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WHOLE AND PART METHODS IN LEARNING
AS AFFECTED BY PRACTICE

A Dissertation Presented to the Graduate
Faculty of the College of Education of
the University of Cincinnati in Partial
Fulfillment of the Requirements for the
Degree Doctor of Philosophy in Education

CINCINNATI
UNIVERSITY
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B. S., Ohio University - 1914

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CHAPTER I

THE PROBLEM AND ITS SETTING

I. INTRODUCTION

Educators have for some twenty years been attending seriously to the result of experimentation. The contagious urge of science has reached the schools and a considerable body of seekers after truth has grown up around the field of experimental pedagogy.

There is evidence of this in the numerous investigations of specific educational problems, and in the great volume of articles appearing in the professional journals, setting forth the virtues of newly developed principles or processes, or exposing the fallacies or waste of the old and long used. The constant influx of standardized measurements and tests is, too, an evidence of the energy being expended by the scientifically minded to cleanse the processes of learning of false theories and wasteful methods of application.

To professional psychologists is due the credit for initiating in their laboratories the scientific investigations which have taken the pedagogical world by storm. The pioneers in this field dealt more particularly with general psychological principles, and did not meet the needs of students who were interested in the psychological aspects of education; their achievements have, however, served to stimulate those who would bridge the gap between educational theory and successful application.

Traditional education still has a value, and still has many supporters, for it has grown out of centuries of use and we cannot afford to cast into the scrap heap the results of pioneers' experiences. They form the ballast for our present psychology of learning. Problems of education have become exceedingly complicated and cannot be satisfactorily disposed of by expressions of opinion or by hasty investigation. There is, therefore, an urgent demand for unprejudiced and extensive study of every problem vital to the well being of learners in every field of endeavor. The only means of determining the value or worthlessness of an educational process is by scientific experimentation under controlled conditions, subjecting the theory evolved to the searching test of rigid application.

There is a demand for more speed in education. The time element has entered into our calculations and the public is demanding a wasteless school; every hour of the pupil's time must count for an hour of progress; useless subjects must be dropped and wasteful methods of instruction eliminated; yet the progress of science is slow. Investigators are not agreed in all matters of educational method; many times their experiments show directly opposite results. Concerning no phase of pedagogy is there greater divergence of opinion than with regard to the question of whole versus part methods in learning. This is the problem we have chosen for investigation. The whole method means the study of an entire mass of subject matter as a unit, i.e., the repetition of the entire mass of material until all is raised above the threshold of memory. In the pure

part method, the learning is accomplished in piecemeal fashion, completely mastering small units and later connecting them in proper serial order. Modified part methods vary the order in which the parts are learned and connected.

The question is one of consequence for all who have to master extended learning problems. A considerable body of literature attests to the vitality of the issues raised, and makes possible certain generalizations. A number of significant questions in this field remain unanswered, however, and the present research is directed to their solution.

Before attempting this experiment, the writer attempted to evaluate the extensive literature on the subject. Following is a brief summary of the major articles read.

2. SUMMARY OF LITERATURE

There have been numerous investigations and experiments in the past quarter of a century, having as their aim the solution of the problem that we are now attacking. The most important studies for our purposes are those of Steffens, Fyle and Snyder, Graham, Freeman, Dolan, Pechstein, Reed, and Brown. Their experimental and theoretical results will be reviewed in the order indicated.

A brief evaluation of these results will follow, and finally a general summary will be presented.

Steffens. As early as the year 1900 Lottie Steffens published the results of some experiments in memorizing. She used nonsense syllables and parts of Byron's "Childe Harold." She undertook to determine whether there is any limit to the application of the

whole method to the learning of poetry. Her findings were in favor of the whole method of learning especially in the field of poetry; but she used no larger unit than one stanza. Later experiments have, in the main, confirmed the earlier work of Steffens.¹ Henderson,² referring to the work of Steffens, says that the psychologist gives no rule as to the length of unit that is most economical to use in committing to memory. Ebbinghaus³ says without citing the authority that "it has been proved that, in order to learn a long poem, monologue or piece of prose, this should not be divided into parts. It is uneconomical to learn each stanza or sentence separately."

Pyle and Snyder. The above statements and findings stimulated Pyle and Snyder⁴ of the University of Missouri to try to determine whether these findings would apply to longer selections as well as to short ones.

They worked only with poetry and used units ranging from 5 to 240 lines. The experiment required the committing of 2500 lines and extended over a period of six months. Only one subject did systematic work and therefore, only his results were reported. The whole method and two forms of the part method were used. The results of the experiment are summarized as follows: "Whether 5 lines or 240 lines of poetry are memorized, learning by wholes is, without exception, more economical than learning by parts, and the relative saving is

1. Steffens, L., *Experimentell Beitrage zur Lehre von ockonimishaw Lernen*, Zet. P. D. Psych., XXII, 1900, pp. 321-382
2. Henderson, E. N., *A Study of Memory for Connected Trains of Thought*, Psych. Rev. Mon. Supp. No. 23, 1903.
3. Ebbinghaus, H., 1885, *Weberdas Gedachkniss*, pp. 110, 122.
4. Pyle, W. H. and Snyder, J. C., *The most economical unit for committing to memory.* Jour. of Ed. Psych., Vol. XV, pp. 133-142.

much greater in the case of the long selections that require more than a single sitting. Corroborative results were obtained from tests upon school children."

Graham. Ida E. Graham¹ of the University of Missouri supported the conclusions of Pyle and Snyder in the same memory tests given to public school children. One half of the children learned by the part method, and one half used the whole method. She found the average time of those using the whole method to be less than the average time of those using the part method. Miss Graham summarizes her findings with reference to the whole method substantially as follows:

1. The imperfect association in the part method is detrimental to learning.
2. Forgetting parts already learned causes less of time and work.
3. Extra time is required to fix together the small units in the part method.
4. The subconscious fixing of materials in intervals between learning periods when learning required more than one sitting seemed to be in the favor of the whole method.
5. General conclusion is that the whole method is superior to the part method.

Freeman. Freeman² says that the whole method is in general better than the part method, that the whole method avoids false associations and makes associations with the thought easier; that the part method loses in associating the last word of the part learned with

1. Graham, Ida E., Unpublished manuscript, University of Missouri.
2. Freeman, F. N., How Children Learn, Pp., 202-203.

the first word of the same paragraph; and that the learner is, therefore, unable to proceed without considerable confusion and loss in time and energy. He also claims that in whole learning, associations are formed with the whole piece of material to be learned and that it therefore takes the form of logical memorizing and is more permanent. He finally admits that difficult parts must have extra time and that unusually long selections may, to the advantage of the learner, be broken up into smaller units. Also, that some individuals may be unable to use the whole method, especially young children, due to the discouragement that comes with failure to see progress; confidence is therefore lost.

¹
Dolan. Miss Edith Dolan, Mary Dill Elementary School, Cincinnati, Ohio, has made a contribution in her special study of the relative values of the whole and part methods from the standpoint of the I. Q.'s of the pupils tested. Miss Dolan chose twelve eighth grade boys and girls from her own school. These were divided into two groups. Group I consisted of three boys and three girls whose I. Q.'s ranged from 125 to 136. Group II consisted of three boys and three girls whose I. Q.'s ranged from 80 to 95. These groups met at a definite time each school day for thirty minutes to study materials chosen from Schott, "Lay of the Last Minstrel."

Miss Dolan used four methods of learning in this experiment; they were the whole method, the pure part method, the direct repetitive part method, and the progressive part method. The findings in this study were as follows:

1. Dolan, Edith, Whole Versus Part Method in Learning Poetry Verbatim, Unpublished Master's Thesis, University of Cincinnati, 1925.

1. Some form of the part method is most economical.
2. The I. Q. of the subject has considerable to do with success by any method.
3. The individual has great weight in the success of learning by any method.
4. Learning levels are not the same for all classes and ages.
5. Children score inaccurately.
6. The part method lacks in connecting facilities; the repetitive part method requires useless repetitions; the progressive part method shows some waste in constantly repeating from the first in the tying up processes; and the whole method is too difficult in long selections for slow children.
7. The final conclusion is that it is not so much a matter of method of learning as of the capacity of the learner, the desire to learn, interest in the work, forming appropriate images and associations, mental reorganization of materials, practicing recall, and making use of rhythm and other devices to aid learning and retaining.

Pechstein. In 1916, Pechstein¹ made an extensive study of "Whole Versus Part Methods In Motor Learning". Dr. Pechstein realized the hitherto meager contributions to this field of educational method and gave his research particularly to the determination of similarities in the results of whole and part methods in rote and logical learning and in learning of the sensory-motor type, using both humans and animals to determine whether these laws hold for animals as well as human under similar conditions.

The findings in this research do not verify the almost universal opinion that the whole method is superior to the part method in any

1. Pechstein, L. A., Whole Versus Part Method in Motor Learning, Psych. Monograph, No. 99, 1917

of its forms. Dr. Pechstein shows that the part method can be modified far superior to the original whole method.

Significant conclusions from this research are listed as follows:

1. The weaknesses of the "part" method are not due to negative transfer in the learning of the motor units, disintegration through time, retro-active inhibition, contiguity of unit functioning, nor unit incompatibility in a larger series. The weaknesses are due to failure in the act of connection, the conditioning factors being traced to the positional aspects of the temporal and spatial series.
2. "Part" procedure possesses certain inherent advantages. These are mainly the complete utilization of the transfer items and the avoidance of diminishing returns due to the excessive length of the motor problem.
3. The strength of all types of improved ("modified") part methods rests upon the progressive elimination and distributive handling of the emotional and positional factors, together with the inherent advantages of any "part" procedure.
4. The complex motor problem is probably always best mastered by one of the several "modified part" methods. The one universally to be preferred is the "progressive part".
5. Distribution of the Learning effort is of value for the "whole" method but not for the "part" procedure.
6. Distribution of the learning effort is of value for the exploring and eliminative stages of learning, not for the rapid mechanizing stage. Here effort should be massed.
7. When the conditions of learning call for a massing of learning effort, the "whole" part becomes increasingly inefficient with increase in problem complexity, the "part" methods increasingly more efficient.
8. The conclusions drawn apply solely to the motor type of learning, though they suggest that the rote and logical type need additional experimentation.*

*

Above statements are selected from the summary by Pechstein, pp. 67 and 69.

Later Pechstein¹ made further investigation with two series of nonsense syllables by part and whole methods. In the first series the arrangement was consecutive, in the second the arrangements was in pairs as 1 and 2, 3 and 4, etc. The syllables were arranged on a drum and could be revolved at the wish of the subject. Three modifications of the part method were used, in addition to the pure part method: The progressive part method, the direct repetitive method, and the reversed repetitive method.

Three conclusions were drawn from this investigation. First, all part methods prove superior to the whole method, both for the maze and for nonsense syllables for all the three criteria of learning, namely trials, errors and time. Second, the progressive part method is consistently superior throughout all the various learning tests, also superior in maze learning. Third, motor learning and learning verbatim obey the same laws of learning, as witnessed by the fact that part methods are more efficient than the whole method in trials, errors and time. Pechstein therefore questions the superiority of the whole method in the field of meaningful material until further investigation shall determine the value of the modified part method more fully.

Reed. Perhaps the most spirited controversy over this subject has taken place between Reed² of Grinnell, Iowa, and Brown of the University of California.

Reed does not know why psychologists favor the whole method. He says that facts seem to favor the part method as much or even

1. Pechstein, L. A., Whole Versus Part Method in Learning Nonsense Syllables, Jour. Ed. Psych., Vol Xv, pp. 109-115.
2. Reed, R. B., Part and Whole Method of Learning, Jour. of Ed. Psych. Vol. Xv., pp. 107-116

more than the whole method, and that Meumann's book, "The Psychology of Learning", has twenty-five pages given wholly to the support of the whole method, while there is only one experiment, that of Steffen supporting its claim. He also states that the facts of Meumann's own laboratory as published by Ebert, Meumann¹ and Pentschew² favor the part method in so far as economy is measured by time saved.

Reed feels that the experiments have been too limited to establish a psychological law, and has therefore repeated some of the experiments of Ebert and Meumann which dealt with nonsense materials, and found the whole method poorest for learning and next to the poorest for relearning. He finds what he calls the mixed method most economical as measured in units of time and most adjustable to the memory span of the learners.

In addition to repeating two experiments by Ebert and Meumann, Reed did first, four experiments with single individuals, second, a group experiment, showing the influence of the part and whole methods of reading upon the comprehension of prose, and third, a group experiment with a large number of individuals, showing the influence of method on the learning of poetry.

In the first experiment, using only a few individuals in memorizing parts of Arnold's "Essay on Numbers", he found that the results both for learning and relearning were generally favorable to the part method; the cases, however, were too few to do more than suggest a possible condition.

1. Ebert, E. & Meumann, E., Weber einige Grundafragen der Psychologie der Webungs phänomene im Bereiche des Gedächtnisses, Arch.p.d. Ges. Psych. Vol.4, pp. 1-252
2. Pentschew, C., Untersuchungen zur Oekonomie und Technik des Lernens, A. P. D., Ges. Psych. I, 1903, 417-426

Having this matter of number of cases in mind, he arranged in the second experiment to use as subjects 169 students, and as materials three chapters from Freeman, "How Children Learn". Some read all the chapter without stopping, while others read each paragraph twice before proceeding to the next. The groups were equal in intelligence or as nearly so as possible, and changed method at each chapter change. After the reading a test was given to both groups to ascertain the comprehension of the chapters. Thirty of the subjects found the part method better, eighteen found the whole method better, and the remainder of the group found the difference sufficiently slight to be negligible.

Two hundred and twenty-six students from the department of experimental psychology formed the group for the third investigation. They memorized poetry using the part, whole and progressive part methods. In this experiment, the progressive part method showed an advantage of 13 per cent over the whole method.

Brown. Brown¹ of the University of California calls Reed to a "strict accountability" on his statements and on alleged omissions in his figures and arguments substantiating the progressive part method of learning.

Brown says that no one has ever claimed that untrained learners adopt the whole method spontaneously or willingly. Steffens likewise says that untrained learners choose uneconomical methods if left to themselves. Brown criticises Reed, also, because he considered time only and not the number of repetitions or the amount of retention.

An additional hauling over the coals is administered to Mr. Reed for allying himself with Steffens against Pentschew and Meumann,

1. Brown, Walter, Part and Whole Method of Learning, Jour. of Ed. Psych., Vol XV, pp. 229-237.

yet accepting only such parts of their data as would support his contention, and also for recording only the time element in his repetition of the work of Ebert and Meumann;

Reed replies to Brown in "A Further Note" in which he defends the results of his investigations by a lengthy review of the materials, methods and findings of those who have investigated the relative values of the two methods of learning. In closing he says, "Conclusions based on results obtained from 177 subjects are not easily invalidated; therefore, the universal endorsement of the whole method by educational authorities is quite unwarranted."

Evaluation. The weight of evidence is, so far, in favor of the whole method as contrasted with the unmodified part method. Certain of the claims made and arguments advanced may be profitably reviewed.

Pyle and Snyder found learning by wholes "without exception" more economical than learning by parts." But Pyle and Snyder reported the results of only one subject and they admit that the materials used were so unequal in difficulty that it was hard to compare the accomplishments from day to day.

Miss Graham used school children for subjects in her verification of Pyle and Snyder's findings. She rests her case for the whole method largely on the claim that imperfect associations are made in the part method. She also alleges that there is a tendency to forget one small unit while learning another, thus consuming extra time to relearn and assemble the small units. Finally, she regards the whole method as superior in subconscious fixation of materials in the intervals between learning periods when learning requires more than one sitting.

Pyle and Snyder, however, used an adult in their experiment and Miss Graham used children. Freeman of the University of Chicago, who supports the whole method, does not claim that it is better than the part method for children. It would seem then that there are not comparable subjects in the Pyle-Snyder and Graham experiments.

