± .13 and with the 3-6-3 data it was .075 ± .134.

All the factors which may have caused these correlations to be insignificant were eliminated as far as possible. Age might be considered a source of error but I am convinced that its influence was negligible, since Hubbert[2] found no effects for a sixty-day interval. It is quite possible, however, that retention would have a large influence in the determination of the size of the correlations, but its exact effect could not be investigated at this time.

There may be, of course, other factors which have not been noted here and which are so subtle that it would be extremely difficult to eliminate them as unit factors. Further study would also be necessary to determine this.

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A P P E N D I X.

TOTAL LEARNING RECORDS
GROSS TIME
(IN SECONDS)

Rat	13	15	16	19	20	21	22
Trial s							
1	484	465	467	565	210	651	627
2	78	158	562	55	40	184	66
3	483	65	112	133	87	43	40
4	23	20	27	112	14	19	20
5	35	34.5	14	47	15	36	13
6	30	16	10	34	11	20	48
7	45	16	7	16	8	20	17
8	35	10		11	15	10	18
9	22	10.5		27	9	12	51
10	21	8		25	8	8	17
11	18	7		11	8	8	20
12	12	8		15		7	10
13	8			10			23
14	12			11			12
15	13			10			65
16	12			12			13
17	13			29			65
18	15			9.2			12

TOTAL LEARNING RECORDS
GROSS TIME
(in seconds)
(cont)

Rat	13	15	16	19	20	21	22
Trials							
19	18			9			8.5
20	22			8			15
21	11			9			
22	10			11			
23	14			11			
24	10			9			
25	11			7			
26	8			11			
27	11						
28	9						

__ Perfect trials.

TOTAL LEARNING RECORDS
GROSS TIME
(in seconds)
(cont.)

Rat	24	25	42	46	47	48	49
Trials							
1	221	424	305	3480	2889	1359	329
2	464	81	1068	271	430	107	588
3	79	69	2939	126	202	2802	190
4	23	20	91	251	515	229	387
5	25	31	34	119	52	39	70
6	11	15	47	42	32	103	134
7	12	19	11	18	11	14	53
8	17	32	16	14	11	9	13
9		15	68	10	11	10	10
10		15	9	9			19
11		13	7	27			5
12		8	7	20			17
13		11		10			12
14		15.5		14			9
15		24		7			10
16		10.5		7			6.5
17		17		8			8
18		13					27

TOTAL LEARNING RECORDS
GROSS TIME
(in seconds)
(cont.)

Rat	24	25	42	46	47	48	49
Trials							
19		10					
20		24					
21							
22							
23							
24							
25							
26							
27							
28							

TOTAL LEARNING RECORDS
GROSS TIME
(in seconds)
(cont.)

Rat	50	51	54	55	56	57	58
Trials							
1	114	2227	216	756	964	464	816
2	3854	1640	2903	215	251	3473	724
3	576	992	316	254	769	1123	214
4	1519	691	187	18	153	196	185
5	96	60	139	19	359	571	92
6	34	70	281	337	689	77	34
7	19	19	1672	31	396	35	14
8	12	15	184	137	883	12	11
9	9	23	1423	14	84	9	16
10	14	14	79	11	47	10	11
11	9	7	44	10	21	7	10
12	12	19	12		15	13	10
13	12	11	10		10	9	9
14		18	9		32	14	
15		18			12	9	
16		13			16	8	
17		10			12	8	
18		47			9	8	

TOTAL LEARNING RECORDS
GROSS TIME
(in seconds)
(cont.)

Rat	50	51	54	55	56	57	58
Trials							
19		20			38	7	
20		11			8	7	
21		8			11		
22		24			9		
23					10		
24					8		
25					7		
26					12		
27					10		
28							

TOTAL LEARNING RECORDS
GROSS TIME
(in seconds)
(cont.)

