THE CORRELATION BETWEEN A HULLIAN CONSTANT AND INTELLIGENCE

by

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A Thesis Submitted to
the faculty of the Graduate School at
The University of North Carolina at Greensboro
in Partial Fulfillment
of the Requirements for the Degree
Master of Arts

Greensboro
April, 1966

Approved by

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APPROVAL SHEET

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April 28, 1966
Date of Examination

ABSTRACT

Hull has suggested the use of the constants found in behavioral equations as measures of individual differences. The present paper suggests that the constant, *a*, in Hull's formulation for habit strength, might serve as a measure of individual differences in learning ability, and attempts to explore that possibility.

A learning task was administered to 32 Ss. The *a*-factor for each S was extracted from his performance data, and an IQ for each S was obtained. A product-moment correlation coefficient as computed between these *a*-factors and IQ's was found to be, .363, significant above the .05 level of confidence. A product-moment correlation coefficient as computed between *a*-factors and teacher ratings of learning ability was found to be not significant. The use of the *a*-factor as a measure of infant intelligence, and to discriminate among truly retarded children and children who are retarded because of emotional or training privations, was discussed. On the basis of the significant correlation between *a*-factor and IQ, further study was suggested.

ACKNOWLEDGEMENTS

The author is indebted to the administration and faculty of Andrew Lewis High School, Salem, Virginia, for their aid in gathering data for this study. Their cooperation was more than could have been expected, and it shortened the time devoted to data gathering to the point that it was considerably less than normal.

Acknowledgement is also due Dr. Kendon Smith for his advice throughout the study and for his suggestions while revising the manuscript; to Dr. William S. Ray, for his advice and guidance in mathematical theory; and to Miss Dorothy Smiley, for her aid in the computations.

Finally, the author would like to thank the members of his family for their understanding and their moral support throughout the period the study was in progress.

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INTRODUCTION

In his _Principles of Behavior_, Hull (1943) discusses the nature of theories, particularly of his own mathematico-deductive theory of learning. A theory, to Hull, means, "A systematic deductive derivation of the secondary principles of observable phenomena from a relatively small number of primary principles or postulates" (Hull, 1943, p. 2). Empirical observation and theory-building are seen as going hand and hand. One takes a few fundamental postulates, based either on general empirical findings or on indirect verification, and tests their validity with further empirical observation. More specifically, Hull himself postulates certain intervening variables (unobservable entities) which are to account for observable behavior. These variables are linked either logically or mathematically both to observable antecedent conditions and to observable responses. From these relationships are deduced theorems and corollaries, from which testable predictions are made.

In _Principles of Behavior_ and later works, Hull (1943, 1951, 1952) advances and revises postulates which deal with sensory impulses generated in receptor organs and with the consequent excitation of afferent tissue (Postulate 1), with the interaction of simultaneous afferent impulses (Postulate 2), and with the innate potentialities of an organism's receptor-effector systems for bringing about need-reduction (Postulate 3). He then goes on to specify 14 additional postulates. In the present paper, however, we are primarily concerned with Postulates 4, 5, 6, 7, 8, and 17.

In essence, Postulate 4 states that whenever an effector activity occurs in close temporal contiguity with receptor activity, and this S-R connection is closely associated with a diminution of a need, there will result an increment of strength in the potentiality of that afferent impulse to evoke that reaction on later occasions; and such increments summate in a manner which yields combined Habit Strength ($_{S}H_{R}$) as a simple, positive growth-function of the number of reinforcements, n. This growth-function is a negatively accelerated curve in which the gains are initially high but of magnitude which diminishes gradually with successive reinforcements. The curve may be represented by the equation, $_{S}H_{R} = (1-10^{-an})$, where a is an empirical constant and n is the number of the reinforced trial. Here, then, is Hull's intervening variable for learning.

It is important to note that learning, according to Hull, depends only on the number of reinforced trials. Other factors are regarded as having no influence on $_{S}H_{R}$. Rather, they serve to change the overt performance level as measured by observable responses. In this connection, Postulates 5, 6, 7, and 8 deal with Drive (D), Incentive Motivation (K), and Stimulus Intensity Dynamism (V). These postulates state that V, D, and K act merely as multipliers of habit strength in the production of Reaction Potential ($_{S}E_{R}$). The general equation then becomes, $_{S}E_{R} = VDK(1-10^{-an})$.

Finally, $_{S}E_{R}$ itself is an intervening variable. It is defined as the strength of tendency to respond, and it is an inferred process close to overt performance. Overt performance, P, is therefore essentially a function of $_{S}E_{R}$, and we may thus say that P is a function of $VDK(1-10^{-an})$.

It is evident that drive, motivation, and stimulus intensity have no bearing on the progress of learning _per se_. In any given learning task the value of the expression representing habit strength, $(1-10^{-an})$, depends on only 2 variables: _n_, the number of the reinforced trial; and _a_, _which varies from individual to individual_ (Postulate 17). Furthermore, the value of the total expression always approaches unity, which is to say, full habit strength for that particular learning situation. Thus, in the general equation, $P = VDK(1-10^{-an})$, performance, P, approaches the value of the product of V, D, and K. This formulation emphasizes the fact that drive, motivation, and stimulus intensity merely determine performance level and have nothing to do with the acquisition of habit strength itself. If the product of V, D, and K be rendered as the constant, M; then $P = M(1-10^{-an})$, and M becomes the asymptote toward which performance tends.

Experimental work with animals lends support to Hull's position. Crespi (1942, 1944), using a runway and measuring performance by speed of running, found that his rats reached asymptotic level of performance at the same time, on the average, regardless of the amount of incentive. Zeaman (1949), employing latency as a measure of performance, found also that the rate of approach to asymptotic level of performance was the same for any given amount of incentive. Strassburger (1950), using a Skinner box and measuring habit strength by resistance to extinction, found that varying deprivation time has no effect on habit strength. Teel (1952), using a unit T-maze, and using longer deprivation times than Strassburger, found that variation in drive level had no effect on habit strength as measured by resistance to extinction. On the other hand, Reynolds (1949), employing resistance to extinction as a measure of habit strength, found learning under low drive to be superior to learning under high drive. All in all, however, Kimble (1961, p. 416) has concluded that Hull's theory has at least not been refuted.

What is the constant, a, in Hull's general equation? Clearly it defines the fractional part of the unrealized distance to asymptote (M) which is added to performance level on each trial. Hull's position, then, is this: in a given learning situation there is a maximal level of performance depending on the biological conditions within the organism at that time. This level may vary from occasion to occasion, but the actual acquisition of habit strength is not affected, because it always approaches unity for that particular occasion.

It follows from the foregoing considerations that if a number of individuals are engaged in the same learning task under the same conditions, and if they each generate a learning curve of the form $P = M(1-10^{-an})$, then, inasmuch as everything else remains constant, the a-factor will determine the shape of each curve as it approaches asymptote.

There is a practical significance to this discussion. If V, D, and K merely determine asymptotic level and do not affect the rate of approach to this level, then, in any given situation, a determines the rate of approach or acquisition and could be used as an index of learning ability uncontaminated by drive, motivation, and stimulus intensity. If Hull is correct, we should be able to extract a value for a from empirical data and use that value as an index of basic ability to learn. Such a development might well solve some of our problems in the testing of intelligence.

Present intelligence testing rests for the most part on level of achievement (i.e., on the performance of the individual as compared with that of other individuals in his age group). Inasmuch as IQ's are based on relative achievement; and, inasmuch as achievement is a matter of performance; and, inasmuch as we know that performance is affected by drive, motivation, and stimulus conditions; we have to expect wide fluctuations in IQ-measures both over short periods of time and throughout the life span. Hull's a-factor might be a more stable measure of ability to learn.

There might also be other benefits. Lower age groups do not have the skills required to participate meaningfully in present testing programs. The use of Hull's equation might allow the construction of simpler testing procedures. This is to say, any learning task which generated an exponential curve would permit the extraction of a measure of the ability to learn. Simple tasks could also be used to discriminate between the truly retarded and those who perform at a low level because of emotional or training privations. Finally, test conditions, motivational factors, time of day, and so on, would no longer need to be carefully controlled.

In spite of these potentialities, a search of the literature indicates that since Hull advanced his concept of individual differences (Hull, 1945, 1951, 1952), no one has studied its possibilities. As late as 1964, Adams (1964, p. 193) says that Hull's views on individual differences seem sound enough, but neither Hull nor anyone else has studied the relation between individual differences and the constants found in behavioral equations.

PURPOSE

The first object of the present study was to obtain empirical measures from a number of subjects (Ss), to isolate the a-factor for each, and to correlate the values thus obtained with IQ's secured from accepted scales. If Hull is correct, there ought to be some relationship between rate of real-life learning as measured by IQ and the rate of learning as Hull defines it. Hypothesis 1, therefore, was that there would be a significant relationship between a-factors obtained from an analysis of empirical data and IQ's obtained from an accepted scale.

Because IQ scores may or may not be measuring learning ability as Hull defines it, an attempt was also made to establish a relationship between a and another criterion of learning ability. A second hypothesis was, therefore, that there would be a significant relationship between Hull's a and a criterion of learning ability quite apart from IQ.

Earlier discussion suggested the possibility of discriminating between the truly retarded and those who score poorly on standard tests because of emotional or training privations. In accordance with the logic of this discussion, an analysis was made of the ability of a to discriminate among Ss with low IQ scores.

METHOD

Subjects

Random-sampling procedures were used to select 45 Ss from a total of 354 eighth-grade students at Andrew Lewis High School, Salem, Virginia. The numbers 1 through 354 were assigned to the respective names on the eighth-grade roster, and numbers were then selected as they appeared in a table of random numbers (Li, 1957). When 45 numbers had been selected, the sample was complete. The students to whom these numbers referred were used as Ss in this study. After the sample was drawn, it was found that 3 Ss had been used in preparing for the present study. They were therefore eliminated. On the day of the test, 5 Ss were absent from school, and another 5 arrived at the test site too late to participate. Thus, the total number of effective Ss was 32.

Task

The memorization and recall of a list of 16 nonsense syllables was the task employed.

Materials

Sixteen CVC trigrams of low associative value were chosen from a recently calibrated list (Archer, 1960). The 16 trigrams were arranged into 16 different lists, each list containing the same trigrams in different order. The order of the trigrams in any list was random. That is to say, each trigram was given a number from 1 to 16. The numbers 1 through 16 were selected as they appeared in a table of random numbers (Li, 1957). When all of the numbers, 1 through 16, had appeared, the first of the 16 lists was complete. The same procedure was then repeated until 16 lists were on hand. (A representative CVC list is reproduced in Appendix A.)

The lists were then prepared for presentation to the Ss. Each list was multilithed on a separate $5\frac{1}{2}$ x $8\frac{1}{2}$ inch sheet of white cardboard. Answer sheets of lined, white paper, size 7 x $8\frac{1}{2}$ inches, were also prepared, and pencils were provided.

Procedure

The test-site was the cafeteria of the school. Security against interruptions was provided by the school authorities. Lighting conditions were uniform throughout the testing area, and noise was at a minimum. A chair was provided for each S; chairs were placed approximately 5 feet apart at long tables.

Before the Ss arrived, a pile of 17 lined answer sheets was placed on the table directly in front of each chair. The sheets were numbered from 0 to 16, the numbers appearing in the upper right-hand corners of the sheets. A pencil was placed on top of each pile. Seventeen white cards, containing the 16 lists of trigrams and a practice list of entirely different trigrams, were placed in a pile to the left of the answer sheets. The cards were in the same order for all Ss, were numbered 0 (the practice list) through 16, and were face down.