Freeman favors the whole method because "associations are formed with the whole piece of material to be memorized and that it therefore takes the form of logical memorizing and is more permanent."

Miss Dolan's contribution is enhanced in value by her selection of groups of children differing so widely in intelligence that it is unlike any other experiment reported here. Miss Dolan found that the I. Q. of the subject had considerable bearing on success by any method.

Pechstein made a timely contribution in his first experiment to the field of motor learning. It is difficult to compare this investigation with those preceding it, due to the introduction of a group of new modified part methods, the use of animal as well as human subjects, and the restriction of the study to motor learning. Pechstein later made further investigation with nonsense syllables, in which he verified his findings in the motor field. These pointed neither to the whole method nor the pure part method, but rather to certain modified part methods as most efficient.

The Reed-Brown controversy, regardless of the merits of the conflicting claims, has been of value in renewing interest in the matter of economical learning. In so far as number of subjects is of value, Reed has made a convincing argument. However, Reed

repeats only one experiment, that of Meumann, as a means of substantiating his views; he relies as much on opinions and theories as he does on scientific investigation. One feels that this debate can be finally settled only by further evidence.

A recent summary by Pechstein attempts "to cover the entire range of experimentation, holding for motor, quasi-meaningful, and logical material of poetry type, for animals and humans, and for varying degrees of intelligence." This summary may be quoted as follows, to serve with brief supplement as a general summary of the literature.

1. "Some form of the part method is more effective than the whole. This is universal for animal and human learning, and for motor, quasi-meaningful, and meaningful material.
2. The progressive and repetitive part methods seem the most effective of the modified part methods.
3. The harder the problem, the more essential to break its learning into parts; massing the learning effort is of value with the use of part methods; massing is disastrous with the whole method.
4. In corollary to the above for humans, the lower the I. Q., the greater the inefficiency of the whole method; the higher the greater its efficiency, although it rarely with an individual, and never with the entire group of high I. Q. learners, surpasses certain forms of the part method.
5. The factors of attitude, emotion, knowledge of results, etc., are powerful. The law of effect is probably underestimated in potency; frequency, overestimated.
6. Part methods are most advantageous during the discovery or the eliminative stages of learning; the whole method, for the final mechanization."

1. Pechstein, L. A., The Whole vs. Part Methods in Learning; Comparison and Summary, Psych. Rev. Mon. Supp. XXIII No. 2

In supplement to the above items, which are derived primarily from Pechstein's own experimentation, may be listed the following:

7. Results in the field of learning prose have to date been confined to a comparison of whole and pure part methods.
8. Age of learner is a conditioning factor, the whole method having especial disadvantages for children.
9. In some experimentation, the criterion for the measurement of improvement has been a major factor in determining the relative superiority of the methods studied.
10. None of the reported experiments has involved prolonged practice, or studied the effects of practice upon the relative merits of the various methods.

3. Specific Problems

The present research is directed primarily toward the solution of the problem suggested in item 10 above, in the field of learning nonsense materials verbatim. Specific questions to which the experimentation discussed in the following chapters is directed may be raised as follows.

1. What are the general effects of practice in learning nonsense materials?
2. How do various whole and part methods compare as to efficiency at the beginning and at the end of prolonged practice?
3. What are the relative effects of practice upon the efficiency of the various methods?
4. What factors are responsible for the effects of practice?
5. To what extent does presentation of materials by whole or part methods control the procedure of the learner?
6. What individual differences are found in the reaction of learners to whole and part methods of presentation?

CHAPTER II

METHOD AND PROCEDURE

Ten University of Cincinnati students, five men of graduate rank and five young women of sophomore rank, served as subjects. The materials for learning consisted of fifteen series of nonsense syllables, twenty-four syllables to the series.

Five methods were used, - the pure part, the whole, the progressive part, the direct repetitive, and the reverse repetitive. The methods are explained as follows:

1. The pure part method means the complete learning of one divisions or unit of the series (six syllables) before attacking the next division. The second division is then completely learned, the third is then mastered, and so on until the entire series is learned, unit by unit. The four parts are then assembled and learned together. The following formula will illustrate: I, II, III, IV, I-IV.

2. The whole method means the straight forward reading of the entire body of materials each time until verbatim mastery is attained. Formula: I-IV.

3. The progressive part method means the study of each unit until learned, and then its immediate connection with all the parts previously learned. Formula: I, II, I-II, III, I-III, IV, I-IV.

4. In the direct repetitive method the subject learns one unit of six syllables, and then goes on into the second unit, repeating the first each time with the second until the second as well is learned. When units one and two are thus mastered, unit three is

added, repeating one, two and three until verbatim mastery of the three is attained. Then the fourth unit of six syllables is added, repeating one, two, and three with four until all are mastered. Formula: I, I-II, I-III, I-IV.

5. In the reverse repetitive method the subject learns the fourth unit of the series first; as soon as this fourth unit is mastered, the third is attacked and mastered, the subject working through this and also through the previously learned fourth unit. Then the second and the first in the order named are learned, the subject ending each trial by going through the previously learned units. This is the reverse of the direct repetitive method mentioned above and has this formula: IV, III-IV, II-IV, I-IV.¹

The subjects began with different methods, e.g., subject A began with the pure part method and used the remaining methods on successive days as follows: whole, progressive part, direct repetitive, and reverse repetitive. Subject B began with the whole method and proceeded regularly with the progressive part, direct repetitive reverse repetitive and pure part. Subject C began with the progressive part method and proceeded regularly with the direct repetitive, the reverse repetitive, the pure part, and the whole, Subject D began with the direct repetitive and proceeded regularly with the reverse repetitive, the pure part, the whole, and the progressive part. Subject E began with the reverse repetitive and proceeded regularly with the pure part, the whole, the progressive part, and the direct repetitive.

1. For a detailed description of these fundamental methods of whole-part learning, see Pechstein, L. A., "Whole vs. Part Methods in Motor Learning" A Comparative Study. Psych. Mon. No.99, 1917.
2. "Two groups of subjects were used, each consisting of 5 individuals, here designated as subjects A-E."

The method of rotation is shown in detail in Table A, which follows.

TABLE A

Table to Show Rotation of Learning Methods.
Subjects

Days	A	B	C	D	E
1	Part	Whole	Prog. Part	Dir. Rep.	Rev. Rep.
2	Whole	Prog. Part	Dir. Rep.	Rev. Rep.	Part
3	Pro. Part	Dir. Rep.	Rev. Rep.	Part	Whole
4	Dir. Rep.	Rev. Rep.	Part	Whole	Prog. Part
5	Rev. Rep.	Part	Whole	Pro. Part	Dir. Rep.
6	Part	Whole	Pro. Part	Dir. Rep.	Rev. Rep.
7	Whole	Pro. Part	Dir. Rep.	Rev. Rep.	Part
8	Pro. Part	Dir. Rep.	Rev. Rep.	Part	Whole
9	Dir. Rep.	Rev. Rep.	Part	Whole	Pro. Part
10	Rev. Rep.	Part	Whole	Pro. Part	Dir. Rep.
11	Part	Whole	Pro. Part	Dir. Rep.	Rev. Rep.
12	Whole	Pro. Part	Dir. Rep.	Rev. Rep.	Part
13	Pro. Part	Dir. Rep.	Rev. Rep.	Part	Whole
14	Dir. Rep.	Rev. Rep.	Part	Whole	Pro. Part
15	Rev. Rep.	Part	Whole	Pro. Part	Dir. Rep.

The above table shows that no two subjects used the same method on the same day. By the end of the fifth day each subject had learned a complete series of syllables by each of the five methods. Subject A began with the pure part method; therefore, the method following profited or was hindered by the practice on the pure part method. Subject B began with the whole method and only ended his five series with the part method. It is easy to see, therefore, that the transfer effect of each subject's first learning series upon the

second may vary, the extent of such being perhaps primarily a function of the method employed, the number of series previously learned, or the two in some combination. In the case of E, then, the part method profited (or was injured) by all the practice preceding it. Subjects C, D, and E proceeded in similar manner, each beginning with a different method and ending with the method that had been first with the subject immediately preceding him. This procedure attempts to equate the effect of practice within each round of five days work.

The materials for this experiment were constructed with considerable care. The syllables were made by the writer in the following manner: Each syllable consisted of three letters- a vowel between two consonants, the syllable itself rejected if it in any way carried meaning (e.g., cat, run, etc.). The vowels were used with equal frequency, but arranged so that there was no regularity in their use, e.g., instead of their appearing in the order a-e-i-o-u, which arrangement might assist the subject in remembering the next syllable, they appeared in random order, such as o-a-u-e-i. No syllables were repeated in any of the lists. The consonants, one on either side of the vowel, were so arranged that they too were used an equal number of times through the entire lists. Finally, the syllables were so arranged that a syllable never began or ended with the consonant possessed by its two adjacent syllables.

These syllables were arranged in fifteen series of twenty-four syllables each and mounted on a mechanically driven drum of the type developed in the Psychological Laboratory, University of Chicago.

The drum was arranged to expose only one syllable at a time. The regularity of the movement of the drum was governed by a metronome.

For the purpose of study or original learning each syllable was exposed to the learner's eyesight for a period of two seconds, until all the syllables constituting the particular unit of learning (the whole, a part, or some combination of parts) had been exposed. If the whole method was in use, the drum was rotated regularly until all the twenty-four syllables had been exposed. Returning then to the beginning, the subject tried to recall and write the first syllable of the series. Subjects were allowed not to exceed four seconds for recall and writing this first syllable. After this trial at recalling syllable one, the first syllable was exposed and the learner was permitted to see whether or not he had written it correctly. He then tried to recall and write the second syllable of the series and after trying, the second syllable was exposed, and so on through the series. In every case, four seconds was allowed for recall and writing, except in such cases as the individual "gave up" more quickly and indicated his readiness to have the drum advanced. These two periods constituted a study or learning period and a reproduction or testing period. This alternate study - reproduction procedure continued until the series was learned and written twice in succession without error. One study-reproduction sequence constitutes a complete trial.

If the pure part method was in use, six syllables were exposed in order, before the first reproduction. Study and reproduction alternated until the six syllables were mastered, with two seconds of time allowed for learning each syllable, and a maximum of four seconds for recall and writing.

In the modified part methods, the method of using the drum and of study and reproduction were the same as in the whole and pure part methods, but the subject continued to study and write the parts already learned in connection with the new divisions of the series.

One minute was allowed at the end of each trial, not particularly for rest, but to give the experimenter time to keep his record accurately, shift the drum, etc.

The trials, errors and time were recorded on blanks prepared especially for that purpose.

The first group, the five graduate men, began their part of the experiment on the morning of February 23, 1928, and proceeded regularly and without interruption, the same hour of the day, five days of the week, until the fifteen series of syllables were completed.

The second group, five undergraduate women, began their part of the experiment on the morning of March 16, and proceeded regularly. Due to their schedule of classes, they were not able to appear at the same hour each day, but there was a definite time assignment for each day. It was thought best, due to the heavy schedule these young women were already carrying, to use ten series in their part of the experiment instead of fifteen used in the case of the men. Subsequent comparisons do not ignore this difference in number of series learned.

The physical conditions were kept as nearly uniform as it was possible to have them. The temperature of the room and the light were constant, the subject sat in the same chair in the same position each day, and the experimenter took the same position each day. The

room was large and well ventilated and no one was permitted to enter to interrupt the subject during the experiment. The blanks provided for the subjects were of good paper, white and ruled to allow for fifteen columns of syllables, thirty-six the column. Seldom was it necessary to use all of this for one series. There was ample room for notes at the bottom of the sheet, for the experimenter to jot down his observations. When one column of syllables was written, the paper was folded or the syllables were carefully covered so that they could not be seen while filling the next column.

The subjects were given specific instructions as to the meaning of the names of methods, e.g., "In the progressive part method, you are to learn the first six syllables of the series, two consecutive writings without error being considered satisfactory; then the second group of six; the two divisions of six are then written together; the third section of the series is learned next and added to one and two already learned; finally, the fourth is learned and the four sections assembled and made the unit of learning." Instruction similar to the above was given for each method to the subjects individually, not to the group, before the experiment was begun. Subjects were also urged to concentrate on the syllables to the exclusion of all else as the drum revolved.

The subjects of Group I (the graduate group) were chosen individually. The experimenter personally solicited their cooperation in this test of learning. He took those who were willing to serve without consideration as to their ability or fitness for this type of work. As shown by the data they were of varying aptitudes for the learning task set.

The subject of Group II were all volunteers. None was solicited individually. The experimenter visited a sophomore class in the Department of Psychology, and after explaining briefly the nature of the experiment that was being carried on, asked for volunteers. More responded than were needed. The intellectual quality of the students from this class was excellent. Judging from standards found in colleges, the I. Q.'s were 120 per cent or better.

These ten subjects, five mature men and five young women, gave every objective sign of doing their best with the learning. There was little evidence of a feeling of drudgery, but generally one of eagerness to do the experiment and interest in the results. The results, however, were not made known to the subjects until after the experiment had been finished. There was more of the contest spirit shown by the young women than by the men.

The method and procedure may be summarized as follows:

1. Ten university students, five graduate men and five undergraduate women served as subjects.
2. The materials consisted of fifteen series of nonsense syllables, twenty-four syllables to the series.
3. Five methods were used, - the pure part, the whole, the progressive part, the direct repetitive, and the reverse repetitive.
4. A method of rotating the methods to equate the effect of practice was devised.
5. Factors such as time allowed for studying and recalling each syllable, method of recording, regularity of time of learning trials, etc., were carefully controlled.

CHAPTER III
GENERAL EFFECTS OF PRACTICE

I. PROBLEMS INVOLVED

Before presenting and discussing the experimental results, it may be in order to note several problems which are involved in a consideration of the general effects of practice.

Individual Differences. Thorndike¹ says "the causes of individual differences in improvement may be considered under three heads: (1) Differences in methods of work which can be taught to one person as well as to another, or somewhat nearly as well; (2) Differences in previous training which, at any given time, must be accepted, but which could have been prevented; and (3) Differences in original nature which must be accepted and allowed for. It is of utmost importance to the educational theory of any function that the individual differences in the rate of improvement in it should be referred to their specific causes along these three lines."

These subjects are not exceptions to the "causes of individual differences in improvement" as stated by Thorndike. We will proceed with this understanding; therefore, in considering the improvement of individual subjects in terms of initial and final status, we will not feel obligated to argue deeply concerning the exact commensurability of these individuals in respect to gains, for it is at once evident that only those individuals who are alike in initial or final status can be compared without assumption.

1. Thorndike, E. L., Educational Psychology, Vol. II, P. 161

Effect of choice of criterion. Differences in methods of portraying practice data often lead to various conclusions. To illustrate, let us consider some tables of Smythe Johnson, found on pages 169 and 170 of Thorndike, Educational Psychology, Volume II. These tables were made from five supposititious cases, each having seven trials, and using as a score units of gross amount. The individuals he designates A, B, C, D, E. In the first computation, using units of gross amount, D improves most, and A and C improve least.

This same table turned into units of time required to do one unit of work, using hundredths of a second as a basis, shows that E improves most and C improves least.

The two sets of curves plotted from this data show in the first case that differences are increased by practice, in the second, considerably diminished.

The inference is then, that the change from the use of one kind of unit of estimate to another in expression of one and the same performance makes an appreciable change in interpretation. The writer calls attention to these facts in order that his interpretations, which are in terms of the three criteria of trials, errors and time, may not be misleading.

Scores as only partial measures of learning. No one is justified in interpreting every change in score as a corresponding change in efficiency. On looking at a curve which rises from point 50 to point 100, one is tempted to believe that the particular function has become twice as efficient- to think of the subjects' ability as having doubles. But a given change in score does not

always mean a corresponding individual change in ability. It may mean many different things, according to the meaning of the score. A given score is the resultant of many forces. Sometimes certain of these are dominant, sometimes others.