Rat	59	60	62
Trials			
1	1265	2665	135
2	291	889	242
3	403	351	331
4	64	351	140
5	267	74	69
6	61	40	20
7	54	17	40
8	102	11	12
9	11	13	33
10	12	8	26
11	7	8	11
12	11	11	9
13	34	10	16
14	21	8	8
15	10	6	8
16	12	8	8
17	7		
18			

TOTAL LEARNING RECORDS
NET TIME

Rat	13	15	16	19	20	21	22
Trials							
1	251	386	390	490	174	494	426
2	71	142	494	40	38	139	64
3	370	57	72	98	67	35	38
4	23	18	27	94	14	19	20
5	29	29	14	41	15	31	13
6	29	16	10	32	11	20	41
7	37	16	7	16	8	20	16
8	31	10		10	15	10	12
9	20	11		25	9	12	39
10	21	8		23	8	8	17
11	18	7		11	8	8	20
12	11	8		15		7	10
13	8			10			23
14	12			11			12
15	13			10			35
16	12			12			14
17	13			24			50
18	14			9			12

TOTAL LEARNING RECORDS
NET TIME
(cont.)

Rat	13	15	16	19	20	21	22
Trials							
19	17			9			9
20	18			8			15
21	11			9			
22	10			11			
23	14			11			
24	10			9			
25	11			7			
26	8			11			
27	11						
28	9						

TOTAL LEARNING RECORDS
NET TIME
(cont.)

Rat	25	42	46	47	48	49	50
Trials							
1	336	230	1193	590	578	263	101
2	46	451	187	318	77	363	1071
3	49	1140	88	117	1015	141	249
4	20	76	162	223	148	190	847
5	25	28	90	40	31	53	81
6	15	34	33	21	73	85	26
7	17	11	15	11	12	43	16
8	23	13	13	10	9	11	11
9	15	51	10	11	10	10	9
10	13	9	9			19	12
11	11	7	27			5	9
12	8	7	17			12	12
13	9		10			12	12
14	12		14			9	
15	20		7			10	
16	11		7			7	
17	17		8			8	
18	13					19	

TOTAL LEARNING RECORDS
NET TIME
(cont.)

Rat	25
Trials	
19	10
20	24

TOTAL LEARNING RECORDS
NET TIME
(cont.)

Rat	51	54	55	56	57	58	24
Trials							
1	826	156	511	677	279	302	187
2	1048	877	130	141	916	315	456
3	222	116	172	407	391	153	47
4	441	92	14	61	127	92	21
5	51	89	14	145	203	59	24
6	46	167	142	324	40	24	11
7	15	70	23	201	22	13	12
8	13	47	27	393	12	11	13
9	17	353	14	58	9	11	
10	14	48	11	23	10	11	
11	7	25	9	19	7	10	
12	17	12		13	13	10	
13	11	10		10	9	9	
14	16	9		27	12		
15	16			11	9		
16	13			16	8		
17	10			12	8		
18	20			9	8		

TOTAL LEARNING RECORDS
MET TIME
(cont.)

Rat	51	54	55	56	57	58	24
Trials							
19	18			31	7		
20	11			8	7		
21	8			11			
22	19			9			
23				10			
24				8			
25				7			
26				12			
27				9			
28							

TOTAL LEARNING RECORDS
NET TIME
(cont.)

Rat	59	60	62
Trials			
1	602	1323	96
2	126	367	109
3	262	171	225
4	52	196	91
5	121	53	47
6	46	34	17
7	35	16	31
8	79	11	12
9	11	12	24.
10	12	8	23
11	7	8	11
12	11		9
13	31	11	16
14	17	10	8
15	10	8	8
16	12	6	8
17	7	8	

TOTAL LEARNING RECORDS
DISTANCE
(in inches)

Rat	13	15	16	19	20	21	22
Trials							
1	307	248	168	207	80	188	199
2	48	125	401	48	50	118	48
3	200	30	40	98	66	47	68
4	28	21	27	76	31	37	44
5	58	24	22	69	41	67	36
6	35	25	20	53	21	45	65
7	77	25	20	25	20	27	21
8	62	20		23	22	22	21
9	51	33		54	21	21	39
10	47	21		51	20	21	35
11	41	20		33	20	20	29
12	21	20		34		19	20
13	21			28			35
14	37			34			21
15	36			28			30
16	37			27			31
17	37			39			20
18	35			20			20

TOTAL LEARNING RECORDS
DISTANCE
(in inches)
(cont.)