When the Ss arrived, they were seated and given the following instructions:

Ss were told to write their full names at the top of the sheet marked 0. They were then to take the top white card, containing the practice list, and study it for 30 seconds; whereupon they were to turn the card over and place it face-down on the far edge of the table. Ss were then to begin writing immediately, on the first answer sheet (0), as many of the trigrams as they were able to recall. Recall time was to be limited to 1 minute. Ss were then to turn this answer sheet over and place it face down on top of the used practice card at the far edge of the table. At this point additional time for any questions was to be allowed. Ss were then to take the first test card from their left and begin studying this card. The procedure just established was thereupon to be followed until all 16 lists had been studied and recalled as well as possible. Ss were told they need not write the recalled trigrams in the same order as they appeared on the study cards. In order to help insure interest and attention, a $1.00 prize was offered to the 5 highest-scoring participants.

Ss were given the practice trial, and, both before and after the practice trial, every effort was made to see that all Ss understood the nature of the task and procedures. The actual learning task was then prosecuted. E used a stopwatch and signalled orally the beginning and end of the various periods. Attendants were stationed throughout the area, as a source of extra pencils and as a precaution against possible cheating.

The length of the period from the beginning of instructions until the completion of the test was 40 minutes. The test was begun at 11:00 a. m., January 12, 1966.

RESULTS

When work began on the extraction of the constant, a, for each S, several problems arose. The nature of the mathematical derivation of a necessitated a knowledge of the value of the corresponding M. Although it would have been possible to derive the value of M by means of a computer, it was thought that this course would be too-time-consuming and costly for this study. It was therefore decided to estimate the value of M for each S.

In arriving at a value of M, it was necessary to recognize that the nature of the mathematical operations required in finding a demanded the use of the logarithm of $(\frac{M-P}{M})$. Because one cannot take the logarithm of a negative number, and because the logarithm of 0 is undefined, M had to be estimated as being higher than any of the empirical P's; otherwise, some of the data would have been rendered meaningless. It was therefore decided to estimate each subject's M as the subject's highest P-value, plus one.

The method of extracting a-values was the standard approach for fitting a straight line by the method of least squares. The equation, $P = M(1-10^{-an})$, was transformed to $\log(\frac{M-P}{M}) = -an$. $\text{Log}(\frac{M-P}{M})$ is a linear function of n, the number of the trial; -a is the slope and also the regression coefficient for the best-fitting straight line. The value of -a can be computed by the usual formula for the regression coefficient, $b_{yx} = \frac{Vxy}{Vx}$ (Ray, 1962, p. 136). In the computing formula for the regression coefficient, Y becomes $\log(\frac{M-P}{M})$ and X becomes n.

After computing a for each S, values of a and M for that S were substituted back into the equation, $P = M(1-10^{-an})$, and values of P were computed for each trial for the S. The resulting curves, fitted to the empirical data, are displayed in Appendix B. The _a_-values for Ss 31 and 32 are too low to produce any meaningful plot. The empirical data are shown, nevertheless, for these Ss.

The requisite IQ-score for each S was readily available from school records. All Ss had been tested on the California Test of Mental Maturity 1 year prior to the date of this study. _These 1-year old IQ-scores were used in this study_. Time and cost factors prevented the use of current test scores.

Table 1, page 13, displays the Ss' respective _a_'s and IQ's. When a product-moment correlation coefficient is computed as between these 2 sets of scores, it is found to be .363. This value is significant above the .05 level of confidence. Hypothesis 1 is therefore confirmed.

In order to test the second hypothesis, a criterion other than IQ was needed, and it was decided to use teachers' ratings. Originally, it was hoped that 3 teachers could be found who would be able to rate a large proportion of the Ss. Because a random sample had been drawn from the entire eighth grade, however, this was impossible. Neither was it possible to find 2 teachers who knew a large number of the same Ss. It was therefore decided to find pairs of teachers who knew small groups of the same Ss and to obtain ratings on as many of the total sample as possible. The best that could be done was to identify 4 small groups (containing 5, 5, 4, and 4 Ss respectively). All of the members of each group were known by 2 teachers.

The 2 teachers were asked to rate each S in their group on his "learning ability." The teachers were carefully instructed to "disregard motivation, past performance, IQ's, and personal factors." Appendix C reproduces the form which teachers used for their ratings. The 2 ratings were averaged for each student, and mean ratings were correlated with a-factors. Table 2, page 14, compares a-factors and teacher-ratings for each group. When product-moment correlation coefficients are computed for these figures, they are found to be these: for group 1, -.614; for group 2, .740; for group 3, -.207; and for group 4, -.867. None of these coefficients is significant. When, using Fisher's method of z' transformation, these 4 coefficients are combined, the resulting correlation coefficient is found to be -.310. This value is not significant. Hypothesis 2 is therefore rejected.

In order to test the third hypothesis, teacher ratings were also used. It was impossible to find even 1 teacher who knew all of the Ss in the lower 25% of the group in respect to IQ scores. A teacher was found, however, who could rate Ss holding 7 of the lowest 9 IQ scores. This teacher was given the same instructions as the other teacher-raters, and she rated the 7 Ss on the same form. Table 3, page 15, compares these ratings with the corresponding a-factors. When a product-moment correlation coefficient is computed for these values, it is found to be .418. This figure is not significant, and hypothesis 3 is, therefore, rejected.

TABLE 1

SUBJECTS' a-FACTORS AND IQ'S

Subject	a-Factors*	IQ
1	.0618	124
2	.0476	97
3	.0281	108
4	.0512	137
5	.0237	95
6	.0704	101
7	.0197	102
8	.0348	131
9	.0560	99
10	.0742	133
11	.0362	83
12	.0347	91
13	.0444	96
14	.0568	108
15	.0516	117
16	.0535	114
17	.0511	110
18	.0547	71
19	.0377	99
20	.0316	89
21	.0508	101
22	.0485	91
23	.0534	98
24	.0471	108
25	.0600	110
26	.0537	88
27	.0611	138
28	.0486	129
29	.0627	114
30	.0330	105
31	.0001	90
32	.0000	98

$r = .363$; $P < .05$ (two-tailed test)

Note: Hull makes it explicit that _a_ be a negative value.

TABLE 2

TEACHERS' RATINGS AND a-FACTORS

	Group 1			Group 2	
S	Ratings	a	S	Ratings	a
6	3.5	.0704	10	7.0	.0742
18	1.5	.0547	12	3.5	.0347
26	2.5	.0537	32	3.5	.0000
20	4.5	.0316	15	4.0	.0516
30	5.0	.0330	19	5.5	.0377

r = -.614 (not significant) r = .740 (not significant)

	Group 3			Group 4	
S	Ratings	a	S	Ratings	a
14	5.5	.0568	7	7.0	.0197
24	5.5	.0471	8	7.0	.0348
27	6.5	.0611	9	4.0	.0560
29	4.0	.0627	23	5.5	.0534

r = -.207 (not significant) r = -.867 (not significant)

The combined correlation coefficient for the 4 groups, using Fisher's z' transformation, is, -.310 (not significant).

TABLE 3

TEACHERS' RATINGS AND a-FACTORS

AMONG STUDENTS HAVING LOW IQ SCORES

S	Ratings	a	IQ
31	1	.0001	90
11	1	.0362	83
12	3	.0347	91
9	3	.0560	99
18	2	.0547	71
22	1	.0485	91
20	2	.0316	89

$r = .418$ (not significant)

DISCUSSION

The primary purpose of the present study was to investigate Hull's suggestion that the empirical constant, a, could be used as a measure of individual differences in learning ability. The author felt that, if Hull was correct, there ought to be some relationship between the rate of learning in a single task and the rate of real-life learning as reflected in the intelligence quotient. While the significant relationship actually found here, between a-factors and IQ's, is by no means conclusive evidence, it does lend support to the author's hypothesis and to Hull's position on innate differences. The significant relationship also suggests further studies with different age groups, different tasks, and larger numbers of Ss. Future studies should investigate systematically any possible effects of V, D, and K on the value of a. If, as was suggested earlier, a-factors might be used as a measure of infant intelligence or in discriminating among retarded children, then a-factors should be tested for stability over long periods of time.

It is important to note that the a-factors extracted from the data in this study vary from .0000 to .0742. This wide range of values suggests that Hull's a-factor would be serviceable as a measure of learning ability.

In the course of the collection and the subsequent analysis of the data of the present study, several unforeseen problems arose. A brief comment on these problems may be of help in evaluating this study and in planning new studies.

First, it was found necessary to estimate asymptotic performance-values for each S, at highest P-value plus 1. This mode of procedure was found to be unsatisfactory for 2 reasons: (1) with several Ss, isolated high scores placed asymptotic values considerably above the average range of scores, and (2) with some Ss, initial high scores were never again equalled or exceeded -- in fact, later scores were considerably lower than initial scores. The problem is, therefore, two-fold. First, M needs to be more accurately determined; and second, the learning task should produce smoother data plots. These inadequacies produced 7 poorly fitted curves out of 32. This is not to say that the fits are not mathematically correct. Rather, the data generated by the task and the method of obtaining asymptotic values produced a curve which is not a good visual fit. It is therefore suggested that in future studies (1) a mathematical derivation of M be used, and (2) a task be chosen which yields a smoother approach to asymptotic level.

The preliminary nature of this study did not permit allowances for such Hullian variables as generalized habit strength and reactive inhibition. The first was controlled as well as possible by the choice of nonsense syllables for the learning task. Inhibitory factors, however, were not controlled. According to Hull's theory, drive must remain constant throughout the learning task; and, since inhibition is considered a drive, all of the conditions were not met. To have allowed for the dissipation of inhibitory factors would have required rest between trials and was a practical impossibility. It was also thought that the nature of the task minimized the inhibitory factor.

It is felt that the use of 1-year-old IQ scores was a major weakness of this study. Time and financial considerations, however, prevented the use of current, individually administered IQ tests. Because this could very well be a major source of error, it is suggested that future studies make provision for current IQ-testing of all Ss.

The second purpose of this study was the attempt to establish a relationship between a and another criterion apart from IQ. The inconclusive nature of the correlation between teacher ratings and a-factors was not wholly unexpected; the inadequacy of the rating system was recognized. In view of the significant results in hypothesis 1, this teacher rating system would no longer seem to be necessary. Rather, considering the unforeseen problems encountered in this study, primary attention should be focused on additional control and care in methodology.

The third object of this study was an analysis of the ability of a to discriminate among Ss with low IQ scores. The nature of the sample again complicated the rating system. It is suggested that, in the future, provisions be made to cover this contingency in the planning stage. In this study, the comparison of teachers' ratings and a-factors was not significant. It should be noted, however, that, of the Ss with IQ scores of 90 or below (Table 1) subject 18 (IQ 71) has an a-factor of .0547. Because a-values in the .05 to .06 range were generally obtained by Ss having IQ's ranging from 88 to 137, we can say that, at least on this learning task, subject 18 learned as well as Ss with considerably higher IQ scores. Furthermore, teachers' ratings, as shown in Tables 2 and 3, placed subject 18 in the "slow" learning category. In this task, therefore, both IQ and teachers' ratings were unable to predict the S's rate of learning.

Admittedly, this is rather slim evidence, but it may justify an attempt to devise a task for a large number of retarded children from which a-factors could be extracted and compared with appropriate criteria.

SUMMARY

The basic purpose of the present study was to test Hull's hypothesis that the empirical constant, a, in the general formula, $_SE_R = VDK\ (1-10^{-an})$, is a measure of individual differences in learning ability.

In order to test this hypothesis, a learning task was administered to 32 junior high school students. The task generated learning curves of the form, $P = M\ (1-10^{-an})$. The a-factors were extracted from the respective students' curves and correlated with the students' IQ's. The resulting correlation coefficient was found to be .363, significant above the .05 level of confidence.