The scores of individual subjects, in particular, are subject to chance fluctuations. When the scores of a group are combined, these fluctuations due to chance become less and tend to disappear, leaving the trend of progress more clearly indicated.

Why failure to improve may occur. Quoting Thorndike/again,

"So far as I am aware of the facts, no mental function has ever been deliberately practiced with an eye to improving it, and with proper opportunity for the law of effect to operate, without some improvement as a result." But improvability has been denied to some functions. Thorndike says in response to that, "then an investigator's failure to find improvement is due to one or more of the following causes: (1) He did not inform his subjects whether they were right or wrong in their judgments, nor what the direction and amount of their error was. Hence the wrong bond was given as much advantage as the right bond. (2) He gave his subjects no adequate motive to improve, (3) He gave practice in so narrow a function that the limit of improvement was reached very quickly."

It would, perhaps, not have been surprising, in view of the above, if the subjects used in this experiment had not improved. They were not informed of their progress; their scores were not revealed to them until after the experiment was finished. No records of any kind were offered, and no assurance was given that

1. Thorndike; Educational Psychology, Vol. II, p.151&152

any one would know the individual results of the experiments.

Effort to improve was doubtless conditioned by the desire of the subjects to cooperate with the experimenter, and their interest in his problem, the general nature of which was familiar to them. The subjects of course knew when they had mastered each learning unit, and had a fair idea of the time required. In general, they were aware of good days and poor ones. Without these conditioning factors, improvement would perhaps not have occurred.

Factors conditioning improvement. Improvement is conditioned by the realization of satisfaction, likes and dislikes, by being content and being annoyed. These factors of improvement have received little consideration, and they are thought of rather vaguely as "aversion to work or zest for success." Every one can, however, appreciate their importance in the improvement of abilities to accomplish in any field of endeavor. In this, the field of nonsense syllable learning is no exception. The effects of the emotional tone, born of satisfaction, on the progress of the school child doing his sums, learning his assignment in language or history cannot be overlooked. The same applies to any game of skill; playing at marbles, golf, etc. Satisfaction is conducive to unremitting devotion to a task, be it learning nonsense syllables or playing a game, and the greater the satisfaction, the more assured the improvement. This matter of interest in and zest for the job influenced more than a little the results of this experiment. Many of the fluctuations of the learning curve, as evidenced from day to day, are due wholly to the emotional set of the subject on that day.

The limits of improvement. Is there a limit to improvement?

No doubt there is a limit to improvement in any function, but it is rarely reached, "save in the case of extremely narrow functions, such as knowing the meaning of one or a few words, being able to repeat a poem, or typewriting a single sentence". Usually limits are not reached save in work or play where excellence is sought with great zeal and intelligence.

Learning nonsense syllables may belong in the category of the "extremely narrow function"; even so, the writer believes that a majority of his subjects did not reach their limits. Boredom and lack of zest for the task of learning account for many of the reverses incident to this experiment.

2. INDIVIDUAL AND GROUP LEARNING CURVES

It seems appropriate now to review the individual and group learning curves of the ten subjects in the light of these brief remarks on the general effects of practice.

Graphs I to X inclusive show the effects of practice on the learning achievement of the individual subjects of Groups I and II.

Group I

Graph I, Subject A.

Subject A began with the pure part method and proceeded with the whole, P.P., and D. R., and R. R., in order named until each method was used three times. It will be observed that the second day the trials, errors and time all increased. This was explained above; changing from the pure part to the whole method accounts for the loss

1. Thorndike, E. L., Educational Psychology, Vol II, p.177

This particular subject had the feeling that it was impossible for him to learn twenty-four syllables by the whole method. The emotional set toward the whole method proved a heavy handicap.

The third day the subject seemed to have had a baptism of confidence and enthusiasm and for three days the trials, errors, and time were considerably decreased. The losses following the fifth series were, in the subject's introspections, charged to a condition of over anxiety to improve; emotion entering again into the learning process. Improvement came with the series following the seventh, with the exception of the errors on the twelfth day, when the whole method was attacked for the third time. This subject and in fact all subjects were willing to sacrifice both trials and errors for improvement in time.

Graph II, Subject B.

Subject B began with the whole method and proceeded with the P.P., D.R., R.R. and pure part methods in the order named until each method had been used three times. The correlation is fairly close; the first discrepancy appears on the second series when the errors fall from 145 to 95 and both trials and time increase. The whole method is especially prolific in terms of errors due to the limited memory span of the subject. There was, therefore, a greater possibility for improvement in errors than improvement in either trials or time. Subject B was not disturbed by an emotional set toward any particular method as much as other subjects were, but fluctuated regularly, reaching the peaks of efficiency on the third and eighth days. His learning curves all show a loss on the fifteenth

day. The subject and the writer are agreed in charging this to the fact that on this day the subject was heavily burdened with an experiment of his own, and that there was a tendency to relax or slow up because of it being the last series.

Graph III. Subject C.

Subject C began with the P.P. method and proceeded regularly with the D.R., R.R., purepart and whole methods in order named until each method had been used three times. This subject made a promising beginning, showing considerable aptitude for this type of memory test; but, true to what seems the custom with this group the subject lost consistently until the fourth day when he showed improvement in all three measures. The fifth day he used the whole method procedure for the first time and the curves representing all three measures of efficiency rise. This is especially true of the error curve. This is true also on the tenth and fifteenth days of the experiment when the whole method was in use. Subject C was unfortunate, especially in the last three days of the first round of this experiment and to some degree throughout the experiment, in having a member of his family in the hospital. This, with the attendant loss of rest and anxiety, undoubtedly impaired his ability to work up to the limit of his capacity.

Graph IV. Subject D.

Subject D was a consistent performer. His curves correlate almost perfectly. His improvement is slow but consistent. He lost gradually until the fifth day of the experiment when the results of practice began to function. This subject mentioned in his

introspections a method of attaching meanings to syllables that helped him very materially in remembering the order of the syllables. It took the subject four days to perfect this system of recall; after the fourth day, the only breaks in the progress that cannot be accounted for by chance fluctuations are the two points of change from a modified part method to the whole method. Subject D was not especially susceptible to the usual emotional influences, and the only times that emotional set toward the task in hand seemed to retard his progress was at the beginning of a series by the whole method procedure. The discouragement of a study reproduction sequence resulting in the retention of only one or two syllables was telling.

Graph V, Subject E.

Subject E made the best record in trials, errors, and time of any of the subjects of Group I. Subject E started with determination to excel in this experiment, he thoroughly believed that he could, and he did. This subject used every means at his command to do the series in the shortest time with the least possible number of trials and errors. Because of this concentration and ultra effort, the subject reached his peak before the experiment was more than two thirds done and then a slight reaction was observable. This is another evidence to the writer that one cannot hold his achievement at the peak of his capacity for many successive days.

Combined Learning Curves for Group I.

Graphs XXXI, XXXII, and XXXIII summarize the individual curves for Group I. These graphs show the same general trend that the individual curves show, rising abruptly at first, before the effects of practice had accrued sufficiently to take care of the daily change of method and falling with equal abruptness after the subjects found themselves and were able to realize from the effects of practice.

The characteristic ups and downs of all learning curves follow the fourth day of practice, but there is general improvement until near the end of round three, then there was evidently a general let down. The men became tired of nonsense learning near the end of the experiment and lost some of the zest and snap that characterized their earlier efforts. This tendency is not at all novel; from an experiment by Wells,¹ 1912, in which he uses five adult men and five adult women 150 minutes each practicing addition of one place numbers, the writer finds that five of the ten subjects, two men and three women, make a poorer showing on the final practice period than they did on the periods immediately preceding the final practice. Book,² 1908, finds in his experiment on learning to typewrite that curves rise rapidly and continuously so long as many possibilities of improvement exist, but as possibilities grow less numerous the rate of improvement grown less and the curve tends to become a straight line and at times an actual loss of efficiency is experienced. The first stages of learning are common to all, but few become masters of anything. As practice continues there are fewer adaptations to make, and those that remain are uniformly more difficult. The final process of polishing off the special associations which frequently offer the only avenue to continued improvement often proves too laborious and the subject stops short of the expert stage and in the stopping drops below his previous record of achievement. Practice, than, has contributed improvement to Group I as follows:

1. Wells, F. L., Thorndike Educational Psychology, Vol. II, P. 236-7
2. Book, N. F., Thorndike Educational Psychology, Vol. II, P. 238

- (a) Trials. The daily average number of trials for Group I was 55.6. The number of trials on the first day was 54, on the last day, 56. On the second, third and fourth days the numbers were 68, 73, and 71 respectively, which accounts for the high average. The ninth, tenth and eleventh days showed the greatest improvement, the numbers on those days being 46, 45, and 46 respectively. Practice seems to have contributed little in the way of improvement in the number of trials necessary for learning nonsense syllables.
- (b) Errors. The daily average number of errors was 269.3. The number of errors on the first day was 336, on the last day, 272. After the abrupt rise of the fourth day the improvement was regular, reaching the best point on the thirteenth day. The fourteenth and fifteenth days show a loss, which will be explained later in the chapter. The general tendency is for improvement in the number of errors to follow practice.
- (c) Time. The average number of seconds consumed each day was 9624. The number of seconds required for the first day was 11365, for the last day 7995. After the abrupt rise shown on the second and third days the general tendency was to improvement, reaching the peak of accomplishment on the thirteenth day. This and the loss on the fourteenth and fifteenth days correlate perfectly with the curve representing the errors. The improvement due to practice is here found more regular and more outstanding than by either of the other criteria.

GROUP IIGraph VI, Subject A.

Subject A began with the pure part method. The subject showed very little improvement and very little fluctuation in trials throughout the experiment. This would indicate that this subject began near the peak of her ability so far as trials may be used as a measure. The losses measured in errors on the second day of practice, and on the seventh day are due to the use of the whole method procedure on those days. Other than these two whole method peaks, the errors curve is quite regular and shows an improvement from the first to last amounting to the difference between 41 errors and 13 errors.

The time element, which we believe the most reliable measure of the effectiveness of method, shows a conservative improvement with few fluctuations. All in all, subject A was a consistent performer, not easily disturbed and showing almost no discomfiture from emotional influences.

Graph VII, Subject B.

Subject B began with the reverse repetitive method. The subject showed very little improvement and few fluctuations in trials, indicating that this subject also began near the peak of her ability so far as trials may be used as a measure.

Subject B made 13 errors on her first series and 3 on her last series. The only decided reverses were on the third and eighth series when the whole method of procedure was in use; thus showing again the inferiority of the whole method measured by the number of errors made. The time element shows improvement beginning with 19' 50'' the first series and ending with 9' 30''. The only conspicuous reverses are on the third and eighth series when the whole method of procedure was in use. The curves representing the time and

errors of Subject B correlate very closely. It is quite evident from these curves that the whole method, estimated in time and errors, is the most expensive for Subject B.

Graph VIII, Subject C.

Subject C began with the direct repetitive method. The subject shows a very slight improvement in trials, with the usual ups and downs, fluctuating between eleven, the greatest number, and five the least number. Subject B was very nervous at times, and her desire to excel brought about a hasty, jerky performance which was conducive to errors and the errors precipitated greater anxiety. This was especially true on the eighth day of practice. On this day the curves all show a loss in efficiency, especially the curves representing errors and time.

On the fourth day the errors curve shows a conspicuous rise. This was Subject C's first attempt to learn by the whole method. The first four trials by this method were mostly errors, the learning then proceeded rapidly. The subject made 24 errors on the first series and 15 on the last.

The time element shows improvement as practice proceeds, beginning the practice with 23' and ending with 15' 30". The rise of the curve on the eighth day is the most conspicuous fluctuation. The correlation between time and errors is only fair.

Graph IX, Subject D.

Subject D began with the progressive part method. This subject's beginning was not at all promising. The trials, errors and time on the first series were 18,83 and 48' 45" in order named. The second series shows a marked improvement. This improvement

was not due to increased ability due to the one practice, or to the difference in the effectiveness of the methods, but to the subject's emotional set. The subject approached the first series with the feeling that it was an impossibility. She found that she could do it and the improvement was immediate.

The curve representing the trials made by Subject D shows little improvement after the second day of practice. It seems evident in this case that there is little if any correlation between the amount of practice and the number of trials necessary to learn nonsense materials. The curve representing the number of errors made is quite unusual, having three especially high points, the first series which has been accounted for above, the fifth and the tenth series. The fifth and the tenth were learned by the whole method which accounts for the increased number of errors on those series. There is a general trend of improvement due to practice, that is, there are fewer errors in series 6 to 10 inclusive than in series 1 to 5 inclusive.

The time curve shows a general tendency to improvement due to practice. After the first sharp drop, already accounted for, there are the usual variations accounted for by chance fluctuation, differences in the physical condition of the subject and variation in the difficulty of the series.

Graph I, Subject E.

Subject E began with the whole method. The curve showing the number of trials from day to day indicates a very slight but regular improvement. Practice again seems to mean little in the

matter of trials. The error curve starts at the high point of 87 and drops abruptly on the second series to a point only three above the final series. This abrupt improvement must not be credited entirely to the effectiveness of the progressive part method which was the second method used. The whole method being the first one used by this subject, there was an emotional set which added to the difficulty. There is a conspicuous reverse on the sixth series which is the whole method the second time. The part of the curve representing the other eight series shows little to distinguish it from the usual practice curve. The loss both in time and errors on the last day is due to a condition of fatigue which the subject could not overcome. The subject was engaged in an extra activity on that day and had lost rest the preceding night which made it impossible for her to match her previous achievement.

Com bined Learning Curves for Group II.

Graphs XXXIV, XXXV, and XXXVI summarize the individual curves for Group II. These graphs show the general trend of the individual graphs. The number of trials, shown in Graph XIV, decreases regularly until the fifth series when there is a gain of eight trials, lost however on the sixth series after which the curve is almost straight. The fluctuation on the fifth series is due to the performance of two subjects, D and E. D changed from the part method, which was not the most economical in trials for her, to the whole method, which was her favorite measured in trials. Subject E changed from the reverse repetitive method which, according to the records, was not her favorite measured in trials, to the pure

part method, which, according to the records, was her best in trials. The sum of these two gains account for most of the fluctuation. On the following day, each of these subjects, D and E, changed from her favorite method, estimated in trials, to her poorest, and the combined loss of the two raised the number of trials to the level of the fourth day's accomplishment.

The curve representing the errors for Group II drops abruptly until the beginning of the second round. There improvement due to practice seems to have ceased. The usual up and down fluctuations characterize the last round, which seems to indicate that the limits of improvement in errors through practice are closely drawn. The time curve shows a consistent gain from the first to the last series. The greatest gain in time was from series one to series two, showing the superior adaptability of the group. The writer believes this time curve is the best measure of the effect of practice that the study of Group II provides.

Group II

Table 20 indicates the trials, errors and time for the first five series after each subject has used each method once. Group II did not make as great a gain measured in per cent as Group I did. The subjects of this group started nearer their maximum; there was therefore a smaller margin for improvement. The general tendency was to gain slowly from the beginning. Three subjects A, B and C, show a loss, measured in errors made, near the beginning, but the other two show gains sufficient to equalize the loss. Group II was more modifiable than Group I, that is, they could change from one method to another with less loss or disturbance.

Group II shows the following results of practice.

- (a) Trials. The daily average number of trials for Group II was 38.8. The number of trials on the first day was 54, and on the last day, 35. This group improved consistently from the beginning through the fifth day of practice. The group showed a loss measured in trials on the sixth day, and gained slightly afterwards. With the exception of the fluctuation on the fifth day, this group, unlike Group I, made a conservative gain, in number of trials throughout the experiment.
- (b) Errors. The daily average number of errors for this group was 128.7. The number on the first day was 248, on the last day 98. There was rapid improvement through the first round, going from 248 on the first day to 86 on the fifth day. Through the second round the usual ups and downs characterize the curve, with little improvement. Practice resulted in a very conspicuous gain in the beginning, indicating the tendency of this group to reach the limit of efficiency early in the experiment.
- (c) Time. The average number of seconds consumed each day was 5967.5. The number required for the first day was 8790, for the last day 4575. The improvement due to practice was rapid through the first round; in the second round the improvement was very slight, correlating closely with the other criteria of measurement.