Rat	13	15	16	19	20	21	22
Trials							
19	41			26			20
20	32			20			20
21	22			19			
22	20			26			
23	23			27			
24	20			20			
25	22			20			
26	21			19			
27	20						
28	20						

TOTAL LEARNING RECORDS
DISTANCE
(in inches)
(cont.)

Rat	24	25	42	46	47	48	49
Trials							
1	119	155	122	468	146	211	119
2	133	84	147	114	158	42	181
3	86	52	457	93	84	456	73
4	34	40	54	74	124	81	99
5	47	54	50	73	43	32	44
6	21	30	27	45	32	76	87
7	21	27	29	32	22	22	63
8	19	27	24	33	23	23	27
9		26	49	27	22	22	25
10		24	24	23			34
11		24	25	61			24
12		20	25	36			25
13		20		22			31
14		25		28			24
15		36		24			36
16		20		24			26
17		22		22			22
18		19					25

TOTAL LEARNING RECORDS
DISTANCE
(in inches)
(cont.)

Rat	25
Trials	
19	18
20	20

TOTAL LEARNING RECORDS
DISTANCE
(in inches)
(cont.)

Rat	50	51	54	55	56	57	58
Trials							
1	37	251	104	405	247	107	197
2	444	220	332	72	75	414	127
3	237	134	57	159	181	177	55
4	396	232	38	23	102	49	100
5	49	46	62	24	169	135	49
6	35.	52	57	144	163	47	36
7	36	26	45	23	100	40	28
8	23	38	43	39	212	29	23
9	23	30	167	22	38	24	24
10	24	23	35	23	29	30	47
11	22	23	31	23	27	25	23
12	24	34	25		29	30	26
13	23	23	22		21	31	22
14		30	23		46	24	
15		32			31	26	
16		38			24	23	
17		24			31	24	
18		31			24	24	

TOTAL LEARNING RECORDS
DISTANCE
(in inches)
(cont.)

Rats	50	51	54	55	56	57	58
Trials							
19		29			72	24	
20		24			23	22	
21		23			24		
22		25			35		
23					28		
24					24		
25					23		
26					24		
27					24		
28							

TOTAL LEARNING RECORDS
DISTANCE
(in inches)
(cont.)

Rat	59	60	62
Trials			
1	240	516	85
2	76	195	98
3	131	174	190
4	40	211	89
5	135	92	61
6	51	70	33
7	39	45	61
8	120	25	23
9	24	24	29
10	31	28	47
11	24	26	27
12	30		23
13	81	23	46
14	38	28	24
15	23	24	23
16	23	23	23
17	22	22	

DISTANCE RECORDS
(unit inches)
3-60-3 rats

Rat	26	27	28	29	31	32
Trials						
I	200.5	282.5	64	738.5	106	372.5
II	126.5	101	475	103	47	189
III	121.5	103.5	89.5	115	112	33
IV	114.5	347.5	40	45	122.5	61
V	69.5	62.5	37.5	64	162.5	72
VI	30	39	133.5	38	36	87.5

Rat	33	34	35	36	37	38
Trials						
I	191	148.5	138	208	298	171.5
II	37	67	159.5	204	62	63
III	165	55	95.5	75.5	99	67.5
IV	172	40	97.5	100.5	44	58
V	33	28	88.5	69	50.5	44
VI	34	26	32.5	52	36.5	28

DISTANCE RECORDS
(unit inches)
3-60-3 rats .