Extracted a-factors were also correlated with teachers' ratings of "learning ability." The correlation coefficients thus obtained were found to be not significant.

An attempt was made to analyze the ability of a-factors to

discriminate among low IQ scores. The results of this test were inconclusive, although it was shown that, with at least 1 S, the *a*-factor suggested considerably more learning ability than the S's IQ score indicated.

Several important weaknesses in the study were discussed, and suggestions made for correcting these inadequacies in future studies.

On the basis of the significant correlation between *a*-factors and IQ's, it was suggested that further study is indicated.

BIBLIOGRAPHY

ADAMS, J. A. Motor skills. Annual Review of Psychology, 1964, XV, 181-202.

ARCHER, E. J. A re-evaluation of the meaningfulness of all possible CVC trigrams. Psychological Monographs, 1960, 74, (10 Whole No. 497).

CRESPI, L. P. Quantitative variation of incentive and performance in the white rat. American Journal of Psychology, 1942, 55, 467-517.

CRESPI, L. P. Amount of reinforcement and level of performance. Psychological Review, 1944, 51, 341-357.

HULL, C. L. Principles of behavior. New York: Appleton-Century-Crofts, 1943.

HULL, C. L. The place of innate individual and species differences in a natural-science theory of behavior. Psychological Review, 1945, 52, 55-60.

HULL, C. L. Essentials of behavior. New Haven: Yale University Press, 1951.

HULL, C. L. A behavior system: an introduction to behavior theory concerning the individual organism. New Haven: Yale University Press, 1952

KIMBLE, G. A. Hilgard and Marquis' conditioning and learning. (2nd ed.) New York: Appleton-Century-Crofts, 1961.

LI, J. Introduction to statistical inference. Ann Arbor, Michigan: Statistics Inc., c/o Edwards Brothers, Inc., 1957.

BIBLIOGRAPHY (continued)

RAY, W. S. Statistics in psychological research. New York: The MacMillan Company, 1962.

REYNOLDS, B. The relationship between strength of a habit and the degree of drive present during acquisition. Journal of Experimental Psychology, 1949, 39, 296-305.

STRASSBURGER, R. C. Resistance to extinction of a conditioned operant as related to drive level at reinforcement. Journal of Experimental Psychology, 1950, 40, 473-487.

TEEL, K. S. Habit strength as a function of motivation during learning. Journal of Comparative and Physiological Psychology, 1952, 45, 188-191.

ZEAMAN, D. Response latency as a function of the amount of reinforcement. Journal of Experimental Psychology, 1949, 39, 466-483.

APPENDIX A

REPRESENTATIVE CVC TRIGRAM LIST

XIC

VAF

FEQ

YIG

CIJ

RIJ

MOJ

QES

POB

NUV

KYH

ZUL

SUW

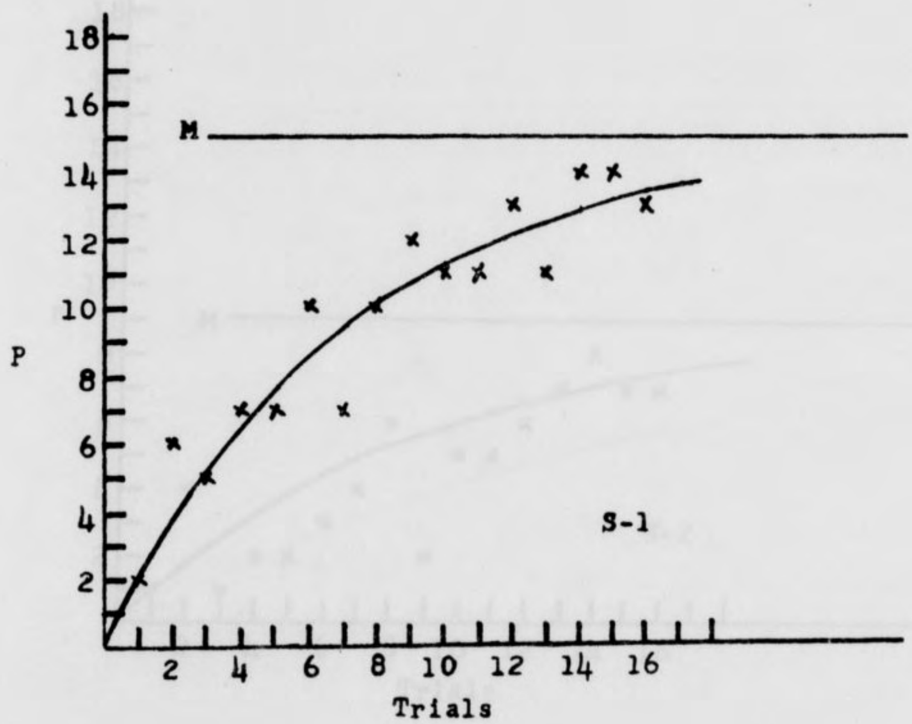
CAX

BEX

VOB

APPENDIX B

SUBJECTS' INDIVIDUAL PERFORMANCE CURVES



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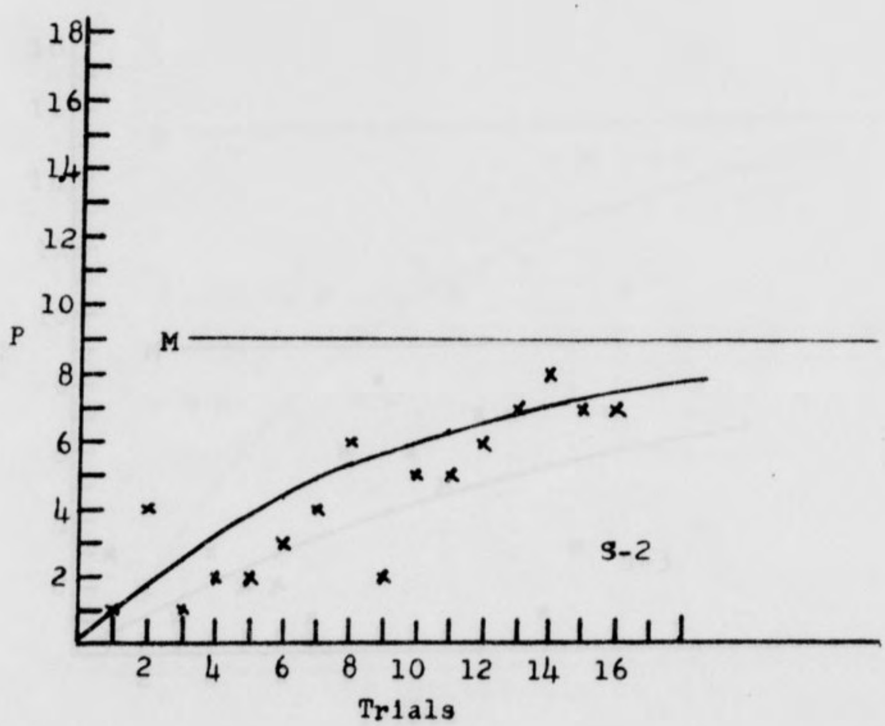

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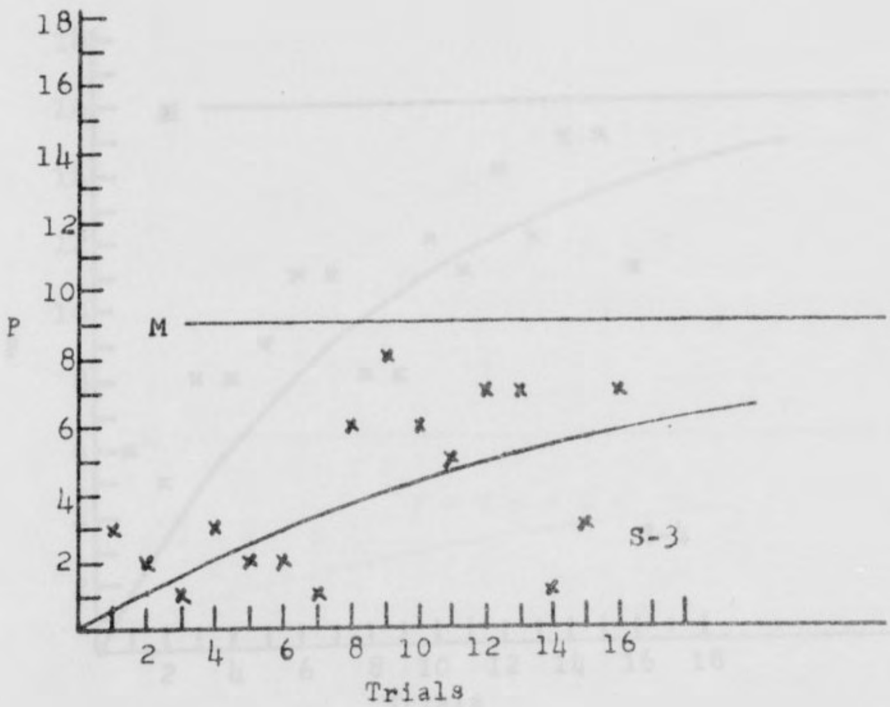

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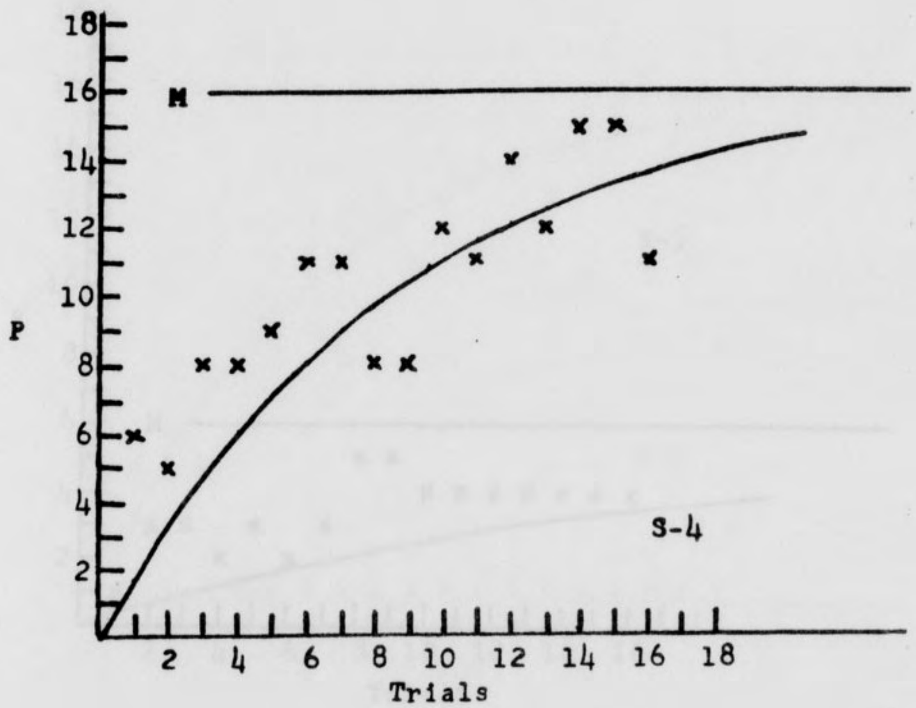