3. IDIOSYNCRASIES OF THE LEARNING CURVES

Group I

Tables I, II and III, and Graphs I, II, III, IV and V show the initial skill of the subjects of Group I as well as the growth of skill as practice proceeds. Table I indicates the trials, errors and time for the first five series after each subject has used each method once. Comparing the first series with the fifth, there is a general tendency to improvement, especially in errors and time.

Little skill in learning nonsense materials was indicated in the first series. This is due to lack of experience in this type of learning. It took some time to form habits of reacting to nonsense situations effectively. Graphs I to V inclusive show a general rise in the learning curve for the second trial, and with some for the third also. The first change of method was the most confusing. All subjects stated to the writer that the second series would have been easier to master without the experience of the first.

This is not at all surprising to the writer. When but one method of doing a thing has been established, confusion and discomfort are frequently occasioned by variations from the usual procedure. Gates¹ says "to attempt to read or to memorize more rapidly, to learn by distributed rather than by concentrated practice, or by the whole instead of the piecemeal method, or to adopt some other new device may lead to temporary difficulties. Temporary confusion and often loss of efficiency should be expected". In the light of the above, we explain the tendency to increased trials, errors and time on the second series. An examination of graphs I to V

1. Gates, A. I., Psychology for Students of Education, p.293.

inclusive, which show the gains and losses from day to day may help to appreciate the variableness of the ability to master nonsense materials.

The ups and downs of the curves following the initial rise which is quite abrupt for Group I, are not unusual in the learning process. These may be charged to chance fluctuations exaggerated because of the fewness of cases, conditions governing the learning abilities of the individual subjects, variations in the difficulty of the tests and the like. Distracting conditions akin to the personal affairs of the subjects of Group I are responsible for many of the fluctuations of the group; i.e., illness in the family of one, the burden of dissertation writing bearing down upon three, etc.

The fluctuations become less conspicuous with the increase of practice. The learning curves tend to approach the straight line as the experiment progresses. This is due to the falling off in possibilities of improvement, the unit of learning capacity becoming more standardized.

The curves representing the three criteria rise on the fourteenth and fifteenth series. The writer believes this due to (1) becoming tired of the job, boredom; (2) the general let down in effort which is common to the last hour of school in the afternoon, Friday afternoon classes, the day preceding a vacation, etc; and (3) fatigue.

Group II

The fluctuations of the learning curves representing this group are not unusual. The rate of improvement the first round exceeds that of Group I, because subjects of Group II are more modifiable

than the subjects of Group I. They could adapt themselves to changing conditions more readily; their learning habits were apparently not so permanently established. They, therefore, made earlier improvement than Group I. The variations from day to day in the second round are due to chance fluctuations, variations in the physical conditions of the subjects and the variations in the difficulty of the series learned. The writer can trace some of the losses directly to the effects of extra preparation made the night preceding for pending examinations in courses being pursued by the subjects. Other changes find their sources in the ebb and flow of attention and interest.

Thorndike¹ gives us four definite leads in the matter of fluctuations in performance and improvement due to practice:

- "1. There is a limit to improvement.
2. Rate of improvement changes, becoming less as practice advances, showing both long-time and short-time fluctuations from week to week and day to day.
3. Individual eccentricities account in large measure for fluctuations in improvement.
4. A fairly long period of fairly slow progress somewhere or other will, of course, be found oftener in practice curves, but even about these vague, moderate fluctuations not enough is known to tell with certainty whether they require any separate explanation apart from that which accounts for the minor ups and downs that characterize all practice curves."

1. Thorndike, E. L., Educational Psychology, Vol II, pp. 88, 111, 239, 242, 284, 285.

4. CHAPTER SUMMARY

1. The causes of individual differences in improvement may be considered under three heads:
 - (a) Differences in methods of work which can be taught to one person as well as to another.
 - (b) Influence of differences in previous training.
 - (c) Differences in original nature.
2. Change from the use of one kind of unit of estimate to another in expression of one and the same performance makes an appreciable change in interpretation.
3. Improvement is conditioned by satisfaction and annoyance, by likes and dislikes.
4. There is a limit to improvement; few, however, reach the limit.
5. Emotional set influences improvement.
6. Rate of improvement changes as practice advances.
7. The subjects of Group I became tired of nonsense learning and lost some of the zest that characterized their earlier efforts.
8. Group II was more modifiable than Group I.
9. Group II showed consistent but conservative improvement in number of trials, a rapid improvement through the first round, little through the second round in errors, a rapid improvement through the first round, little through the second round in time.
10. The idiosyncrasies of the learning curves are due to (a) confusion due to change of method, (b) becoming tired of the job, (c) chance fluctuations, (d) fatigue, and (e) an end slump.

CHAPTER IV

THE EFFECTS OF PRACTICE ON THE RELATIVE EFFICIENCY
OF WHOLE AND PART METHODS

I. INTRODUCTION

It has been shown that practice tends to bring improvement in efficiency in learning nonsense materials, when the results from the various subjects and methods of presentation are combined. To a certain degree, the same general tendency appears in the learning curves for the individual subjects, with method disregarded. The problem of this chapter is to analyze out the influence of practice on the relative efficiency of the various methods of presentation which have been studied.

Significant questions to be answered may be stated here.

- (1) Under practice, do the differences in efficiency of the methods become accentuated or tend to disappear?
- (2) What are the relative amounts of improvement shown in the efficiency of the various methods?
- (3) To what extent is there correlation between the values of the methods at successive stages in practice? These questions will be discussed in the following sections.

The data are presented in Tables I, II, and III, and in Graphs XVI, XVII, and XVIII. These present the combined scores, for each criterion, of all subjects in each group, for each method in each round. By "round" is meant a sequence of five days, during which each of the five methods is employed once for each subject, and likewise once on each day of practice.

The data are discussed in terms of the three criteria and of

the two groups separately before generalizations are made.

2. THE TENDENCY OF THE METHODS TO APPROACH EQUALITY
OF VALUE.

(a) Trials

Group I. Graph XVI shows the trend of the methods measured in trials. In the first round there were $57\frac{1}{2}$ trials by the part method, 81 by the whole method, 58 by the progressive part method, 50 by the direct repetitive method and $59\frac{3}{4}$ by the reverse repetitive method. The difference in trials between the best and the poorest methods is 31. In the third round there were $43\frac{3}{4}$ trials by the part method, 45 by the whole method, 56 by the progressive part method, 50 by the direct repetitive method and 47 by the reverse repetitive. In this round, the difference in trials between the best and poorest is $12\frac{1}{4}$. The difference between the extremes has decreased 60.5 per cent. The fact that the methods found best and poorest in the first round do not hold their relative places in the third round will be discussed later.

Group II. In the first round by Group II, $35\frac{1}{2}$ trials were made by the part method, 41 by the whole method, $51\frac{3}{4}$ by the progressive part method, $41\frac{1}{2}$ by the direct, repetitive method, and 39 by the reverse repetitive method. The difference in trials between the best method and the poorest method is $12\frac{3}{4}$. In the second round, 34 trials were made by the part method, 31 by the whole method, $41\frac{1}{2}$ by the progressive part method, $35\frac{1}{4}$ by the direct repetitive method and 36 by the reverse repetitive method. The difference in trials between the best method and the poorest method is $10\frac{1}{2}$. The difference between the extremes has decreased 17.6 per cent.

(b) Errors

Group I. In the first round by Group I there were 324 errors by the part method, 799 by the whole method, 187 by the progressive part method, 163 by the direct repetitive method, and 212 by the reverse repetitive method. The difference between the best method and the poorest method measured in number of errors is 636. In the third round there were 196 errors by the part method, 348 by the whole method, 143 by the progressive part method, 155 by the direct repetitive method and 131 by the reverse repetitive method. The difference between the best and the poorest in this round measured in errors is 217. The difference between the extremes has decreased 65.8 per cent.

Group II. In the first round by Group II there were 139 errors by the part method, 330 by the whole method, 121 by the progressive part method, 92 by the direct repetitive method and 100 by the reverse repetitive method. The difference between the best method and the poorest method expressed in errors is 238. In the second round, there were 112 errors in the part method, 211 in the whole method, 75 in the progressive part method, 54 in the direct repetitive method and 56 in the reverse repetitive method. The difference between the best and the poorest in this round expressed in errors is 157. The difference between the extremes has decreased 34 per cent.

(c) Time

Group I. The sum of the seconds required for each subject of Group I to do one series in the first round by the part method is 13208, whole method 14420, progressive part method 11313, direct repetitive method 9198, and reverse repetitive method 11880.

The difference in time between the best and poorest methods is 5222 seconds. In the third round the time for the part method was 7435 seconds, whole method 8005, progressive part method 8055, direct repetitive method 7795, and reverse repetitive method 7625. The difference in time between the best and poorest methods is 620 seconds. The difference between the extremes has decreased 91 per cent.

Group II. In the first round the part method consumed 6440 seconds, the whole method 7975, progressive part method 7425, the direct repetitive method 6340, and the reverse repetitive method 6620. The difference in time between the best and poorest methods is 1635 seconds. In the second round the part method consumed 5630 seconds, the whole method 5150, the progressive part method 4780, the direct repetitive method 4490, the reverse repetitive method 5045. The difference in this round between the best and the poorest method is 1140 seconds. The difference between the two extremes has decreased 30 per cent.

(d) Summary

Groups I and II both show a tendency for the differences found between the best and poorest methods in the first round to become markedly smaller in the final round. This statement is true by all criteria employed. The tendency is shown more markedly for Group I, which had three rounds of practice, than for Group II, which had only two rounds.

Although the tendency for differences in efficiency of the various methods to be diminished is apparent by all criteria, it is most marked as to time, and least marked as to trials.

Time is probably the most significant criterion of efficiency,

as will be shown later in this chapter. The difference between the best and poorest methods by this criterion was reduced on the third round, for Group I, to 9 per cent of its size on the first round.

The claim is commonly made that practice accentuates differences between individuals. However that may be, practice appears to reduce differences in efficiency between whole and part methods, so far as this experiment is concerned. For the subjects with longer practice, and by the most important criterion, these differences were reduced almost to the vanishing point.

3. THE RELATIVE AMOUNTS OF IMPROVEMENT UNDER THE METHODS STUDIED

(a) Trials

Group I. Table XVI shows the sum of the trials for each method, round by round. The gains made in rounds two and three are as follows:

	Part	Whole	P. P.	D. R.	R. R.
Round Two	$15\frac{1}{2}$	30	(loss) $3\frac{3}{4}$	$5\frac{1}{4}$	$7\frac{1}{4}$
Round Three	$8\frac{3}{4}$	<u>6</u>	$5\frac{3}{4}$ (loss)	$5\frac{1}{4}$	$5\frac{1}{2}$
Total Gain	$24\frac{1}{2}$	36	$9\frac{1}{2}$	0	$12\frac{3}{4}$

The whole method, which started with the highest number of trials, shows the most improvement. The direct repetitive method, which started with the lowest number, shows the least improvement.

Group II. Table XXXI shows the sum of the trials for each method, round by round. The gains the second round were as follows:

Part	Whole	P. P.	D. R.	R. R.
$1\frac{1}{2}$	10	$10\frac{1}{2}$	$6\frac{1}{4}$	3

The progressive part method, which shows the highest number of trials in the first round, made the most improvement. The part

method which made the lowest score in trials in the first round, made the least improvement.

(b) Errors

Group I. Table X shows the sum of the errors for each method, round by round. The gains made in rounds two and three are as follows:

	Part	Whole	P. P.	D. R.	R. R.
Round Two	45	358	28	54	93
Round Three	<u>83</u>	<u>92</u>	<u>16</u>	(loss) <u>46</u>	(loss) <u>12</u>
Total Gain	128	450	44	8	81

The whole method, which started with the highest number of errors, shows the greatest improvement. The direct repetitive method, which started with the fewest errors, showed the least improvement. Both this method and the reverse repetitive lost on the third round.

Group II. Table XXVIV shows the sum of the errors for each method, round by round. The gains made in round two are as follows:

Part	Whole	P. P.	D. R.	R. R.
27	119	46	38	44

The whole method, which started with the highest number of errors, shows the greatest improvement. The direct repetitive method which started with the fewest errors, shows the least improvement.

(c) Time

Group I. Table V shows the sum of the time for each method, round by round. The gains made in rounds two and three are as follow

	Part	Whole	P. P.	D. R.	R. R.
Round Two	3763"	4495"	1858"	1443"	1630"
Round Three	<u>2310</u>	<u>1920</u>	<u>1400</u>	(loss) <u>10</u>	<u>2625</u>
Total Gain	6073	6415	3258	1403	4255

The whole method, which was most expensive in time in the first round, made the greatest improvement. The direct repetitive method, which was the most economical in time in the first round, made the least improvement.

Group II. Table XXIII shows the sum of the time for each method, round by round. The gains made in the second round were as follows:

Part	Whole	P. P.	D. R.	R. R.
810"	2825"	2645"	1850"	1575"

The whole method, which was the most expensive in time the first round, made the most improvement. The part method, which was second best in time the first round, made the least improvement. This is the only time in which a method other than the one that was best of all in the first round showed the smallest amount of improvement.

(d) Summary

The methods making most and least improvement from first round to last round may be indicated in a summary tabulation.

		Most Improvement	Least Improvement
Trials:	Group I	Whole	Direct Repetitive
	Group II	Progressive Part	Part
Errors:	Group I	Whole	Direct Repetitive
	Group II	Whole	Direct Repetitive
Time:	Group I	Whole	Direct Repetitive
	Group II	Whole	Part

In every instance, the method which made the greatest improvement was the least effective in the first round. In every instance but one, the method which made the least improvement was the most effective in the first round. In the one exception, the method which gained least was next to most effective in the first round.

4. THE CORRELATION BETWEEN THE STANDING OF THE METHODS FOR SUCCESSIVE ROUNDS OF PRACTICE

Graphs XVI, and XVII and XVIII show the gross scores of Groups I and II in trials, errors, and time. It is our purpose to analyze these graphs and account as far as possible for the changes in correlation among the five methods.

Group I. It will be noticed that the graphs showing the learning progress in trials, errors and time for Group I show a perfect correlation for the first round. The gains by all methods from the beginning to the end of the first round, shown in Table I, are quite conspicuous. By the end of the second round the correlation for this group was not destroyed but disturbed.

The whole method advanced in time from fifth position to fourth, in errors remained fifth, and in trials advanced from fifth to second position. The pure part method advanced in time from fourth position to third, remained fourth in errors, and advanced in trials from fourth to third. The reverse repetitive method went from third position in time in the first round to fifth position in the second round, advanced in errors from third position to second, and in trials lost, going from third position to fourth. The progressive part method continued second in time, but fell back from second to third in errors, and from second to fifth in trials. The direct repetitive method continued first throughout the first and second rounds.

At the end of the third round the whole method is fifth in time, fifth in errors and second in trials. The pure part method is first in time, fourth in errors and first in trials. The reverse repetitive method is second in time, first in errors and third in trials. The progressive part method is fourth in time, second in errors and fifth

in trials. The direct repetitive method is third in time, third in errors and fourth in trials.

Group II. The whole method took fifth position in time, fifth in errors and third in trials the first round in Group II; in the second round this method was fourth in time, fifth in errors and first in trials. The progressive part method took fourth position in time the first round, third in errors and fifth in trials; in the second round the same method was second in time, third in errors, and fifth in trials. The reverse repetitive method took the third position in time, second in errors and second in trials the first round; in the second round this method was third in time, second in errors and fourth in trials. The pure part method took the second position in time, fourth in errors and first in trials the first round; in the second round it was fifth in time, fourth in errors and second in trials. The direct repetitive method is first both rounds in time and errors, fourth the first round in trials and third the second round.