Rat	43	44	45	63	65	66
Trials						
I	209	238	116	290	647	378
II	301	158	127	83	89	193
III	138	51	105	129	83	64
IV	58	82	78	161	189	125
V	49	35	51	178	158	44
VI	50	32	28	59	35	41

Rat	67	68	69	70	71	72
Trials						
I	52	108	91	158	176	177
II	212	64	469	122	162	81
III	40	55	82	67	134	378
IV	179	396	48	129	57	122
V	67	63	39	42	56	35
VI	37	52	57	212	215	26

DISTANCE RECORDS
(unit inches)
3-60-3 rats

Rat	73	75	74
Trials			
I	110	153	198
II	73	167	369
III	45	70	34
IV	128	122	34
V	28	47	32
VI	30	46	30

GROSS TIME RECORDS
(in seconds)
3-60-3 rats

Rat	26	27	28	29	31	32
Trials						
I	260	1144	302	4700	140	625
II	227	277	2940	151	35	181
III	161	163	142	98	23	18
IV	190	738	69	49	134	42
V	53	66	20	32	86	39
VI	16	42	172	61	13	55

Rat	33	34	35	36	37	38
Trials						
I	280	267	250	595	878	299
II	57	26	185	356	47	28
III	260	32	27	77	40	40
IV	374	23	89	63	20	61
V	14	12	57	38	23	25
VI	17	8	13	23	16	15

GROSS TIME RECORDS
(in seconds)
3-60-3 rats
(cont.)

Rat	43	44	45	63	65	66
Trials						
I	486	1773	171	1060	2246	1731
II	2419	722	1350	297	251	499
III	218	47	154	210	167	59
IV	85	141	77	499	440	151
V	33	40	43	473	226	48
VI	38	17	13	105	28	29

Rat	67	68	69	70	71	72
Trials						
I	72	154	173	490	1034	524
II	850	108	2157	295	315	169
III	48	132	230	243	212	1002
IV	586	37	67	660	71	200
V	113	720	40	60	75	240
VI	42	60	47	641	736	15

GROSS TIME RECORDS
(in seconds)
3-60-3 rats
(cont.)

Rat	73	75	74
Trials			
I	149	599	451
II	142	1028	1691
III	95	167	35
IV	247	177	21
V	18	34	17
VI	23	20	15

NET TIME RECORDS
(in seconds)
3-60-3 rats

Rat	26	27	28	29	31	32
Trials						
I	196	643	224	1580	95	499
II	196	198	1103	117	32	144
III	129	123	103	61	11	17
IV	145	423	58	38	73	31
V	31	56	17	21	60	30
VI	14	38	86	51	13	34

Rat	33	34	35	36	37	38
Trials						
I	218	175	182	321	443	194
II	37	11	141	244	42	16
III	174	27	19	52	39	33
IV	196	16	69	33	20	45
V	11	12	41	28	19	19
VI	16	8	13	20	15	13

MET TIME RECORDS
(in seconds)
3-60-3 rats.
(cont.)

Rat	43	44	45	63	65	66
Trials						
I	296	348	98	525	1223	745
II	527	202	587	91	144	255
III	132	38	128	118	122	52
IV	56	35	73	131	368	46
V	26	33	34	210	159	36
VI	28	15	12	64	22	25

Rat	67	68	69	70	71	72
Trials						
I	53	108	127	393	278	273
II	420	81	911	174	229	119
III	36	94	136	98	156	588
IV	310	30	52	240	50	145
V	76	360	35	43	59	17
VI	28	50	43	291	322	14

NET TIME RECORDS
(inseconds)
3-60-3 rats
(cont.)

Rat	73	75	74
Trials			
I	124	232	279
II	98	458	904
III	70	98	43
IV	172	114	23
V	17	29	18
VI	20	18	17

PATERSON'S DATA
DISTANCE RECORDS
(in inches)
6-60-6 rats

Rats	2	3	5	6	7	8
Trials						
I	111	188	133	214	302	227
II	123	113	153	86	110	225
III	70	53	67	128	71	168
IV	66	44	149	43	47	46
V	37	46	83	69	40	29
VI	45	53	69	20	29	19
VII	111	69	116	40	72	84
VIII	38	23	44	47	34	27
IX	36	25	38	47	20	19
X	40	19	68	39	20	19
X	25	19	33	20	19	19
XII	19	19	29	19	24	19

PATERSON'S DATA
DISTANCE RECORDS
(in inches)
6-60-6 rats (cont.)