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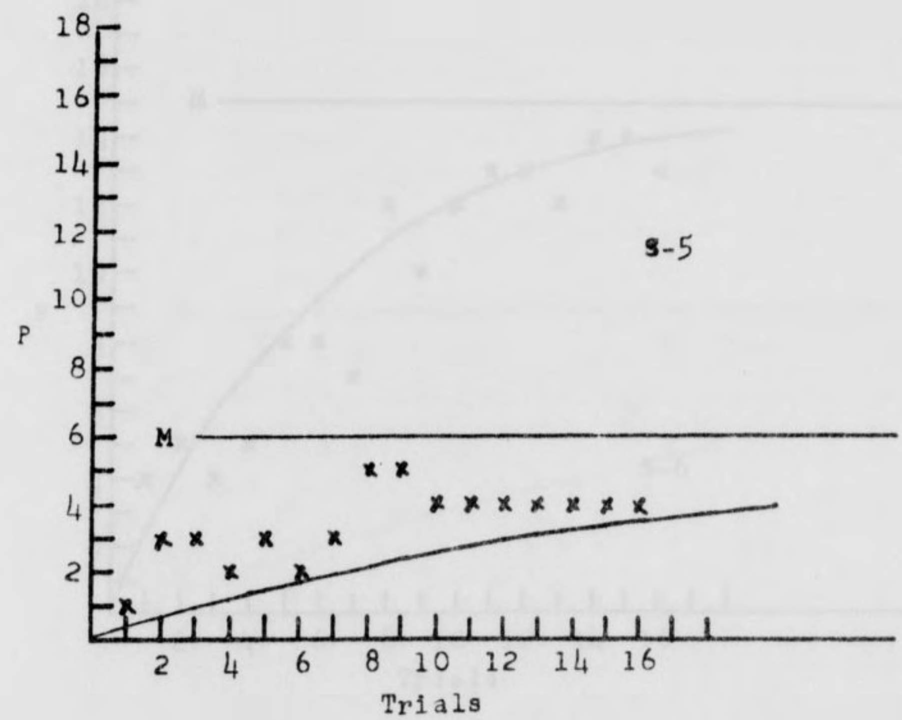

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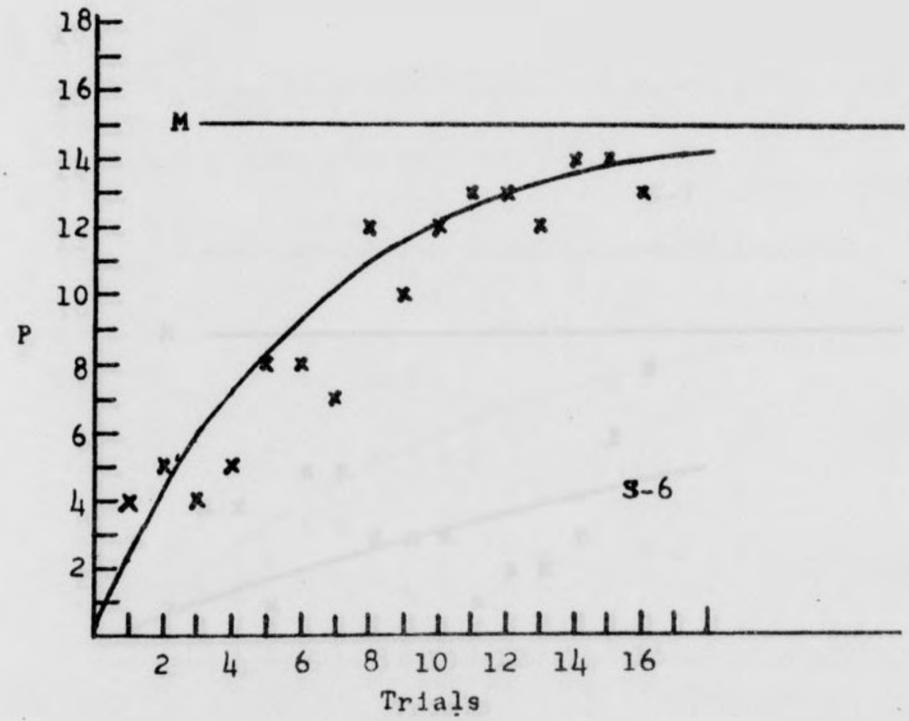

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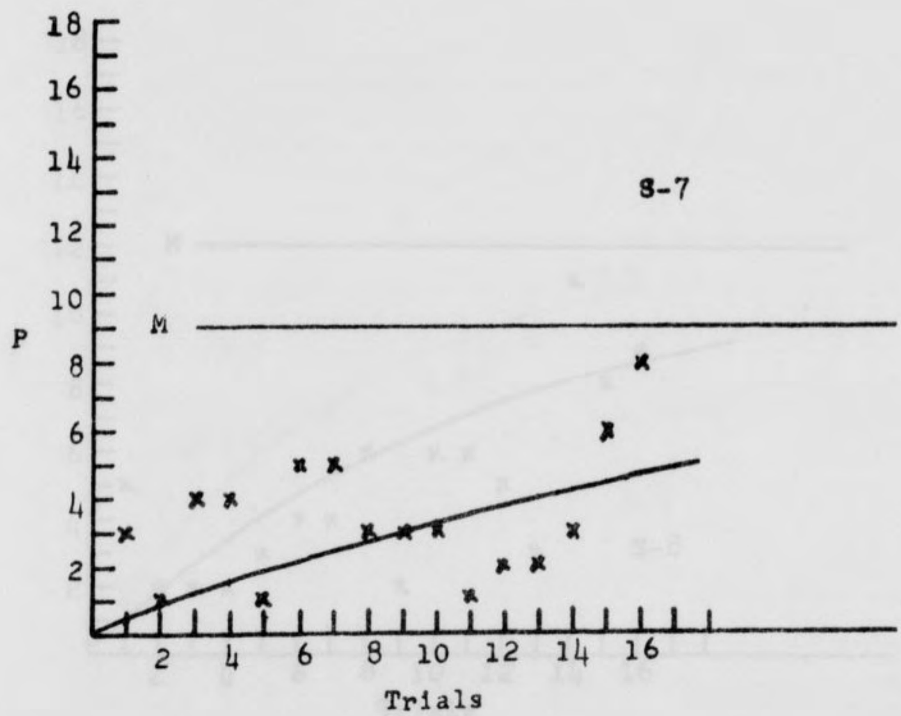

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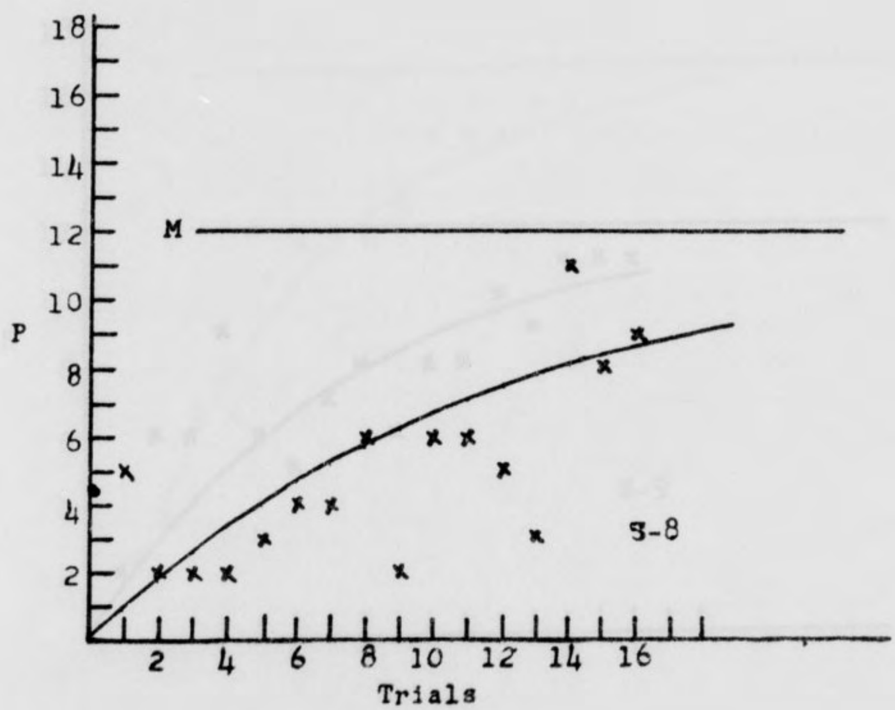

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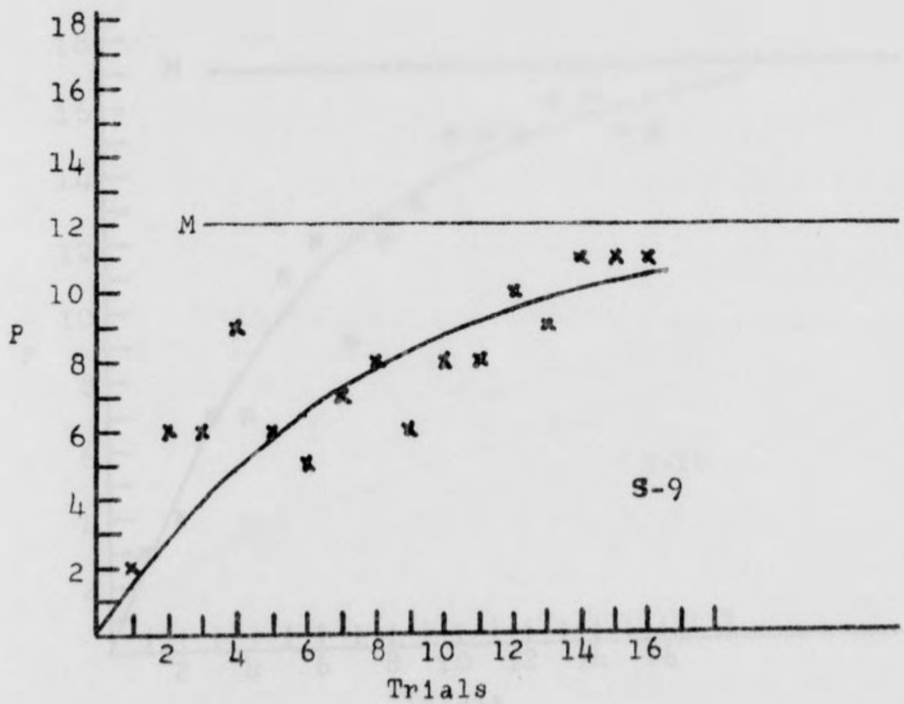

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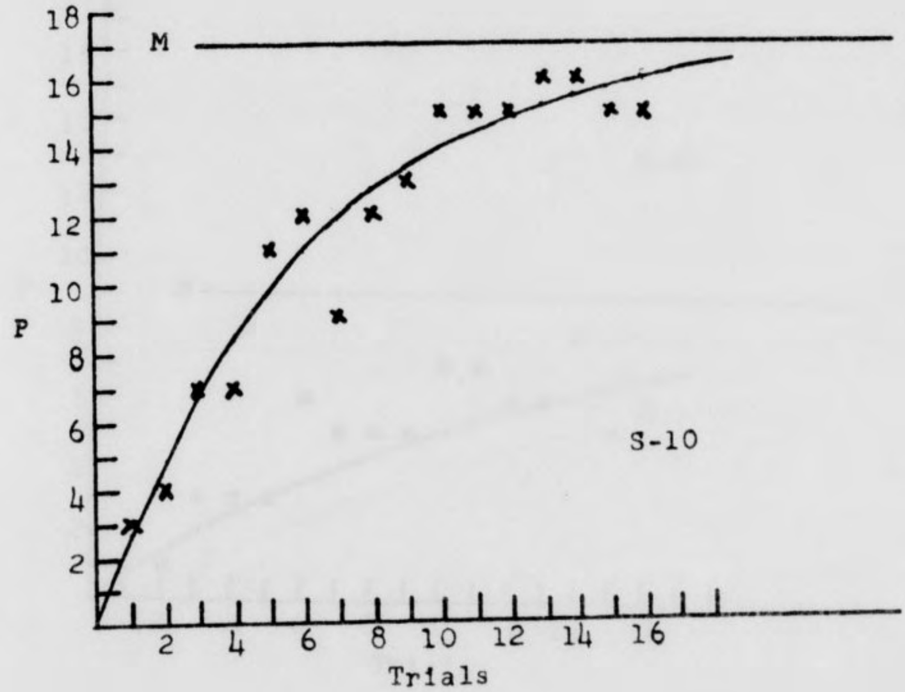