Summary. If the rankings of the methods for the first round are compared with those for the second round, it will be noted that the resemblance is fair for time for both Groups I and II; very close for errors for Group I, and perfect for errors for Group II, very confused for trials for Group I, but fair for trials for Group II.

If the third round is now compared with the second, it will be found that so far as ranking is concerned there is practically no relationship to be discovered.

Another group of comparisons may be made: comparisons of results by the various criteria, one with another. The significant facts may be briefly noted.

For the first round, Group I results by all criteria agree perfectly; Group II results not very closely. After the first round, the three criteria give results which are decidedly out of agreement.

These results call for comment as to the significance of the criteria used, and their relative importance.

5. SIGNIFICANCE OF CRITERIA

"Comparison of the amount and rate of improvement of one individual in a given mental function with the amount and rate of another individual in the same function is by no means simple and straightforward; and the statements of ordinary life about the amount and rate of learning - such as that John improved twice as much or three times as rapidly as James or that John improved in addition very much more and faster than he did in subtraction - would in most cases require for justification a rather elaborate set of hypotheses about the measurement of change in mental functions."

Take an example from Wells' (1912) experiment in improvement in addition. Thorndike says of this: "Consider, for example, in connection with the data about addition, the question, 'Who improved most, - No. 2, who from 180 attained to 380 additions done in five minutes; or No. 10, who from 290 attained to 540?' Shall we compare the 380-180 with the 540-290; or the $\frac{380-180}{180}$ with the $\frac{540-290}{290}$ or using the time required per addition, compare the $\frac{300}{180} - \frac{300}{380}$ with the $\frac{300}{290} - \frac{300}{540}$; or is there still some better way?"

Suppose that a boy progressed from 60 to 90 in the mark attained in geography and from 100 to 200 in the mark for additions

1. Thorndike, Educational Psychology, Vol. II, p.165

done in five minutes. Who knows whether the former represents only half as much improvement as the latter? Suppose then that a method of learning nonsense syllables shows an improvement at the end of the second round of 1000 seconds. Who knows just what degree of improvement in trials and errors would constitute an equal gain; or what degree of correlation the laws of learning and the amount, rate and limit of improvement presuppose? We know that possibilities of improvement vary with varying conditions and aptitudes. It seems reasonable to assume that a given per cent of gain or loss measured in trials does not necessarily represent the same fact that the same per cent of gain or loss in errors does.

After careful study and consideration, the writer is using the time element as the primary criterion for the evaluation of the various methods, although the other criteria are not neglected. An investigation of experimentation in addition by Wells¹ and Thorndike, substitution tests by Dearborn² and Starch³, typewriting by Swift and Schuyler, telegraphy by Bryan⁴ and Harter⁴, improvement in mental multiplication by Starch and Thorndike, improvement in ability to memorize by Dearborn and improvement in tossing balls by Swift⁵ shows that time is used by all of these investigators as the criterion for the measurement of progress.

1. Wells, The Relation of Practice to Individual Differences, A. J.P. Vol. XXIII, 75-88
2. Dearborn, W. F., Experiments in Learning, Jr. of Ed. Psych. Vol. I, pp. 375-388
3. Starch, Daniel, Transfer of Training in Arithmetical Operations, Jr. of Ed. Psych., Vol. II, pp.306-310
4. Bryan, N. L. and Harter, N., Studies in the Physiology and Psych. of the Telegraphic Language, Psych. Rev., Vol. IV, pp.27-3 Vol. VI, pp. 345-376
5. Swift, The Learning Process, Psych. Bull., Vol IV, pp.307-310

"It may seem to superficial thought that the number of words or letters written is a better measure of the amount of exercise of the function than the time spent. To write a letter ten times, one may claim, is surely ten times writing it once. It is not. The first writing of a word may mean an examination of the key board and the selection of the right response from many. The rejection of the other responses is as truly a part of learning as merely hitting the one key. The thousandth writing of a word is physiologically a vastly different thing in the amount of exercise which it gives the function in question. I do not, however, assert that 'one minute of practice is more truly equal to another minute of practice' than one word written is equal to another 'word written', though that is my opinion. Units of time are better as the units of amount of practice because they are always easily intelligible, and can be used uniformly for all functions."

"Time spent has the advantage of simplicity, uniformity, intelligibility and comparability."

It seems probable that it is easier to think in terms of hours, minutes and seconds, than in terms of numbers added, number of letters substituted, number of syllables learned, number of trials at learning, or number of errors in the learning. Time is the same for all functions and all subjects, regardless of the nature of the experiment, the machinery for carrying it on, or the rules and regulations which govern the practice. Every one understands the meaning of the terms hour, minute, and second. Time is a common

1. Thorndike, E. L., Educational Psychology, Vol II, P. 245
2. Ibid, p. 295

language. But numbers added, errors made, trials, and the like have to be defined and interpreted. If functions are comparable at all, time enables us to compare them. Furthermore, we make our plans for learning in schools and trades in terms of time. An eight hour day, a twenty hour school week, a fifty minute period; there is, therefore, an advantage in thinking of learning in terms of time.

6. REASONS FOR GREATER IMPROVEMENT IN MORE

DIFFICULT METHODS

Possibilities for Improvement. There is greatest possibility of improvement in the method that is most difficult at the beginning. If one is already habituated to some degree to a certain set of conditions, he is obviously likely to be closer to his limit of skill for these conditions than for ones to which he is not habituated at all.

This is especially true in the use of the whole method. Few subjects are in the habit of using the whole method, therefore, it required a longer period of practice to reach the limit of skill in the whole method than it does in the methods that are more in use. The rate of improvement for all methods changes, becoming less as practice advances; the method showing the greatest decrease in improvement is the one that was employed in the beginning with greatest ease. Negative acceleration is not a universal rule of learning, but we find two cases in the third round of Group I where the scores for the direct repetitive method, representing the number of trials, errors, and time show a loss (increased score) by all criteria. The direct repetitive method up to this time was the best; it was the easiest of all methods to employ in the beginning.

Effort on hardest methods. Another tendency that influenced the correlation of these results was the effort of the subjects to

bring the record of the methods that were the most difficult in the beginning up to the standards of the methods that were easiest in the beginning. For example, subjects generally felt that it was a greater accomplishment to do a given series by the whole method in a given time than it was to do a series in the same time by one of the modified part methods. This had a tendency to produce what Thorndike calls a "positive opposite change", or the strengthening of one bond or function at the expense of another. There entered here also the element of satisfaction. "Whatever does favor the repetition and satisfyingness of the desirable bonds, and the disuse and annoyingness of the undesirable bonds, will, other things being equal, favor improvement. The most noteworthy psychological conditions of improvement come under this head." When a subject finds satisfaction in a certain improvement, he works at his maximum power to accomplish it.

7. CHAPTER SUMMARY

1. Practice tends to decrease the differences in the effectiveness of the various methods.
2. For Group I, the difference between best and poorest methods was reduced, from the first round to the third round, by 25 per cent in terms of trials, 65.8 per cent in errors, and 91 per cent in time.
3. For Group II, the difference between best and poorest methods was reduced, from the first round to the second round, by 17.6 per cent in terms of trials, 34 per cent in errors, and 30 per cent in time.

4. The method that was the most difficult to employ at the beginning of practice showed most improvement. This is the whole method.
5. The method that was the best at the beginning of practice showed the least improvement. This is the direct repetitive method.
6. The graphs showing the learning progress in trials, errors, and time for Group I, show a perfect correlation for the first round.
7. The correlation became less perfect as practice proceeded.
8. There is less change in correlation in Group II than in I; but Group II practices less than Group I.
9. It is not reasonable to expect identical rates of gain by all criteria.
10. Time is used by most investigators as the criterion for the measure of progress, and is regarded as the most important criterion in this investigation.
11. Possibilities for improvement are greatest in those methods which are most difficult at the beginning of practice.
12. Effort to improve is greatest for those methods which are most difficult at the beginning of practice.

CHAPTER V

ANALYTICAL AND COMPARATIVE STUDY OF METHODS

I. METHOD BY METHOD

A. Pure part

From Tables VI, XI, XXIV and XXIX we find the pure part method fourth in value in both the time consumed and the number of errors made. Since the pure part method is inferior to all the other forms of the part method, there are evidently some elements of weakness involved in this method.

There was throughout the experiment, as shown by the records, a heavier loss due to disintegration through time by the pure part methods than by any other of the part methods. The syllables of units 1 and 2 of the series, which had been learned and written correctly twice in succession, not infrequently seemed entirely gone when the subject came back to that part of the series after learning units 3 and 4 of the series. This pure part method required then, more time, and was conducive to many errors in the final process of assembling units 1, 2, 3, and 4 of the series.

A large percentage of the learning by all methods was accomplished through the use of place association. The subjects remembered that "xuc" came fifth in the series rather than remembering that "xuc" followed "zof", etc. This association once broken up, there was a condition of general demoralization until a new set of associations could be formed.

Another custom common to all subjects and all methods was the one of attaching meanings to the syllables. No difference how meaningless the syllable, most of the subjects could devise a sentence, jingle, or story by attaching some kind of significance, often far fetched, to the materials presented. There was no way of preventing this - it was wholly subjective and had to be admitted.

There was more waste in connection in the pure part than in any other of the part methods, less evidence of positive transfer and less improvement due to practice. Two individuals of Group I made their best time records in the pure part method, and one individual of Group II made a better time record in the pure part method than in any other of the part methods. This same individual, D, made her best time record in the whole method. At no time was the pure part method superior to the other forms of part method measured in terms of errors.

B. The Progressive Part

Tables VI, XI, XXIV and XXIX give the per cent of total time and errors charged to each method. The progressive part method appears second in value measured in time and errors.

Much the same may be said of place association and its relation to the progressive part method of learning that has been said above of its relation to the pure part method. The subject loses less because of disintegration through time, since the parts of the series learned first are reviewed with each new unit, keeping those syllables first learned fresh in mind. There is, therefore, less of loss in connection.

There is no evidence of greater transfer in this than in the pure part method, nor is there greater improvement due to practice.

The needless repetitions of parts already known consume time unnecessarily. For example, unit 1 of the series is learned independently of all others; is then rewritten at least twice, and generally more than twice, with unit 2; is written again at least twice with 2 and 3; and is finally written at least twice with 2, 3, and 4. If there were no errors made in the whole series, which would be most unusual, the first unit of the series must be written at least eight times. In most cases, the first unit of a series, when using the progressive part method is written twelve or more times. This seems a needless expense of time, and this, more than any other element of waste, accounts for this method being other than best among the methods.

Four subjects of Group II each doing two series by the progressive part method made only eight errors in the first unit of all the eight series after the first correct writing, but the first unit was written forty-nine times after the second correct writing. Allowing one error to a writing, which is the least possible estimate, there would still be forty-one writings of this particular section without an error. This is an extravagance of time and energy.

C. Direct Repetitive

Measured in trials, errors and time, the direct repetitive method is the most economical. Tables VI, XI, XIV and XIX furnish the data for errors and time. From the original records it is found that six of the ten subjects made the fewest trials in the

direct repetitive method, three made an equal number in the direct repetitive and the reverse repetitive method, and only one, subject D of Group II, made the fewest trials in the reverse repetitive method.

The particular advantage of this method is that there is a continuous expansion of the unit of learning. As soon as the first division of the series is learned, the second division is added and mastered, the learner reviewing each time the familiar syllables while learning the unfamiliar. There is no loss in association in this procedure as there was in the pure part method, where the learning of each fraction of the series as an independent unit tends to erase the associations previously formed in the preceding sections. This is true also of the progressive part method, in which each part of the series is learned independently before attempting to join it to the part or parts already learned.

It is the unanimous opinion of the subjects that there is an unnecessary extravagance in time and energy in the numerous repetitions of the first and second units of the series in the direct repetitive method. In this, as in the progressive part method previously discussed, the first unit of the series is written at least eight times. The average number of times Group II wrote the first unit of each series by the direct repetitive method was 9.5. This means ninety-five writings of the first six syllables by the five subjects of Group II, each doing two series by the direct repetitive method. This count does not include those trials up to and including the first correct writing of the first unit.

There were ten errors by all the subjects of Group II in the first unit, after the first correct writing; it is therefore evident that this first unit of the series was written without error at least eighty-five times after the first correct writing.

The factors of advantage, however, especially the gradual growth of complexity of the learning situation, are probably sufficient to show the direct repetitive method the superior one in the early stages of practice.

D. Reverse Repetitive

This method is the reverse of the direct repetitive discussed above. In it the subject learns part 4 of the series first, he then attacks part 3, continuing through part 4 each time until both 3 and 4 are mastered. Parts 2 and 1 are added in like fashion. This necessitates the writing of part 4 as many times, unnecessarily, as part 1 was written in the direct repetitive method.

Advantage rests in the gradual growth of the learning situation, and in keeping the connections fresh in mind by the constant repetitions of the learned with the unlearned. Subjects generally preferred, however, to attack the strange portion of the material for learning at the close rather than at the beginning of the series. In this reversed repetitive method, the last of each study period was always spent on the familiar, giving time and opportunity for the loss of the new and unfamiliar.

E. Whole Method

In the five rounds of the methods, three by Group I and two by Group II, the whole method was fifth (fifth is the poorest) three times and fourth twice in time, fifth without exception in

errors, fifth once, third once, second twice, and first once in trials.

In as much as the whole method is best only once and poorest nine times out of the fifteen, there must be some element of weakness not common to the other methods.

(1) The first disadvantage of the whole method which the writer wishes to record is the emotional reaction of the subjects to the method. Most of the subjects faced it with a feeling of fear, a feeling that it could not be done. Twenty-four syllables is so far beyond the memory span that it was discouraging to the subject. He could see no progress for the first few trials at least. This discouragement often developed into a state of mental confusion, in which the subject seemed wholly incapable of concentration.

(2) The introspections of subjects show that they were not able to make progress until they ceased trying to memorize the series as a unit and began to concentrate on pivotal syllables, generally at the beginning and end of the series.

(3) The learning was generally accomplished ultimately by place association.

(4) The advantage was in the continuity of the associations. When the series was finally memorized, it was seldom that the subject failed to write it the second time correctly.

F. Summary

1. The pure part method loses because of disintegration through time and the complexity of the act of connection. Frequently the syllables learned in the first unit of the series seemed entirely gone when the subject came back to that part of the series after learning the last units. The associations had faded out.

2. The progressive part method loses less because of disintegration through time; the parts learned first are reviewed with each new unit. There is, therefore, less of loss in connection. The needless repetitions of parts already known consume time unnecessarily, and more than any other element of waste, accounts for its being other than best among the methods.

3. The particular advantage of the direct repetitive method is the continuous expansion of the unit of learning. There is an unnecessary extravagance in time and energy in the numerous repetitions of first and second divisions of the series of this method.

4. In the reversed repetitive method, part 4 of the series is written as many times unnecessarily as part 1 of the direct repetitive is. The gradual growth of the unit of learning is an advantage. The subjects were unanimous in the opinion that having the unfamiliar precede the familiar in the study-reproduction sequence was a distinct disadvantage.

5. The whole method is conducive to emotional instability, fear and discouragement. Twenty-four syllables is far beyond the memory span of any subject; mental confusion is the result. Learning was generally accomplished by place association. The chief advantage of the whole method was in the continuity of the study. No breaks between parts, and no lost connections occur.

2. GENERAL FACTORS

A. The emotional Set

The first particularly significant observation of the writer was the emotional set of the subject on approaching the whole method procedure. There was a feeling that it could not be done that way, and there was an effort to conjure up some way of doing

the whole method in parts. This emotional attitude was by no means an asset to the learner.