Rats	9	10	11	18	20	24	25
Trials							
1	237	175	219	445	699	298	238
2	50	114	135	190	50	152	113
3	44	41	119	143	46	22	101
4	49	49	50	160	19	43	90
5	49	42	44	33	27	20	36
6	43	55	37	33	27	48	39
7	62	45	49	29	43	45	142
8	30	46	23	26	29	38	65
9	19	41	39	30	18	25	63
10	18	30	30	19	18	19	81
11	34	30	18	22	22	19	81
12	19	42	38	18	35	19	24

PATERSON'S DATA
DISTANCE RECORDS
(in inches)
6-60-6 rats (cont.)

Rat	26	28	29	30	32	33	34
Trials							
1	139	260	203	147	345	190	308
2	76	295	202	93	224	336	72
3	51	390	304	73	108	94	73
4	52	175	91	48	231	100	49
5	21	39	30	178	241	62	72
6	119	51	35	30	117	20	63
7	57	162	49	301	46	59	136
8	25	56	33	55	45	23	46
9	22	39	25	43	28	28	31
10	61	39	22	27	24	18	32
11	20	23	18	27	18	34	21
12	19	31	19	19	18	19	30

PATTERSON'S DATA
DISTANCE RECORDS
(in inches)
6-60-6 rats (cont.)

Rat	35	36	38	40	42	43
Trials						
1	483	333	265	116	158	152
2	68	313	110	122	118	132
3	138	148	89	70	38	64
4	61	141	30	96	43	50
5	34	60	25	34	18	96
6	22	63	25	31	30	47
7	46	51	37	63	65	54
8	27	43	42	46	59	34
9	20	27	19	74	30	47
10	21	113	19	24	21	40
11	22	24	21	23	25	64
12	28	19	31	19	22	42

PATERSON'S DATA
DISTANCE RECORDS
(in inches)
6-60-6 rats(cont.)

Rat	44	47	48
Trials			
1	121	242	198
2	81	220	173
3	73	26	72
4	52	34	50
5	42	33	26
6	29	41	22
7	63	74	44
8	40	38	56
9	27	19	96
10	25	24	27
11	20	40	26
12	26	31	22

PATERSON'S DATA
GROSS TIME RECORDS
(in seconds)
6-60-6 rats

Rat	2	3	5	6	7	8	9	10
Trials								
1	181	484	286	632	700	540	874	611
2	223	186	423	234	172	501	158	264
3	77	69	195	224	90	340	68	80
4	46	35	231	53	30	49	126	84
5	27	33	109	78	29	23	50	48
6	21	35	54	12	22	14	43	57
7	58	55	201	50	126	105	64	55
8	23	11	31	22	26	15	13	24
9	12	10	30	19	11	10	7	22
10	18	18	36	13	10	9	9	17
11	13	13	15	8	10	11	13	40
12	66	6	9	5	16	7	11	34

PATTERSON'S DATA
GROSS TIME RECORDS
(in seconds)
6-60-6 rats (cont.)

Rat	11	18	20	24	25	26	28
Trials							
1	603	611	876	477	370	195	574
2	299	156	41	276	275	154	634
3	320	85	77	16	81	36	470
4	104	89	9	18	48	25	125
5	76	14	18	7	14	9	22
6	47	17	12	18	10	57	20
7	64	40	52	38	180	43	240
8	14	11	11	16	35	10	21
9	23	17	6	11	67	7	12
10	16	7	7	9	39	41	12
11	8	8	13	6	66	6	11
12	22	7	11	5	12	6	11

PATERSON'S DATA
GROSS TIME RECORDS
(in seconds)
6-60-6 rats (cont.)