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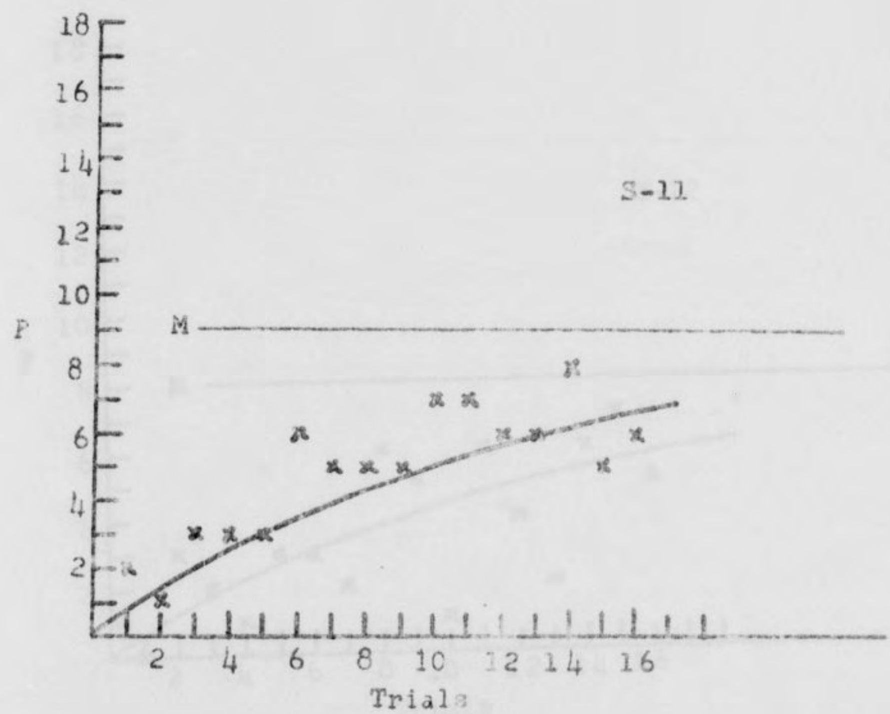

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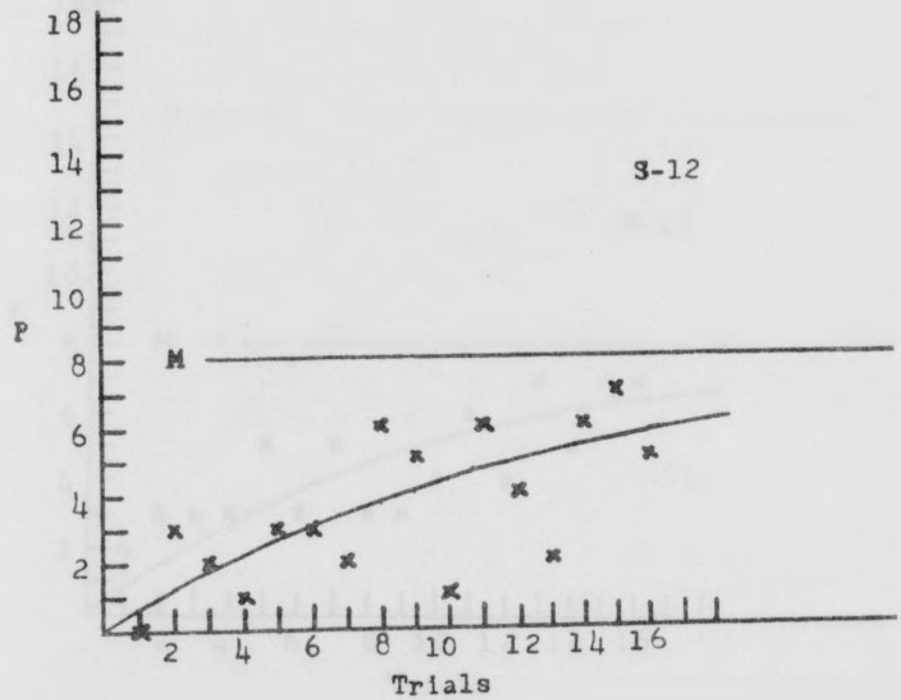

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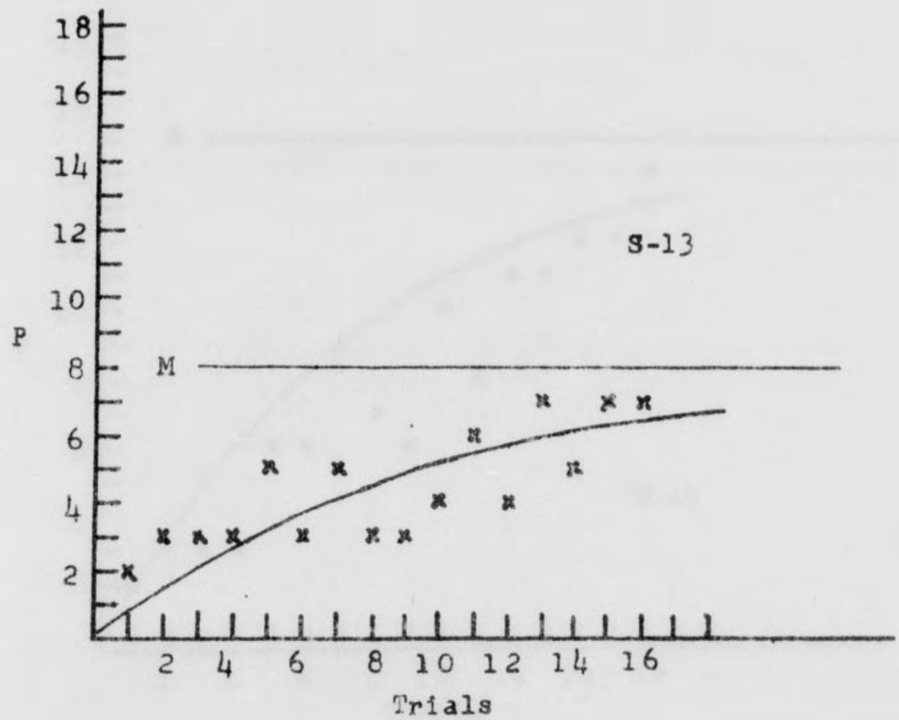

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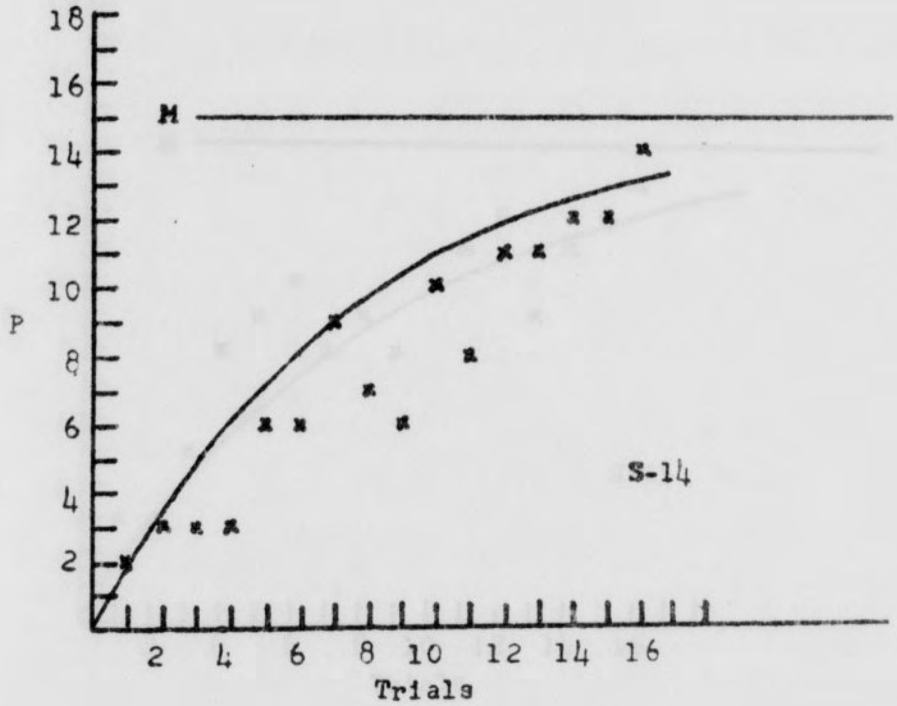

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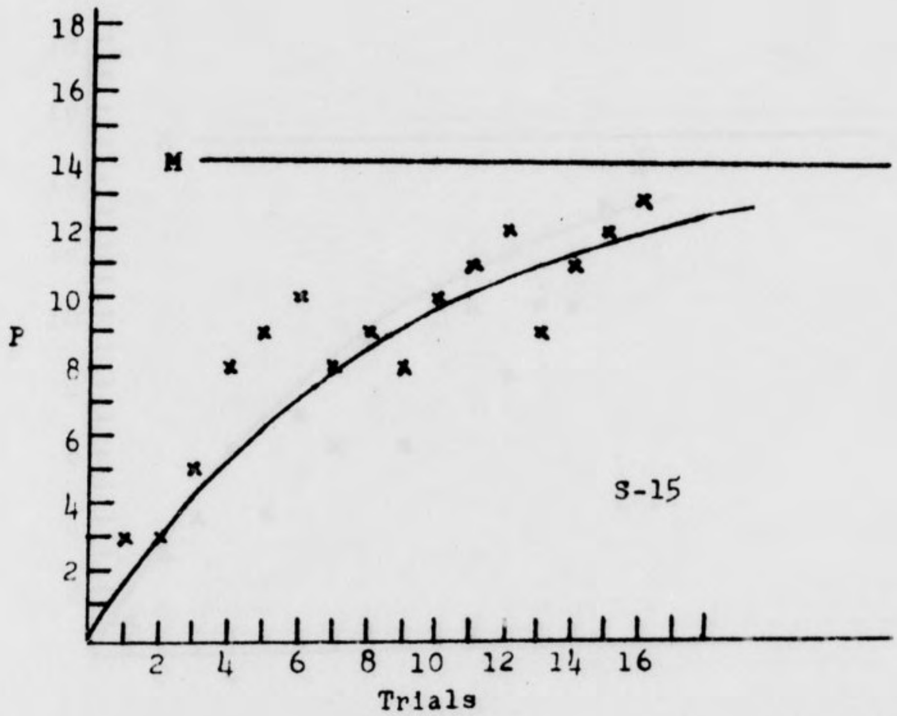