Book¹ says: "But what about our question, the retroactive effect of pleasant and unpleasant feelings upon the learner's ability to do and to improve?.... Pleasant feelings, had undeniably, in our experiments, a stimulating and helpful effect upon every part of the work, unpleasant feeling a depressing, retarding effect. Pleasant feelings produced something like an increased irritability in the neural basis of every psychophysical activity in operation at the time. Success brings pleasure and the pleasure spurs the learner on to greater effort and more successful work. An unpleasant feeling tends to interrupt the natural, easy and correct movement of attention by taking forcible possession of consciousness and dominating it. Instead of consciousness being focused on the details of the work, it is filled with unpleasant feelings, which not only take attention off the details of the work, but create a 'set' of mind unfavorable for the work.

"In all moderate degrees unpleasant feelings serve as a distraction and produce, or further aggravate, a failure of attention. If exceedingly severe, they may, however, serve as an incentive to efficient effort and thus entirely counteract their usual effect. That is to say, one's mistakes or the unpleasant feelings which follow, may in rare cases, serve to arouse the

1. Book, W. F., Psychology of Skill, pp. 206-207

learner to greater voluntary endeavor and so prove advantageous. Pleasant feelings always seemed to stimulate the right flow and movement of attention and, therefore, made every part of the work, go better. Every increase in effectiveness caused more pleasure, it seemed, and the pleasurable feeling gave, in turn, the proper "set" of attention for still more easy and successful work. The learner could try both harder and more effectively when he was feeling good. He had to waste no effort in trying. Only when success led to complacent self-satisfaction and slackened voluntary attention did the effect of the pleasant feeling become disadvantageous. When it lessens effort to a considerable degree, its unconscious helpful effect may be more than counteracted. In our experiments however, this never occurred. All pleasant feelings attending the success had a helpful reactionary effect on the work."

Thorndike¹ says: "There is a conflict of theory and of practices with respect to the value of emotional fervor in learning. In the case of intellectual functions, the balance of opinion is that, apart from the eager but quiet zest for the work itself and for success in it, all emotional excitement is distracting, that not only violent love, grief, humiliation and disgust, but also even moderate fear of on-lookers, exultation at success, and anger at competitors or at oneself, are to some extent wastes of energy and preventives of improvement."

In the part methods there was a feeling of confidence generated as the experiment progressed that transferred from one

1. Thorndike, E. L., E.d. Psychology, Vol. II, p. 226

part method to the other; and from unit to unit in any one part method; but this confidence in ability did not function in the whole method procedure. The habits and attitudes that aided in the part and modified part methods were impaired when the whole method was attacked.

B. The Difficulties Within the Learning Units

Graph XXI, showing the number of times each syllable was missed by all the subjects of Group I in the part method, shows the syllable missed least frequently to be number 1 and the one missed most frequently to be number 17. It is reasonable to expect the subject to remember the first syllable or syllables of a series, since some such factor as primacy or intensity is no doubt operative. In all the graphs representing the part methods the curve is low on syllables 1 and 2, 7 and 8 and frequently 13 and 19. This is due to the divisions of the twenty-four syllables into sections of six syllables each. The initial syllable of each section, numbers 1, 7, 13, and 19, are remembered better than those near the middle or at the end of the series. Syllable number 17 was missed most often by the part method, this, therefore seems a point of unusual difficulty in the pure part method.

Syllable number 17 is also the one missed most frequently by the whole method. The writer knows of no reason why the 17th syllable should be missed more frequently than the 15th or 16th or any other syllable near the middle of the series of 24 syllables, and can conjecture only that this syllable is per se very difficult to grasp.

In the whole method of procedure (Graph XXII) the curve rises with comparative regularity from the first to the middle or near the middle of the series and then falls with about the same regularity to the last syllable. This is probably due in the first place to the application of the laws of primacy and recency, and also to the fact that most of the subjects made an effort at first to retain only a limited number of syllables at the beginning and end of the series, adding a few each trial adjacent to those at the beginning and end. Obviously this would cause the syllables near the middle of the series to be missed most frequently, but should not be construed to mean that they are more difficult or that they could not be learned as easily as any other of the syllables. If, for example, the subjects should concentrate on the six syllables nearest the middle of the series, adding a few each trial, gradually making progress toward the extremes, it would then appear that the syllables near the ends were more difficult for learning or that the subject was less able to retain those syllables than those of the mid-section.

Graphs XXIII, XXIV, and XXV show the frequency of errors for the progressive part, the direct repetitive, and the reverse repetitive methods.

Syllable number 11 is the most frequently missed in both the progressive part and the direct repetitive methods, with syllables number 5 and 6 of both methods second in frequency. The rise and fall of both graphs is easily accounted for, inasmuch as the points of high frequency invariably occur between the beginning and end of the subdivisions of the twenty-four syllable series.

Graph XXV is unlike the others in that the high point of frequency is on syllable number 23, next to the last one. This is due to the backward learning in this method. The last six syllables of the series are repeated many more times than the others, giving opportunity for more errors there than in those syllables nearer the beginning of the series. It is not at all surprising that syllables 1 and 7 should have the fewest errors recorded against them, begin the initial syllables of the first and second divisions of the series.

Graph XXVI shows the frequency of errors for the group, all methods. Beginning with syllable number 1, it rises regularly to number 5. Numbers 5 and 6 are practically equal in number of errors and then there is a sharp drop on number 7.

The same is true of numbers 13, 19 and 24. Syllable number 17 is the high point for the entire group, as it was for both the part and whole methods. Syllables number 11 and 23 also rise considerably above the average.

Summarizing these points of difficulty for Group I, we find the point of greatest difficulty in the pure part method to be syllable number 17; whole method, syllable number 17; progressive part method, syllable number 11; direct repetitive, syllable number 11; reverse repetitive method, syllable number 23; all methods combined, syllable number 17.

Syllable number 17 is evidently the most difficult, having been missed by the subjects of Group I twenty-two times more than any other syllable. Syllable 23 appears second in difficulty and syllable 11 third.

In Group II the syllable showing the greatest difficulty by the pure part method is number 9; whole method, number 16; progressive part method, number 23; direct repetitive method, number 9 and 10; reverse repetitive method, number 17; all the subjects of Group II five times more than any other syllable.

The fact that the points which seem to offer the greatest difficulty to both groups I and II are consecutive syllables is at least interesting. It suggests that the general location of greatest difficulty was at about syllable 16 or 17, i.e. about two-thirds of the way through the series, but that chance may account for the particular point found most difficult by a given group.

It is a more notable finding, from the graphs discussed in this section, that errors tend to be distributed within the limits of the learning units for the various part methods after the same fashion as within the wider limits of the whole series for the whole method. Herein lies a strength of the part methods; for a slight piling up of errors at each of perhaps four points in the whole series (one point for each unit) is preferable to a single heavy piling up of errors, with gradually shading off on each side, as found for the whole method.

The fact that errors do not, however, shade off uniformly from the point of greatest difficulty for the whole method, but rather are noticeably diminished at certain points, raises a further question which will be discussed in Chapter VI.

C. Distribution of Errors According to Method

Group I. Table IX shows the distribution of errors among the methods by the individual subjects of Group I. Subject A made the fewest errors in the reverse repetitive method, B and D in the direct repetitive method, C and E in the progressive part method. All of the subjects of Group I made more errors in the whole method than in any other.

Table X shows the group distribution of errors among the several methods. In the first and second rounds, this group made the fewest errors in the direct repetitive method; in the third round, the reverse repetitive method is the best.

Table XI shows the distribution expressed in per cent. The direct repetitive method shows the smallest percentage of errors made and the whole method the greatest; the difference is 31 per cent. The errors made by the whole method procedure were 3.7 times those of the direct repetitive method procedure.

Group II. Table XXVII shows that subjects A, B and D make fewer errors in the direct repetitive method than in any other. Subject C made the fewest in the progressive part method and Subject E the fewest in the reverse repetitive method. Four of the five subjects made more errors in the whole method than in any other. Subject D made four errors more in the progressive part method than in the whole method. Table XXVIII shows the group distribution of errors among the several methods. The fewest errors were made both the first and second rounds by the direct repetitive method procedure.

Table XXIX shows the distribution expressed in per cents. It shows a difference of 30.6 per cent of errors between the

direct repetitive method in which the fewest errors occur and the whole method in which the greatest number of errors occur. There are 3.7 times as many errors in the whole method as there are in the direct repetitive method.

Further data, showing the same tendency for the whole method to yield more errors than the direct repetitive method, may be found in Tables IX, X, XI, XXXII, and XXXIII.

The reasons why more errors occur with the whole method than with the direct repetitive method have been largely indicated in the early part of this chapter, wherein the strengths and weaknesses of each method were outlined.

D. Difficulties in Connection

Pechstein¹ finds that waste in part learning in the maze problem "occurs only in the act of connection and is here traceable almost entirely to the influence of place association." He says, "It seems logical to assign the difficulty of the act of connection in part learning to the break up of these specific positional factors." By "positional factors," Dr. Pechstein means place association which refers to the "definite location of an element of a problem in reference not only to the remaining details of that problem but to the entire environment."

The present writer found little difficulty of connection in methods other than the pure part. There were 90 errors made in the act of connection in the pure part method by all the subjects. This is an average of 3.6 errors in connection to the series. Inasmuch as there were 1280 errors made by all subjects in the

1. Pechstein, L. A., Whole Vs. Part Methods in Motor Learning Chapters IV and V.

part method, it does not seem that 90 of these is an exorbitant share to occur in the act of connection. The difficulties were less in the process of connecting than in the ability to retain the syllables between the connections.

E. Learning Effort in Relation to Length of Material to be Learned

It would be a difficult matter to find a more accurate basis for comparing the length of materials used and the learning effort than that furnished by the use of nonsense syllables. The lists are equal in length and as nearly equal in difficulty as it is humanly possible to have them.

In the whole method, twenty-four syllables was the unit of learning. In the part method, six syllables was the learning unit. Is it reasonable to assume that one-fourth of the time required for learning the twenty-four syllable should be required for learning the six syllables? Figures taken from the records of the experiment will answer the question. The average time required for the subjects of Group I to learn a series of syllables by the whole method was 2896 seconds. The average time required for the same group to learn the first part of the series (one fourth of it) by the part method was 242 seconds. The series were in length as 1 to 4, the time was as 1 to 12. Many similar data may be found in the tables, all pointing in the same direction. This indicates that diminishing returns are secured for the expenditure of energy beyond a certain point. The above statements agree with Pechstein's findings.¹

1. Pechstein, L. A., Whole vs. Part Methods in Motor Learning, Chapter VI.

3. CHAPTER SUMMARY

1. The pure part method suffers loss because of disintegration through time.
2. More errors are made in the act of connection in the part method than in the modified part methods.
3. Modified part methods consume time unnecessarily in the repetitions of parts already learned.
4. The particular advantage of the modified part methods is the continuous expansion of the unit of learning.
5. The whole method is conducive to emotional instability, fear and discouragement. The advantage is in the continuity of the study.
6. Syllables are missed more frequently near the middle of a series than at the beginning or end.
7. Syllable number 17 is the one missed most often by Group I; syllable number 16 is the one missed most often by Group II.
8. In the whole method, errors are piled up toward the center of the series very heavily; in the modified part methods, errors are piled up to a slight degree within each unit of six syllables, but total errors are fewer.
9. The difficulties experienced in the act of connection by the subjects in this experiment were not serious.
10. The relation between learning effort and length of material to be learned is one of diminishing returns.
11. Measured in errors, the direct repetitive method is the most economical for Groups I and II and the whole method the least economical. The ratio is 1 to 3.7.

CHAPTER VI

THE POSSIBILITIES IN PROLONGED PRACTICE

I. INTRODUCTION

An analytical and comparative study of the methods employed has been presented in the preceding chapter. This was based upon the data for fifteen practice periods for Group I, and ten practice periods for Group II. What would be the results, were practice to be continued indefinitely?

Answers to this question must be speculative, of course, but it is possible to review some considerations bearing upon the problem. In the present chapter, the following points will be discussed; the tendencies found in the data; the extent to which control of objective conditions controls the process of learning; and the special case of whole method presentation as a control factor. In large part, the chapter will summarize the findings of preceding chapters.

2. TENDENCIES FOUND

It is in order here to restate the facts noted in Chapter IV, with a view to their implications for extended practice.

Diminishing importance of method as such. In Chapter IV, we have shown that the relative importance of method decreases with the growth of practice. In respect to time, the scatter of the methods for Group I was reduced almost to the vanishing point (Graph XVIII). This was accomplished in fifteen periods of practice. The difference between the best method and the poorest method, at the end of five periods of practice was more than 500 seconds; after ten more periods of practice the

difference between the same two methods was less than 250 seconds. There was a general tendency to improve, but the rates of improvement under the various methods were such as to bring them nearly to a common value in the third round of practice. This is true in part also with respect to trials and errors for Group I, though the scatter is not reduced to the narrow limits that characterize the time scores. Group II shows the same tendency, although not so pronouncedly, its practice extending through only ten periods.

Greatest improvement with methods at first least effective.

The methods that were most difficult at first made the greatest gains. This is true for all criteria and for both groups. Likewise, the methods in which the subjects were at first most successful made the least gains. The facts have been presented in Chapter IV.

In general, it is the whole method which proved poorest at the start, and which improved most. Special attention will be given to the whole method in the later sections of this chapter.

3. CONTROL OF OBJECTIVE CONDITIONS AND CONTROL OF LEARNING

It is possible to control conditions of improvement, that are external, such as length of practice period, time of day, amount of food, and the like, but it is not possible to force the individual learner to take advantage of the controlled conditions if he chooses to accept the condition but not the advantage.

It is possible to prevent the child's counting on his fingers but he can use his toes or his teeth for the same purpose. Lip readers can be frowned upon sufficiently to break the learner of moving his lips in silent reading, but he can continue to vocalize without moving his lips. It was possible to arm the beardless

shepherd boy with Saul's armour and put a helmet of brass on his head and a coat of mail around him and to gird a sword upon his armour, but when he met the enemy, he cast aside these cumbersome "external conditions" for something that would function in his hour of need.

One may present fifty lines of poetry, a chapter from American history or from the Bible as a whole, but is there any assurance that such material will be learned as a whole? It is altogether probable that some lines or parts will appeal to the already accumulated fund of materials and will be retained after one or two readings. The more difficult portion will form independent learning units, and though the parts learned easily may be repeated with the more difficult, the act of controlling repetitions will not control subjective mental experiences, sensations, images, memories, feelings, emotions, and impulses. While the experimenter is presenting as a whole, the subject may practice recall of the difficult lines or portions, thus making a modified part learning from a whole presentation.

4. WHOLE METHOD PRESENTATION AS A SPECIAL CASE

The tendency to break nonsense materials into small units for the accomodation of the memory span is as great as or greater than the tendency to subdivide the meaningful materials mentioned above. It is impossible for the learner to retain an entire series of twnety-four nonsense syllables the first trial. For him to devise a plan to assist his retentive powers is to be expected. (The introspections shown later will illustrate this point.)

The following description of the acquisition of a learning unit of twenty-four syllables under whole method conditions seems to the writer to be typical. The subject undertakes to retain the first two or three syllables and the last one or two the first trial; he does not attempt to remember or reproduce the intervening syllables. The second trial, the general tendency of the subject was to retain syllables number 7, 13, and 19 and make these pivotal syllables; from these three pivotal syllables and the two extremes, the subjects closed the breaks between, usually finishing near the middle of the series. The series of twenty-four syllables was, therefore, made into four learning units. The presentation was by wholes, but the writer believes the learning was by parts.

The whole method has shown the greatest capacity for improvement so far. This superiority measured in improvement is the result of (a) overcoming a feeling of fear and inferiority when attacking the whole method procedure, (b) adjustment of the materials to the memory span, (c) development of a technique of learning long series of syllables, (d) cultivation of habits of control in attention, (e) establishing pivotal points by which connections were made more secure and special relationships were simplified, (f) and ultimately the development of a modified part method.