Rat	29	30	32	33	34	35	36
Trials							
1	470	175	455	281	529	471	441
2	138	88	173	510	59	73	273
3	481	82	64	133	63	90	104
4	49	22	127	88	24	36	97
5	18	163	110	40	38	29	31
6	15	13	34	13	24	10	20
7	26	599	43	56	111	43	56
8	16	35	17	15	19	16	33
9	8	14	11	9	11	8	16
10	11	11	11	11	11	11	155
11	8	15	10	15	9	11	14
12	8	80	6	8	10	12	8

PATERSON'S DATA
GROSS TIME RECORDS
(in seconds)
6-60-6 rats (cont.)

Rat	38	40	42	43	44	47	48
Trials							
1	767	163	285	183	128	319	420
2	145	104	188	170	99	278	243
3	166	82	28	51	43	18	63
4	23	73	22	38	24	17	33
5	10	22	13	81	21	18	9
6	13	16	17	31	11	16	8
7	40	129	63	123	176	202	181
8	27	113	42	20	31	29	51
9	14	205	14	41	11	11	157
10	10	15	13	16	25	12	18
11	10	15	12	33	18	22	16
12	38	10	8	21	10	12	11

PATTERSON'S DATA
NET TIME RECORD
(in seconds)
6-60-6 rats

Rat	2	3	5	6	7	8	9	10
Trials								
1	178	390	252	459	540	356	584	357
2	200	168	361	194	142	375	91	190
3	75	68	156	212	74	232	58	70
4	46	34	190	49	29	44	78	62
5	26	33	104	68	28	23	42	37
6	21	33	51	12	22	14	39	43
7	55	44	172	34	79	74	50	34
8	19	11	28	20	24	15	13	23
9	12	10	30	19	11	10	7	19
10	18	7	35	13	10	9	9	17
11	13	6	15	8	10	11	13	37
12	6	6	9	5	16	7	9	30

PATERSON'S DATA
NET TIME RECORDS
(in seconds)
6-60-6-rats (cont.)

Rat	11	18	20	24	25	26	28
Trials							
1	411	518	744	311	239	122	410
2	246	128	38	173	199	107	394
3	217	58	62	15	73	31	387
4	84	83	9	18	46	24	122
5	60	14	18	7	14	9	22
6	41	17	12	18	10	57	20
7	34	26	30	32	144	37	177
8	14	11	11	16	35	10	21
9	23	17	6	11	65	7	12
10	16	7	7	9	39	39	12
11	8	8	13	6	62	6	11
12	22	7	11	5	12	6	11

PATERSON'S DATA
NET TIME RECORDS
(in seconds)
6-60-6 rats (cont.)

Rat	29	30	32	33	34	35	36
Trials							
1	288	152	333	210	406	403	344
2	131	77	156	352	50	62	221
3	299	65	62	107	58	88	97
4	46	22	118	84	24	35	92
5	18	129	109	38	38	29	31
6	15	13	34	13	24	10	20
7	26	385	40	51	97	38	50
8	16	31	17	15	19	16	30
9	8	14	11	9	11	8	16
10	11	11	11	11	11	9	130
11	8	15	10	15	9	11	12
12	8	10	6	8	10	11	8

PATERSON'S DATA
NET TILE RECORDS
6-60-6 rats (cont.)
(in seconds)

Rat	38	40	42	43	44	47	48
Trials							
1	424	130	186	132	109	242	215
2	100	88	128	135	86	207	179
3	116	68	23	45	41	18	53
4	20	65	22	33	22	17	27
5	10	19	13	76	21	18	9
6	13	16	17	28	11	16	8
7	19	93	51	66	83	109	128
8	25	65	38	17	25	26	43
9	11	125	14	32	11	11	116
10	9	13	12	16	21	12	17
11	10	14	12	33	18	22	15
12	27	10	8	21	10	12	11