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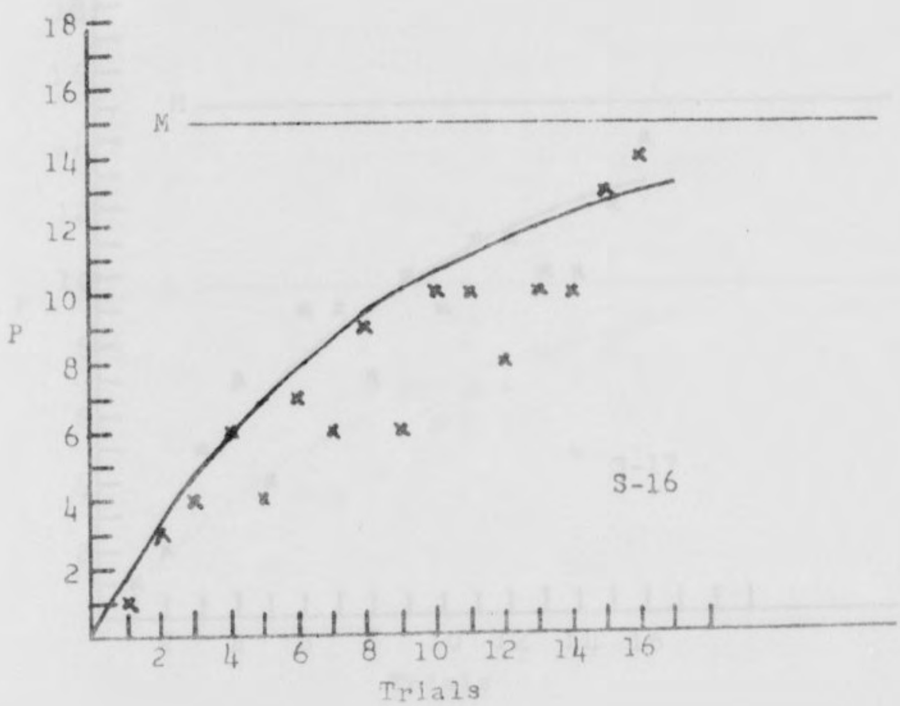

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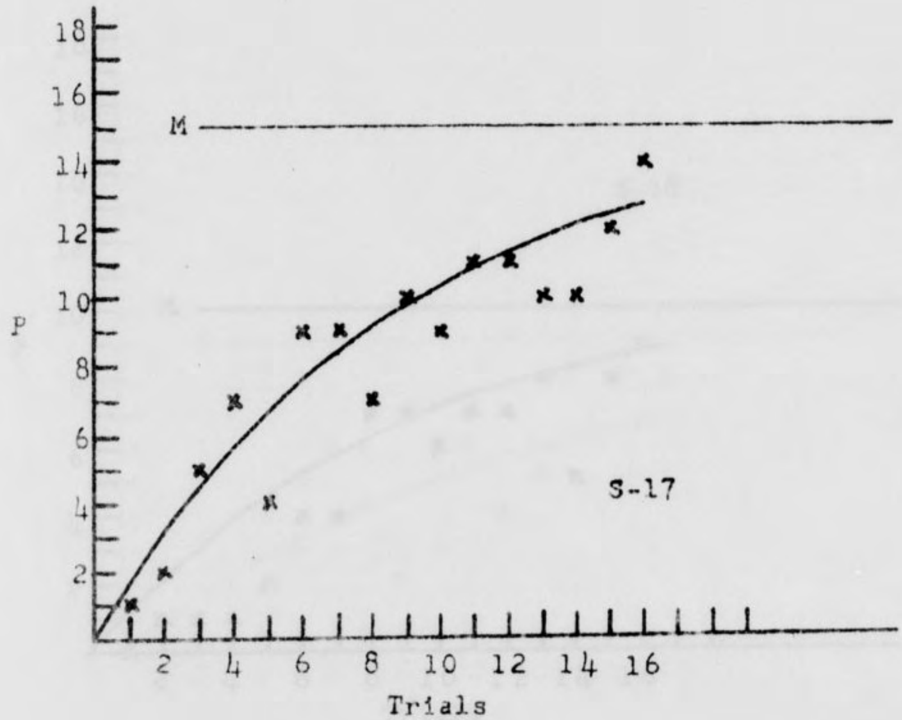

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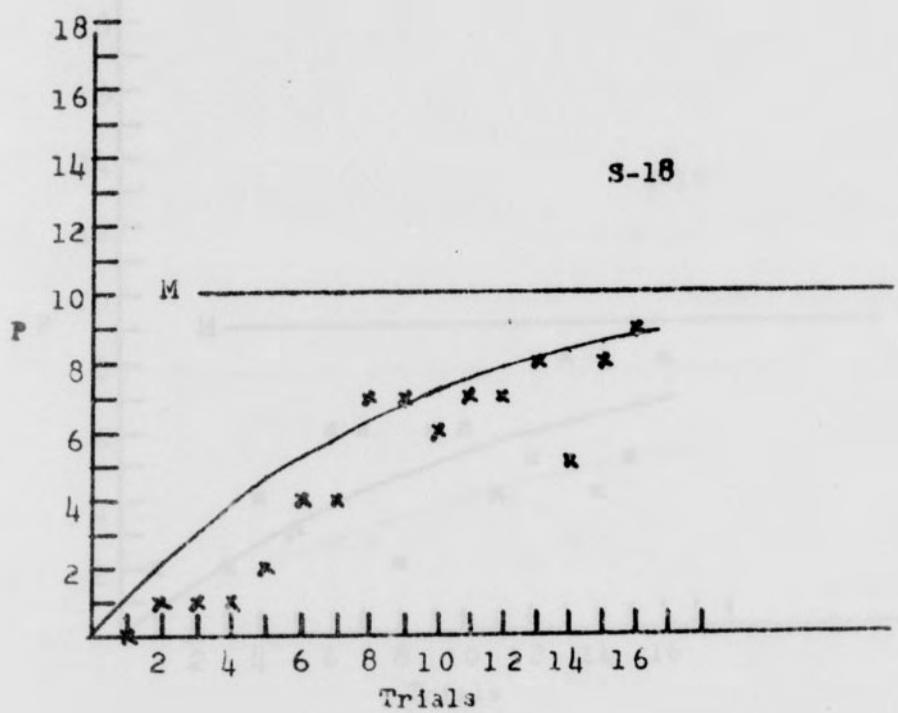

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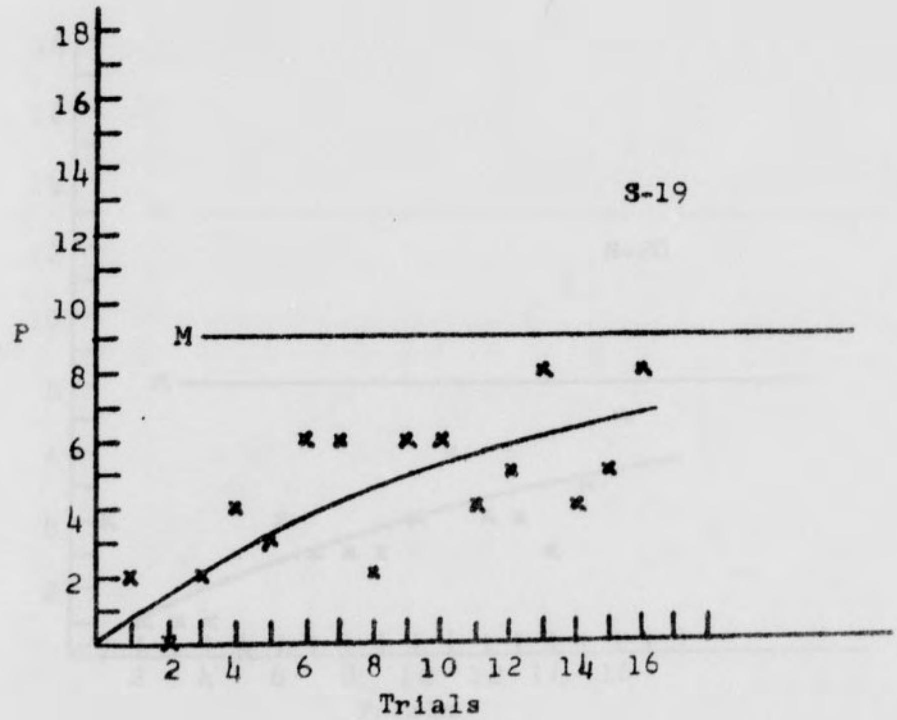

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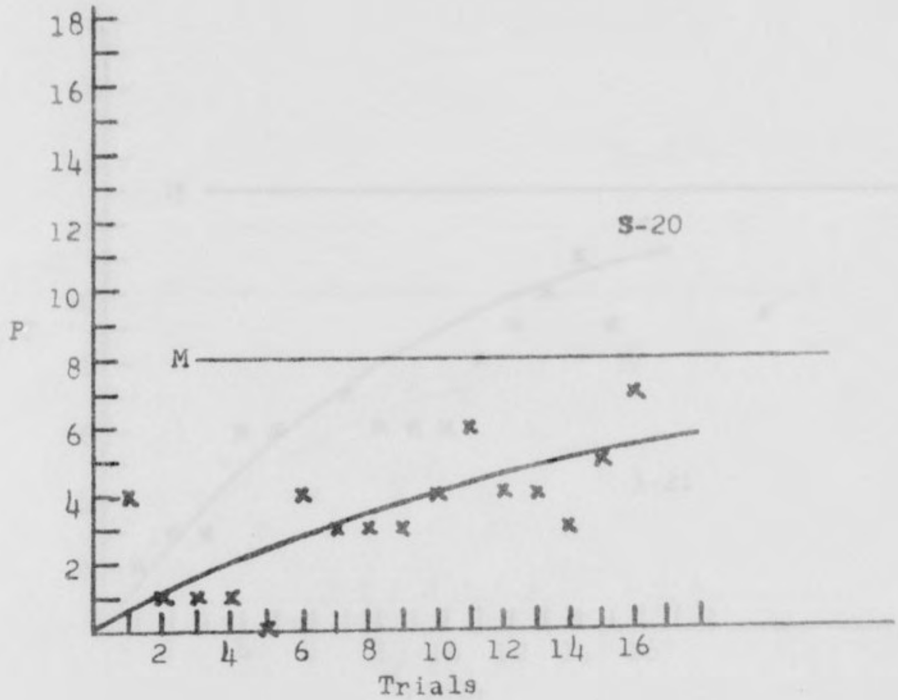

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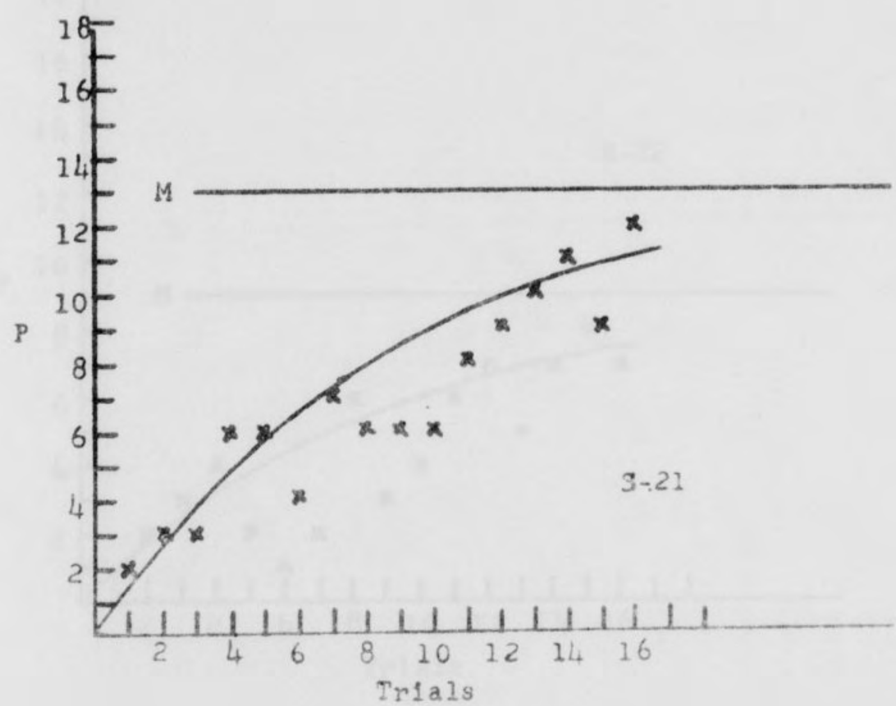