How long improvement can continue or just what the limits of improvability are, is, in its finality, a matter of individual capacity. Until the limit of efficiency is reached, improvement is possible. Under the proper stimulus to interest and effort, achievement in both the whole and part methods should continue.

much beyond the limits of this investigation. The writer believes that the feeling of necessity has so far goaded the subjects into a more intensive effort to excel by the whole method procedure than by the part methods. Is it not possible, then, that the whole method is at the end of fifteen periods of practice as near or nearer the limit of efficiency as any of the part methods? The whole method as such, in the opinion of the writer, would never be superior to the modified part methods in learning nonsense syllables. On the other hand, the possibilities which lie in making divisions according to the individual memory spans of subjects may reveal a strength in whole method presentation that has not yet been recognized.

5. CHAPTER SUMMARY

1. Under practice, method of presentation as such shows diminishing importance.
2. The methods of presentation which are most difficult at first, and notably the part method show greatest improvement.
3. Control of the external conditions of learning does not control the actual procedure of the learner.
4. In particular, the whole method of presentation allows the learner to develop special skills and devices.
5. The development of such skills and devices together with the change from undesirable emotional and volitional attitudes to desirable ones, account for the improvement under the whole method.
6. It is very evident that the limits of improvement were not reached for any method in the present investigation.

7. It is not known whether the whole method of presentation would ultimately surpass the other methods in efficiency under further practice.

CHAPTER VII
INTROSPECTION OF SUBJECTS

I. INTRODUCTION

Statements were secured from all subjects as to their general reactions to the experiment. While these have been used as a basis for much of the earlier discussion, it seems well to quote them directly.

Group I consisted of subject who had had more psychological training than those of Group II. The reports from Group I are accordingly more complete. The following excerpts seem most significant.

2. GROUP I

Subject A. This subject states that his greatest difficulty in learning nonsense syllables was to convince himself that he could accomplish the learning by any method.

"After a few trials I found that I could learn six syllables. This encouraged me to continue with another six and so on until the twenty-four syllables were learned in parts. Then the task of putting them together seemed hopeless but was finally accomplished. The learning of one group of six syllable seemed to completely erase from memory those previously learned. There seemed to be no means of associating, no reason why they should stick. I approached the whole method with a feeling that it was impossible for me to accomplish in that way. The first trials resulted in confusion, discouragement, disgust and what then seemed to be fatigue. To learn twenty-four syllables as a whole is, to me, an

impossibility. The only way that I could do it was to learn not to exceed five syllables at a time, to practice recall on these while the others were being exposed. With the first division learned I would add to it a few more. The modified part methods were easier for me because of the gradual growth of the learning difficulty."

Subject B This subject is not easily confused, has confidence in his ability to do what he attempts, never hurries. He says that he knew before starting the experiment that he could learn nonsense syllables by any method but expected it to take longer than it did.

"I began with the whole method and could see no progress until the sixth trial, when I was able to remember a very few of the syllables in order. I could remember the syllables but the difficult matter was to place them correctly. It was necessary to establish two or three points between the beginning and end of the series from which I could connect both forward and backward. Another advantage taken was in using the full time allowed in the study-reproduction sequence to practice recalling forward two syllables and backward three or more as time would permit. The second and fifth series were more difficult and confusing than the first. The pure part method was the poorest one for me, as the disconnected parts were as hard to put together, after learning them independent of the whole series, as the learning itself was. The reversed repetitive is my favorite."

Subject C. This subject began with the progressive part method. His introspections show that he believed in his ability

to learn nonsense materials but found that it required more time than he anticipated.

"I found learning nonsense materials more exhausting than I had expected. The whole method was especially expensive in nervous energy. After finishing a series by the whole method there was a feeling of fatigue or nervous tension. The difference in the time, necessary for completing a series did not depend as much on the method as on the condition of the subject. Some days, due to illness in my family, I was not as capable as others. The unnecessary repetitions in the modified part methods were confusing and to me a useless expense of energy. The pure part method was weak in connecting facilities. There was lack of continuity. However, if I were choosing a method for my own convenience it would probably be the pure part method, because it is easy to learn the short units. My second choice would probably be the whole method. Either method seems to avoid needless repetitions."

Subject D. This subject made a very discouraging start, losing by all criteria until the fifth series, when he gained in one day all that he lost in the four days preceding. The subject's determination to improve was a very telling asset.

"It seemed impossible at first to learn nonsense syllables by any method, but unpromising as the first day's work was, it was more than doubled in difficulty by the end of the fourth practice. It was a case of accumulating discouragements rather than a case of accumulating results of practice. Something had to be done. I therefore conceived the idea of attaching meanings to

the syllables. This helped a very great deal. When using the whole method procedure, I made no effort to retain more than five syllables the first one or two trials; the four were numbers 1, 7, 13, 19, and 24. After learning those and making pivotal points of them, I was able to close the gaps usually finishing with the portion of the series between syllables 13 and 19. Improvement came with practice, but it was largely practice in manipulation rather than practice in remembering. The pure part method was next to the whole method in difficulty until I learned to practice recall of the connecting syllables all through the learning. The direct repetitive is my favorite of all the methods. The connections are kept intact and the division into four points eliminates the disadvantages of the whole method."

Subject E. "I began the experiment without an opinion as to the relative difficulty of the methods. The first series seemed very difficult and effects of fatigue were very evident during the last fourth of the period. Improvement came much faster than I expected and I reached the peak of my performance in the second round. After that my enthusiasm waned somewhat, and the results followed the decrease in enthusiasm. The whole method was most difficult at first. After developing a system for subdividing the series and attaching meanings to the syllables, it became as easy or perhaps the easiest of the methods. Of the part methods, the pure part is my favorite. The modified part methods are burdened with the machinery of method, making them inefficient for my use."

3. GROUP II

Subject A. "I approached the experiment without knowledge of what I was to do and without forming an opinion as to the difficulty of the task. It did not worry me in the least. The whole method was too long to remember any of the syllables at first. I learned, after a few trials, to concentrate on a few syllables each time until all were learned. The pure part method was harder for me than the whole method. I couldn't remember one part while learning another. The modified part methods were easiest. I do not know which was best, they were so much alike."

Subject B. "I did not expect anything in the beginning, just learned the syllables and did not care which method would finally be superior. The direct repetitive method seemed to fit my memory best. The whole method took so long the first time, so I tried learning it in halves the second time and got along much better."

Subject C. "Nervousness caused me to make many mistakes, especially in the last of a period when I was tired. The pure part method was the most difficult for me. It was so hard to hold the first part of the series, while learning the last part and connecting up the series was equal in difficulty to doing it from the beginning. The direct repetitive method was easiest for me, the learning unit increased in size so gradually and the connections were all made when once through."

Subject D. "It was not as difficult a task as I expected and a little practice worked wonders. It made me tired and nervous at first but after the first round I enjoyed it. After the initial round the direct repetitive method was easiest and

the progressive part method was hardest. The whole method did not seem harder than the part methods, for I tried to learn only five syllables each trial and did not worry about the rest of them."

Subject E. "I felt before beginning that it would be an easy task, but it was not as easy as I expected it to be. Improvement was encouraging, and the satisfaction that came from the work increased from day to day. Learning was accomplished almost entirely by place association. The whole method was the most difficult in both rounds. The whole method was not so difficult in the second round, I divided it into three learning units and attached them one at a time. I cannot say which of the part methods was easiest for me, it was just a matter of chance or the condition of the learner."

4. CHAPTER SUMMARY

1. The subjects of Group I are generally agreed that:
 - (a) The emotional set was a disadvantage to learning long lists of syllables.
 - (b) Long series were more easily mastered after they learned to divide them into smaller parts.
 - (c) The pure part method is less efficient than the modified part methods.
 - (d) The differences in value among the modified part methods are small.

2. The subjects of Group II state, generally, that:
- (a) They began the experiment without a detrimental emotional set.
 - (b) They did not worry about results.
 - (c) They manipulated materials to accommodate their memory spans, especially in the whole method procedure.
 - (d) They modified part methods were most economical in terms of expenditure of nervous energy.

CHAPTER VIII
SUMMARY AND CONCLUSIONS

The chapters of this experiment have been summarized one by one. It is the purpose of this chapter, therefore, to draw together the summaries thus far made and state the final conclusions

I. Previous investigations.

- a. There is a lack of agreement as to the relative values of the part and whole methods of learning.
- b. Most investigators have found the whole method the most economical.
- c. Results are frequently unstable because of insufficient data to substantiate the conclusions.

2. The general effects of practice.

- a. Practice tends to decrease the differences in the effectiveness of the various methods, thus causing them to approach a common value.
- b. Practice in learning nonsense materials tend to improvement by all methods, the methods that were most economical in the beginning showed the least improvement.
- c. There was less of correlation as practice proceeded.
- d. It is not reasonable to expect a commensurable rate of gain in all criteria.
- e. Time is used by most investigators as the criterion for the measurement of progress.

3. Comparison of improvements in the various methods.

- a. The whole method made the greatest improvement.
- b. The direct repetitive method made the least improvement.

4. Analytical and comparative study of methods.
 - a. The pure part method is weak because of disintegration through time. The lack of connecting facilities is also a source of weakness.
 - b. The frequent repetitions in the progressive part method overcome the losses enumerated in the pure part method procedure. Needless repetitions, however consume time unnecessarily.
 - c. The advantage of the direct repetitive as well as the other modified part methods is the continuous expansion of the unit of learning. There is an unnecessary extravagance in time and energy in these modified part methods in the repetitions of the first and second divisions of the series.
 - d. The whole method is conducive to emotional instability, fear and discouragement.
 - e. The chief advantage of the whole method is the continuity of the study. There are no breaks between parts and no lost connections.
 - f. The points of greatest difficulty in this experiment were syllable number 17 for Group I and syllable number 16 for Group II.
 - g. Length of units of learning and learning effort are not commensurable.
5. The effects of controlling objective conditions of learning.
 - a. It is possible to control external conditions of learning but it is not possible to force the learner to conform to the external conditions.

- b. Whole method presentation does not assure whole method learning.
- c. The whole method is as near, probably nearer, the limit of efficiency in this investigation as the part methods are.
- d. There are possibilities in dividing materials presented by the whole method not yet recognized.

CONCLUSIONS

- I. The general effects of practice.
 - a. Ability to learn nonsense materials by any method increases with practice.
 - b. Practice tends to decrease the differences in the effectiveness of the various methods.
 - c. The methods approach a common value as practice proceeds.
 - d. As practice increases, the correlation among the criteria of measurement decreases.
 - e. The rate of improvement varies as practice advances.
 - f. Practice contributes more to the methods that are difficult to employ in the beginning than it does to those that are less difficult.
- 2. A comparison of the efficiency of the whole and part methods at the beginning and at the end of practice.

At the beginning of practice the relative merits of the methods, named in order of efficiency, were as follows:

Group I, all criteria.

Direct Repetitive, progressive part, reverse repetitive, pure part, whole.

At the end of practice the positions, according to efficiency were as follows:

Trials: Pure part, whole, reverse repetitive, direct repetitive, progressive part.

Errors: Reverse repetitive, progressive part, direct repetitive, pure part, whole.

Time: Pure part, reverse repetitive, direct repetitive progressive part and whole methods tie for fourth position.

The difference in time is so small that it is negligible.

Group II

Trials: Pure part, reverse repetitive, whole, direct repetitive progressive part.

Errors: Direct Repetitive, reverse repetitive, progressive part, pure part, whole.

There is little difference in number of errors between the best and the poorest of the part methods of this group.

The whole method shows a greater number of errors than all other methods combined.

Time: Whole, pure part, direct repetitive, reverse repetitive, progressive part.

The finishing positions were as follows:

Trials: Whole, pure part, direct repetitive, reverse repetitive, progressive part.

Errors: Direct repetitive and reverse repetitive, tie, progressive part, pure part, whole.

Time: Direct repetitive, progressive part, reverse repetitive whole, pure part.

3. The relative effects of practice upon the efficiency of the various methods.

a. All methods increase in efficiency with practice.

- b. The modified part methods show the least improvement from practice; the subjects began nearer the limit of efficiency in these methods.
 - c. The pure part method showed more improvement from practice than the modified part methods. There were greater possibilities in this method than in the modified part methods for improvement in the connection of parts.
 - d. The whole method showed the greatest improvement. The possibilities in this method were in the control of emotions the adjustment of the series to the memory span, the development of devices to assist retention, and the formation of habits of concentration.
4. The factors that control the results of practice.
- a. The emotional tone is an influence in the learning process that cannot be overlooked.
 - b. Improvement is conditioned by satisfaction and annoyance, by likes and dislikes.
 - c. The effects of practice depend in a measure on the relative difficulty of the methods used.
 - d. The possibility of using devices to aid retention is responsible for much of the improvement.
 - e. Interest and effort were powerful factors for improvement in this investigation.
 - f. The individual eccentricities of the subjects account for many variations in the results of practice.
5. Does the method of presentation control the procedure of the learner?
- a. It is possible to control external conditions of learning.

but it is not possible to control the procedure of the individual learner.

- b. There is no way of controlling the subject's inner awareness, his confidential relations with his mental processes, his percepts, images and emotions.
 - c. A portion of the material used in this experiment was presented by wholes, but the subjects revealed in their introspections that they chose to accept it in such parts as would best accommodate their memory spans.
 - d. Whole method presentation, therefore, does not assure whole method procedure in learning.
6. Differences in individual reactions to whole and part methods..
- a. The emotional attitude is highly individual. The effectiveness of study in this experiment was many times conditioned by the emotional responses of the learner.
 - b. The degree of initial efficiency varied among the subjects. A rapid initial improvement indicated an early limit in efficiency.
 - c. There was a tremendous difference shown by the various subjects in the amount of interest in and zest for the work.

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Table I
Results in trials, errors, and time of series 1-5 inclusive, Group I.

Meth.	Subject A Group I Series 1-5		Subject B Group I Series 1-5		Subject C Group I Series 1-5		Subject D Group I Series 1-5		Subject E Group I Series 1-5										
	T. E.	Time	T. E.	Time	T. E.	Time	T. E.	Time	T. E.	Time									
Part 1	10 $\frac{3}{4}$	93	2640	5	15 $\frac{1}{4}$	106	3660	4	11	59	1260	3	24 $\frac{1}{4}$	275	6743	4	6 $\frac{1}{4}$	29	1205
Who. 2	21	112	2830	1	13	145	2700	5	10	83	1540	4	28	391	4880	5	9	78	2470
P. P. 3	10 $\frac{1}{4}$	32	2164	2	18 $\frac{3}{4}$	94	3309	1	9	22	1800	5	9 $\frac{1}{2}$	30	2405	1	10 $\frac{1}{2}$	20	1635
D.F.R. 4	11 $\frac{3}{4}$	34	1668	3	10	26	1465	2	10 $\frac{1}{4}$	23	2395	1	11	33	2590	2	7	8	1080
R. R. 5	12 $\frac{3}{4}$	25	2265	4	13 $\frac{3}{4}$	48	2700	3	13	63	2420	2	12 $\frac{1}{4}$	53	3435	3	8	15	1060
Total	66 $\frac{1}{2}$	236	11567		70 $\frac{3}{4}$	419	13834		53 $\frac{1}{4}$	280	9415		85	782	18053		40 $\frac{3}{4}$	150	7450

Order

Order

Order

Order

Order

Table II

Results in trials, errors and time of series 6-10 inclusive, Group I.