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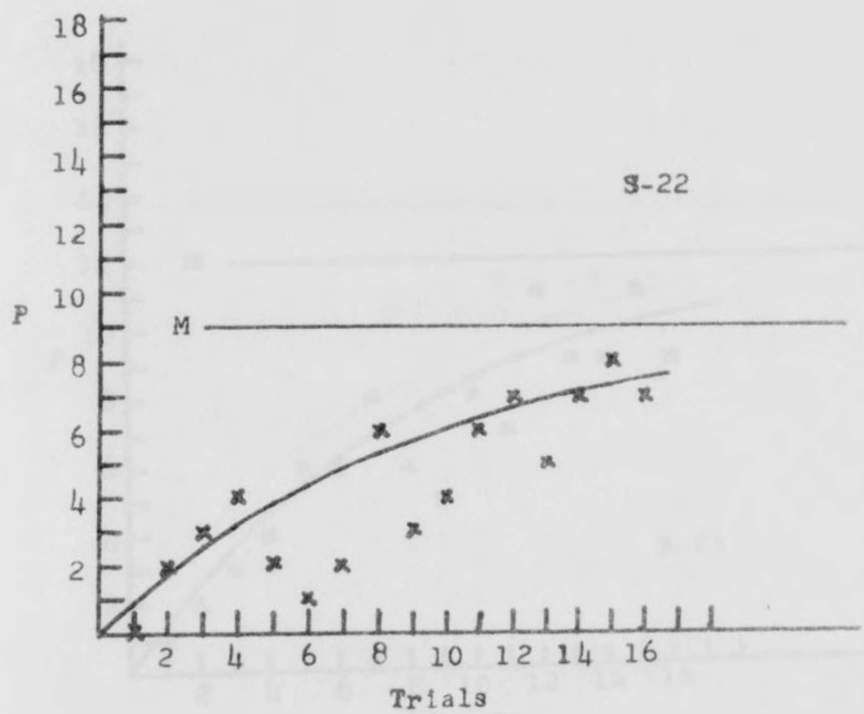

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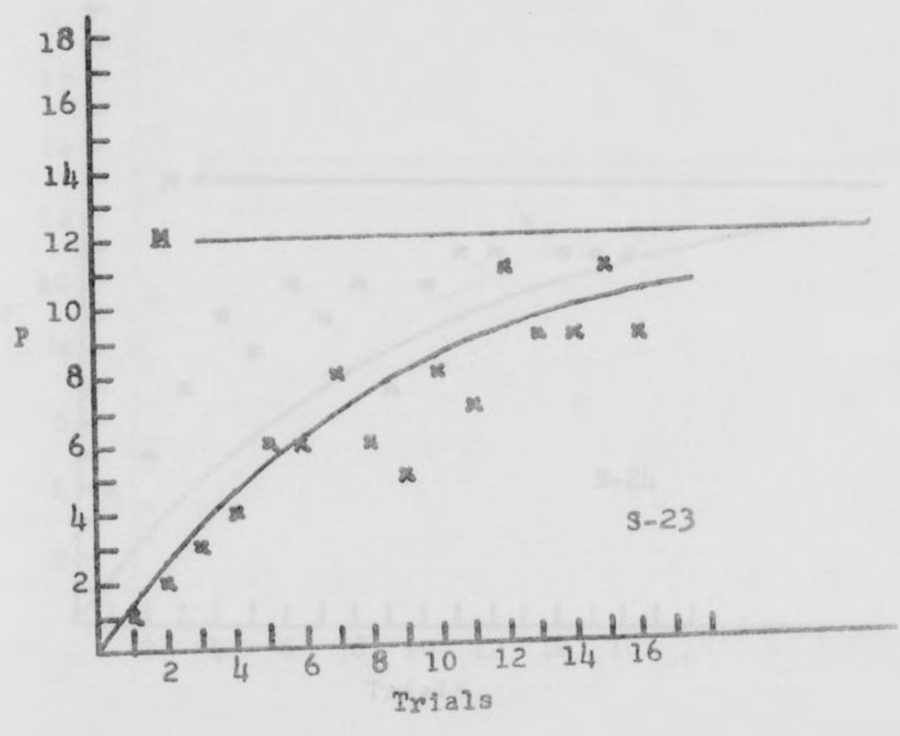

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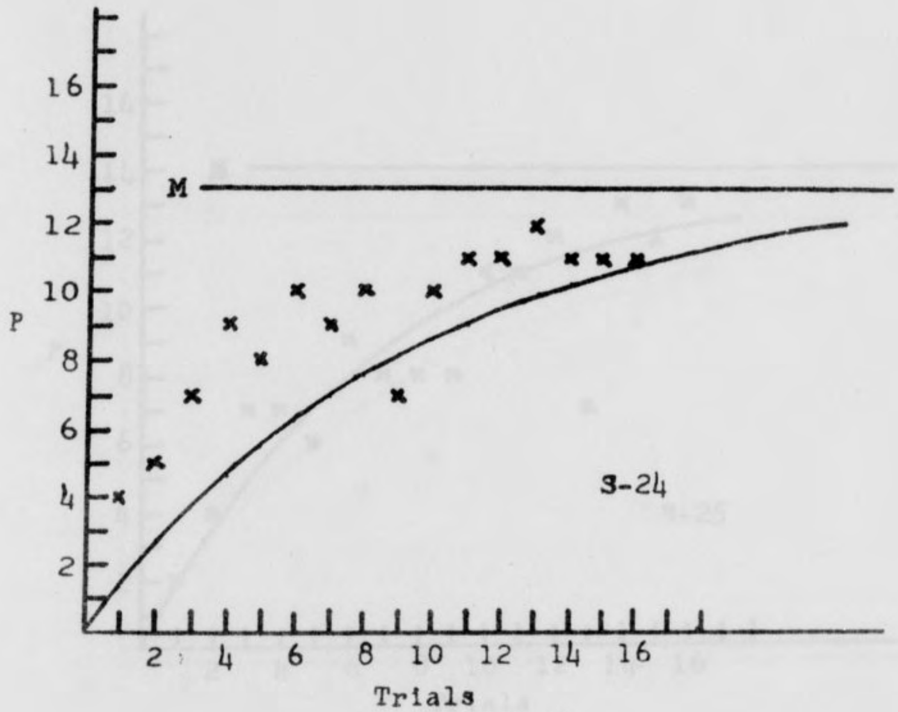

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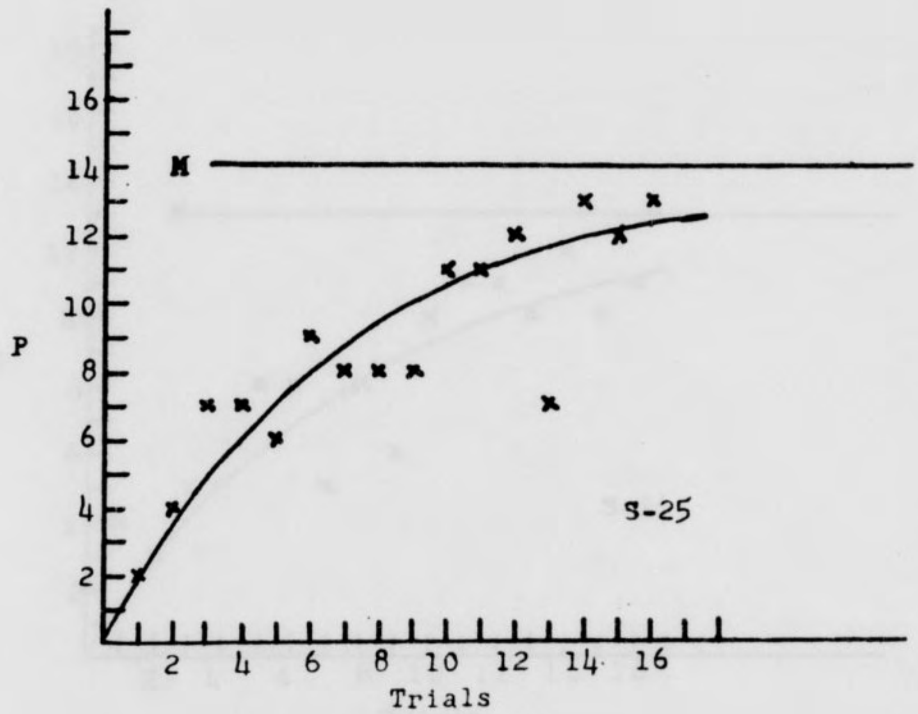

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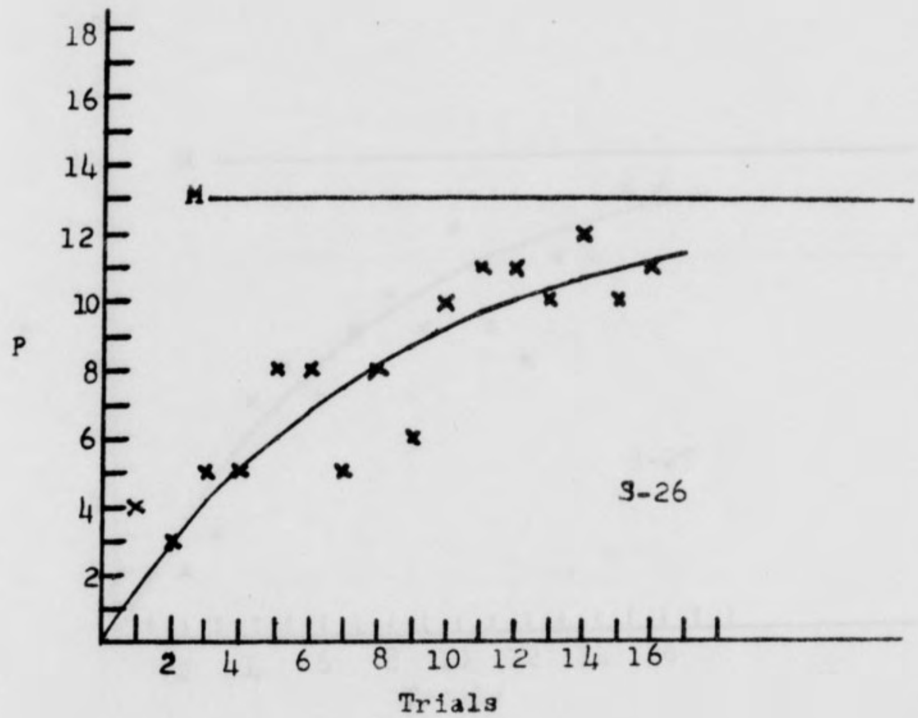

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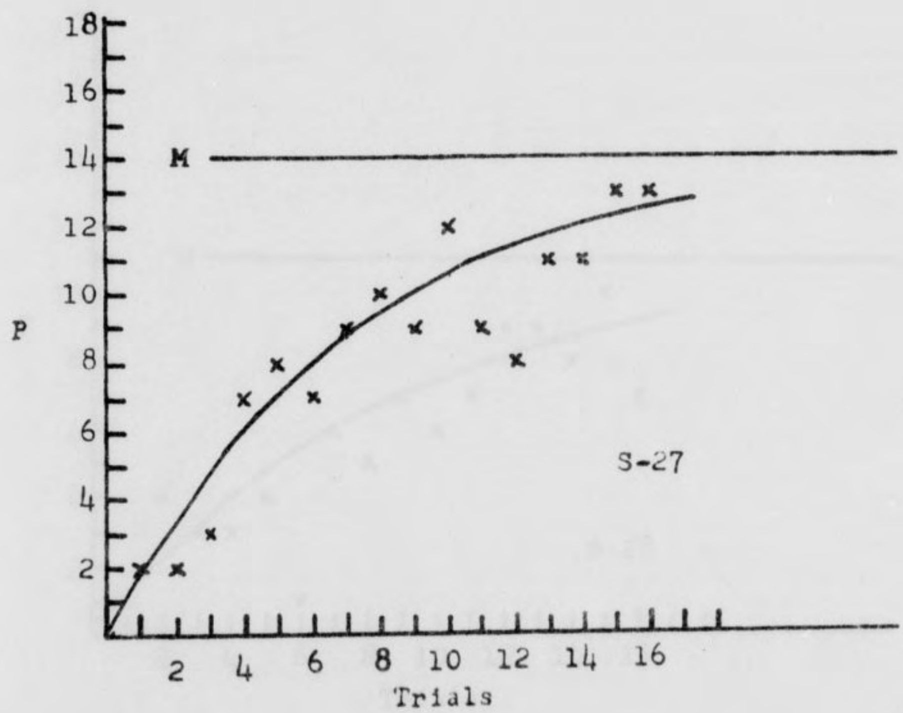

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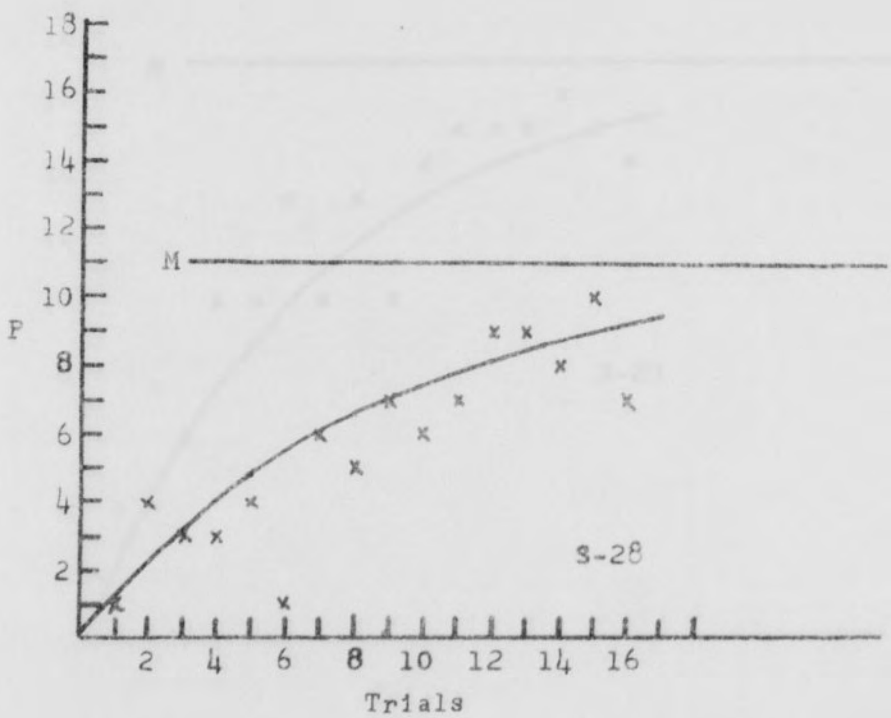

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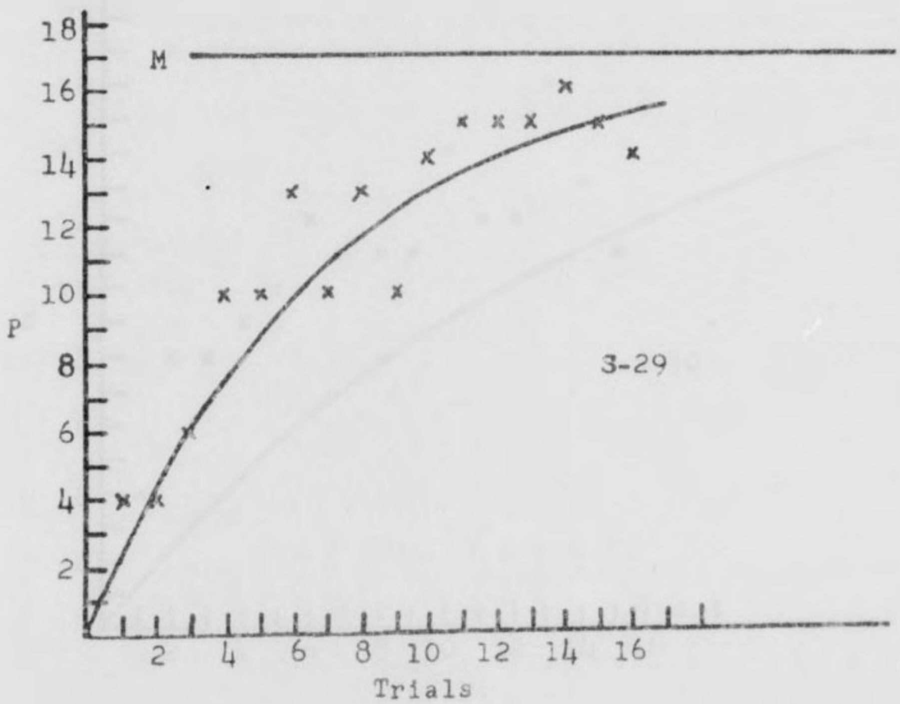

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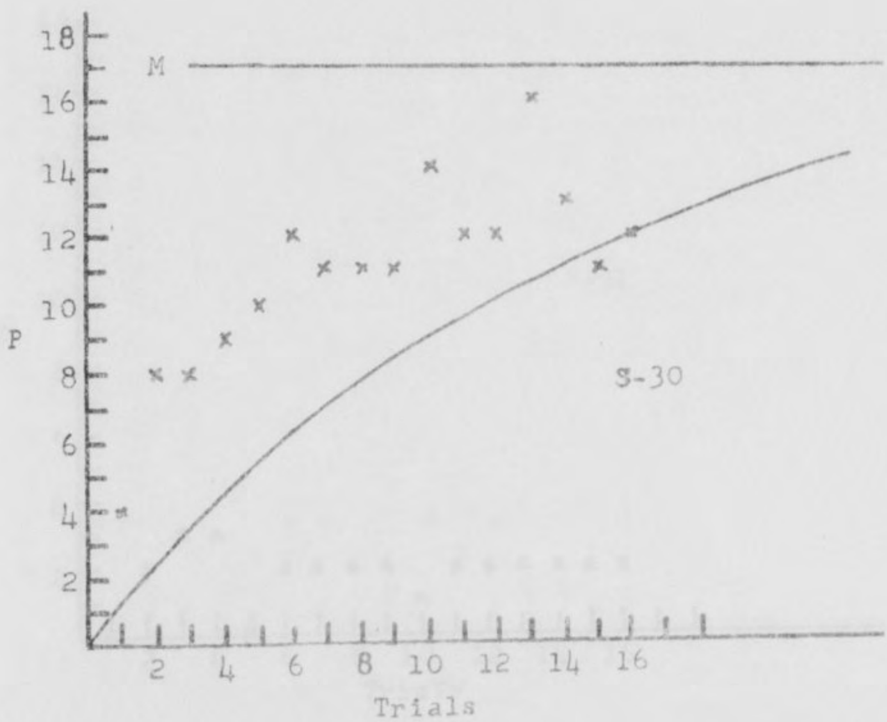

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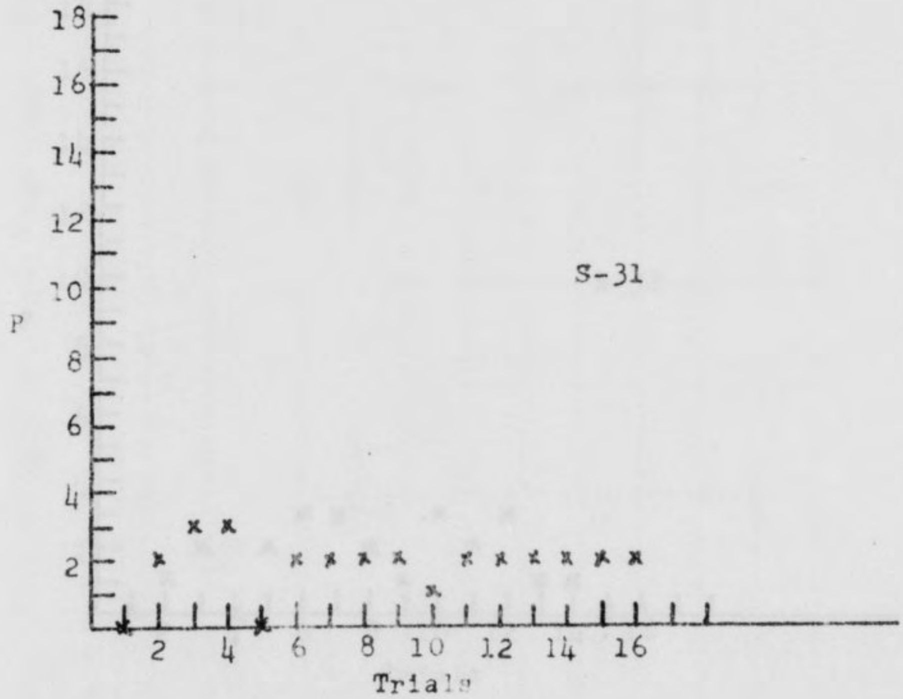

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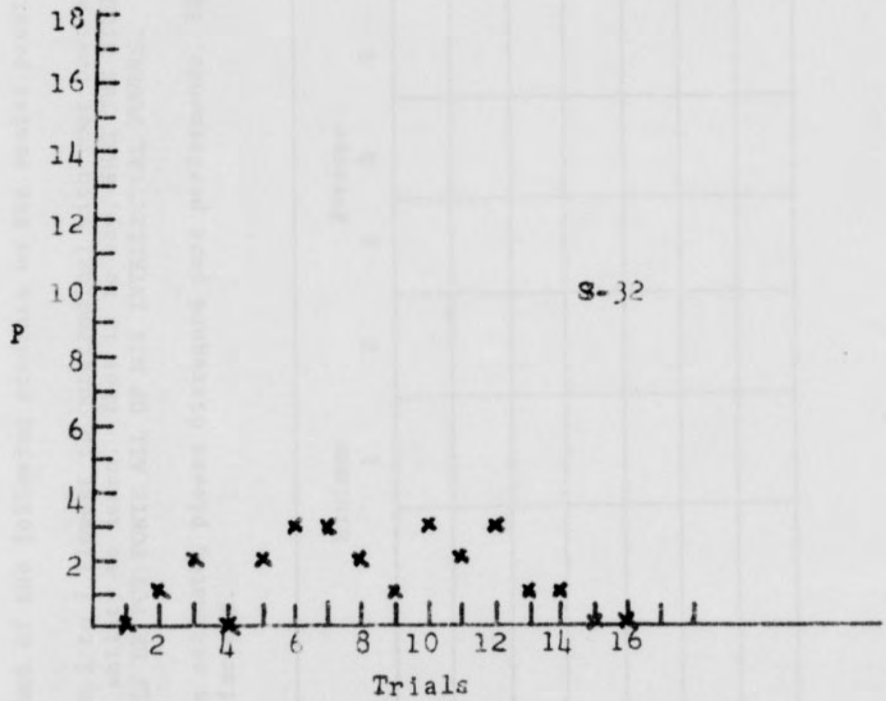

APPENDIX C

TEACHER'S RATING FORM

Please rate each of the following students on the scales provided for each.

Rate each from 1 to 7 (lowest to outstanding) with your best estimate of the student's ability to learn. That is to say, WHAT THE STUDENT COULD DO ACADEMICALLY IF HE PUT FORTH ALL OF HIS INTELLECTUAL POWERS.

In making this estimate, please disregard past performance, IQ, motivation, and personal factors.

Name	Minimum 1	2	3	Average 4	5	6	Outstanding 7