Meth.	Subject A Group I Series 6-10			Subject B Group I Series 6-10			Subject C Group I Series 6-10			Subject D Group I Series 6-10			Subject E Group I Series 6-10			
	T.	E.	Time	T.	E.	Time	T.	E.	Time	T.	E.	Time	T.	E.	Time	
Part	6	11 $\frac{1}{4}$	2520	10	11 $\frac{1}{2}$	1960	9	96	1040	8	12 $\frac{1}{4}$	3120	9	7 $\frac{1}{2}$	1125'	
Who.	7	14	2780	6	13	2160	10	9	1370	9	10	2725	10	5	890	
P. P.	8	17	1975	7	12 $\frac{3}{4}$	2160	6	14	1650	10	10 $\frac{1}{2}$	2580	6	7 $\frac{1}{2}$	1090'	
D. R.	9	9 $\frac{1}{2}$	1320	8	8 $\frac{1}{4}$	1405	7	9 $\frac{1}{4}$	1590	6	8 $\frac{3}{4}$	2010	7	9	1440'	
R. R.	10	9 $\frac{1}{2}$	1850	9	9 $\frac{1}{2}$	1665	8	13	1905	7	10 $\frac{3}{4}$	3240	8	9 $\frac{3}{4}$	1590'	
Total		61 $\frac{1}{4}$	293	10445	55	202	9300	141 $\frac{1}{4}$	202	7675	52 $\frac{1}{4}$	274	13675	38 $\frac{3}{4}$	72	6135'

Order

Order

Order

Order

Order

Table III

Results in trials, errors and time of series 11-15, inclusive, Group I

Meth.	Subject A Group I Series 11-15		Subject B Group I Series 11-15		Subject C Group I Series 11-15		Subject D Group I Series 11-15		Subject E Group I Series 11-15	
	T.	E. Time	T.	E. Time	T.	E. Time	T.	E. Time	T.	E. Time
Part	118 $\frac{3}{4}$	35 1570	10 76 1680	14 12 52 1935	13 6 $\frac{1}{2}$ 24 1320	14 6 13 930	<i>Order</i>			
Who.	1211	96 1370	9 106 1655	15 9 87 1500	14 10 84 2070	15 6 55 1410				
P.P.	1314 $\frac{3}{4}$	48 1380	11 $\frac{1}{4}$ 32 1830	11 11 $\frac{1}{2}$ 33 1570	15 10 24 1910	11 8 $\frac{1}{2}$ 11 1365				
D.F.	1412 $\frac{1}{2}$	36 1635	11 $\frac{1}{2}$ 28 1770	12 8 $\frac{3}{4}$ 26 1140	18 1975	12 8 $\frac{1}{2}$ 20 1275				
R.R.	1511 $\frac{1}{2}$	31 1495	9 23 1470	13 9 11 1255	12 8 $\frac{1}{2}$ 20 1840	13 9 $\frac{1}{2}$ 15 1265				
Total	58 $\frac{1}{2}$	246 7450	50 $\frac{3}{4}$ 255 8405	50 $\frac{1}{4}$ 209 7400	43 $\frac{3}{4}$ 170 9115	38 $\frac{1}{2}$ 114 545				

Table IV

Comparison of individual results in trials, errors and time for the series 1-5, 6-10, 11-15 inclusive, Group I.

	Subject A Group I			Subject B Group I			Subject C Group I			Subject D Group I			Subject E Group I		
	T.	E.	Time	T.	E.	Time	T.	E.	Time	T.	E.	Time	T.	E.	Time
Series 1-5	66 $\frac{1}{2}$	296	11567	70 $\frac{3}{4}$	419	13834	53 $\frac{1}{4}$	280	9415	85	782	18053	40 $\frac{3}{4}$	150	7450
Series 6-10	61 $\frac{1}{4}$	293	10445	55	202	9300	54 $\frac{3}{4}$	202	7675	52 $\frac{1}{4}$	274	13675	38 $\frac{3}{4}$	72	6135
Series 11-15	558 $\frac{1}{4}$	246	7450	50 $\frac{3}{4}$	265	8405	50 $\frac{1}{4}$	209	7400	43 $\frac{3}{4}$	170	9115	38 $\frac{1}{4}$	114	6545

Table V

Time spent on each method by Group I

	Part	Whole	P. P.	D. R.	R. R.
Series 1-5	13508	14420	11313	9198"	11880
6-10	9745	9925	9455	7755	10250"
11-15	7435	8005	8055	7795	7625"
Total	30688"	32550	38823"	24748"	29755"

Table VI

Per Cent of total time required for each method by Group I,
Fifteen series

	Part	Whole	P. P.	D. R.	R. R.
Series 1-5	22.5	22.	13.7	15.2	19.7
Series 6-10	20.6	21.6	20.	16.5	21.7
Series 11-15	19.1	20.6	20.6	20.	19.6
Total	20.9	22.1	19.6	16.9	20.4

Table VII

Statistical findings in time for each individual of Group I,
Fifteen series.
A comparison of time required for each method in the first,
second, and third rounds.

		Part	Whole	Pro. Part	D. R.	R. R.
Subject A	1	2840	3320	3184"	1668"	3265"
	2	2520	3770	1975"	1320"	1850"
	3	1570"	1820"	1380"	1635"	1495"
Total		6730"	3320"	5519"	4623"	5610"
Subject B	1	3660"	3700"	3309"	1665"	2700"
	2	1960"	2160"	2160"	1395"	1665"
	3	1680"	1655"	1830"	1770"	1470"
Total		7300"	6515"	7299"	4830"	5835"
Subject C	1	1260"	1540"	1800"	3395"	2420"
	2	1040"	1370"	1650"	1590"	1905"
	3	1935"	1500"	1570"	1140"	1355"
Total		4235"	4410"	5020"	5125"	5580"
Subject D	1	4745"	4480"	2405"	2590"	2415"
	2	3130"	3725"	2580"	2010"	3240"
	3	1820"	2070"	1910"	1975"	1640"
Total		9185"	9875"	6995"	6575"	8515"
Subject E	1	1265"	3470"	1635"	1030"	1030"
	2	1125"	890"	1090"	1440"	1590"
	3	920"	1410"	1365"	1375"	1565"
Total		3310"	4770"	4090"	3795"	4215"

Table VIII

The percent of his whole time that each individual of Group I gave to each method.

	Part	Whole	P. P.	D. R.	R. R.
Subject A	22.8	23.7	18.7	15.7	19.
Subject B	23.1	20.6	23.1	14.7	18.5
Subject C	17.2	18.	20.5	20.9	22.7
Subject D	27.3	23.6	16.8	16.1	16.2
Subject E	16.1	23.5	20.5	18.8	19.4
Average	21.3	21.9	19.9	17.2	19.1

Table IX

The number of errors made by each subject of Group I in the various methods.

	Part	Whole	P. P.	D. R.	R. R.
Subject A	175	355	155	101	64
Subject B	234	355	139	82	118
Subject C	157	173	83	109	115
Subject D	164	534	92	84	104
Subject E	49	171	40	51	45
Total	799	1588	489	427	446

Table X

Number of errors made in each method by the group, Group I.

	Part	Whole P	P. P.	D. R.	R. R.
Series 1-5	324	799	187	163	212
Series 6-10	279	441	159	109	119
Series 11-15	196	348	143	155	131
Total	799	1588	489	427	462

Table XI
Per cent of errors in each method, Group I

	Part	Whole	P. P.	D. R.	R. R.
	21.3	43.3	13.	11.3	11.9

Table XII

The following comparisons of errors which accrued to the whole and direct repetitive methods for each subject of Group I are taken from Table IX.

Subjects	Errors in whole method	Errors in direct repetitive method	Comparison
A	355	101	3.5 to 1
B	355	82	4.3 to 1
C	173	109	1.6 to 1
D	354	84	4.2 to 1
E	171	51	3.3 to 1

Table XIII

Comparison of the errors of the whole and direct repetitive methods by rounds, Group I.

	Whole Method	Direct Repetitive Method	
Round I	799	165	4.9 to 1
Round II	441	109	4.0 to 1
Round III	348	155	2.2 to 1

Table KIV

Statistical findings in trials for each individual of Group I, fifteen series.

A comparison of trials required for each method in the first, second, and third rounds.

		Part	Whole	Prog. Part	D. R.	R. R.
Subject A	1	$10\frac{3}{4}$	21	$10\frac{1}{4}$	$11\frac{3}{4}$	$12\frac{3}{4}$
	2	$11\frac{1}{4}$	14	17	$9\frac{1}{2}$	$9\frac{1}{2}$
	3	$8\frac{3}{4}$	11	$14\frac{3}{4}$	$12\frac{1}{2}$	$11\frac{3}{4}$
Total		$30\frac{3}{4}$	46	42	$33\frac{3}{4}$	$33\frac{1}{2}$
Subject B	1	$15\frac{1}{4}$	13	$16\frac{3}{4}$	10	$13\frac{3}{4}$
	2	$11\frac{1}{2}$	13	$12\frac{3}{4}$	$8\frac{1}{2}$	$9\frac{1}{2}$
	3	10	9	$11\frac{1}{4}$	$11\frac{1}{2}$	9
Total		$36\frac{1}{2}$	35	$42\frac{3}{4}$	$29\frac{3}{4}$	$32\frac{1}{2}$
Subject C	1	11	10	9	$10\frac{1}{4}$	13
	2	$9\frac{1}{2}$	9	14	$9\frac{1}{2}$	13
	3	12	9	$11\frac{1}{2}$	$8\frac{3}{4}$	9
Total		$32\frac{1}{2}$	28	$34\frac{1}{2}$	$28\frac{1}{4}$	35
Subject D	1	$24\frac{1}{2}$	28	$9\frac{1}{2}$	11	$12\frac{1}{2}$
	2	$12\frac{1}{4}$	10	$10\frac{1}{4}$	$8\frac{3}{4}$	$10\frac{1}{2}$
	3	$6\frac{1}{2}$	10	10	$8\frac{3}{4}$	$8\frac{1}{2}$
Total		46	48	30	$28\frac{1}{2}$	$31\frac{1}{2}$
Subject E	1	$6\frac{1}{2}$	9	$10\frac{1}{2}$	7	8
	2	$7\frac{1}{2}$	5	$7\frac{1}{2}$	9	$9\frac{3}{4}$
	3	6	6	$8\frac{1}{2}$	$8\frac{1}{2}$	$9\frac{1}{4}$
Total		$19\frac{3}{4}$	20	$26\frac{1}{2}$	$24\frac{1}{2}$	27

Table XV

The per cent of his whole number of trials that each individual made on each method. Group I.

	Part	Whole	Prog. Part	D. R.	R. R.
Subject A	16.5	24.7	22.5	18.1	18.1
Subject B	20.8	19.8	24.2	16.8	18.2
Subject C	20.6	17.1	21.7	17.2	22.1
Subject D	23.7	26.5	16.5	15.7	17.4
Subject E	16.9	17.1	22.5	20.8	23.8
Average	19.7	21.04	21.56	17.72	19.72

Table XVI

Trials made on each method by Group I

	Part	Whole	Prog. Part	D. R.	R. R.
First round series 1-5	67 $\frac{1}{2}$	81	58	50	59 $\frac{3}{4}$
Second round series 6-10	52	51	61 $\frac{3}{4}$	44 $\frac{3}{4}$	52 $\frac{1}{2}$
Third round series 11-15	45 $\frac{1}{4}$	45	56	50	47
Total	162 $\frac{3}{4}$	177	175 $\frac{3}{4}$	144 $\frac{3}{4}$	159 $\frac{1}{2}$

Table XVII

For per cent of trials on each method, Group I

	Part	Whole	P. P.	D. R.	R. R.
First round series 1-5	21.3	25.6	18.5	15.8	19.8
Second round series 6-10	19.8	19.4	23.5	17.0	20.0
Third round series 11-16	17.9	18.6	23.2	20.7	19.4
Total	19.8	21.6	21.5	17.5	19.4

Table XVIII

Table of Gains for Group I

	Part	Whole	P. P.	D. R.	R. R.
Gain in seconds of round II over round I.	3763	4435	1654	1443	1630
Gain in seconds of round III over round II	2310	1920	1450	Loss 40	2625

Table XIX

Gains reduced to a percentage basis

Gain in per cent of the time of round II over round I.	27.8	31.1	16.3	15.6	13.7
Gain in per cent of time of round III over round II.	23.7	19.3	15.3	Loss .005	25.6

Table XX

Table showing the results in trials, errors and time of series 1-5 inclusive, Group II.

Meth.	Subject A Group II Series 1-5			Subject B Group II Series 1-5			Subject C Group II Series 1-5			Subject D Group II Series 1-5			Subject E Group II Series 1-5					
	T.	E.	Time	T.	E.	Time	T.	E.	Time	T.	E.	Time	T.	E.	Time			
Part I	10	41	2070"	2	5	720	3	7 $\frac{1}{4}$	34	1560"	4	7 $\frac{1}{2}$	27	1220"	5	5 $\frac{3}{4}$	13	870
Whole	2	9	1530	3	8	1500	4	8	59	2500	5	6	48	1020	1	10	87	1425
P. P.	3	8 $\frac{1}{2}$	1265	4	7 $\frac{1}{2}$	915	5	9 $\frac{1}{2}$	12	1110	1	18	83	2925	2	8 $\frac{3}{4}$	23	1210
D. R.	4	8	1375	5	5 $\frac{3}{8}$	745	1	8 $\frac{3}{8}$	24	1380	2	9 $\frac{3}{4}$	27	1680	3	9 $\frac{1}{2}$	21	1160
R. R.	5	4 $\frac{1}{4}$	1370	1	7	1170	2	11	27	1410	3	8 $\frac{3}{4}$	32	1650	4	7 $\frac{3}{4}$	14	1020
Total	30 $\frac{3}{4}$	158	7610	33 $\frac{1}{2}$	105	5050		44 $\frac{3}{4}$	156	7960		49 $\frac{3}{4}$	217	8495		41 $\frac{1}{2}$	158	5685"

Order

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Table XXI

Table showing the results in trials, errors and time of the Series 6-10 inclusive, Group II.

Meth.	Subject A Group II Series 6-10		Subject B Group II Series 6-10		Subject C Group II Series 6-10		Subject D Group II Series 6-10		Subject E Group II Series 6-10											
	T.	E.	T.	E.	T.	E.	T.	E.	T.	E.										
Part	6	7	19	1280	7	4 $\frac{1}{2}$	6	720	8	9 $\frac{1}{2}$	53	1510	9	6 $\frac{1}{4}$	21	1210	10	6 $\frac{3}{4}$	20	910
Who.	7	6	42	1170	8	5	28	850	9	5	36	995	10	7	48	1145	6	8 $\frac{1}{2}$	54	990
P. P.	8	7 $\frac{3}{4}$	11	965	9	7 $\frac{1}{2}$	5	715	10	8 $\frac{1}{4}$	15	930	6	10 $\frac{1}{4}$	21	1500	7	7 $\frac{3}{4}$	9	670
D. R.	9	7 $\frac{1}{4}$	9	1020	10	5 $\frac{3}{4}$	3	560	6	7 $\frac{1}{2}$	18	1095	7	7 $\frac{3}{4}$	13	1025	8	7	10	790
R. R.	10	7 $\frac{1}{2}$	13	1030	6	5 $\frac{1}{2}$	2	920	7	8 $\frac{1}{2}$	17	1230	8	7	11	1145	9	7 $\frac{1}{2}$	12	720
Total		35 $\frac{1}{2}$	94	5465		28 $\frac{1}{4}$	44	3765		38 $\frac{3}{4}$	139	5760		38 $\frac{3}{4}$	114	5815		36 $\frac{1}{2}$	105	4070

Order *Order* *Order* *Order* *Order*

Table XXII

Comparison of individual results in trials, errors and time series 1-5, 6-10.

	Subject A		Subject B		Subject C		Subject D		Subject E						
	T.	E.	T.	E.	T.	E.	T.	E.	T.	E.					
Series 1-5	$39\frac{3}{4}$	158	7610	$53\frac{1}{4}$	105	5050	$44\frac{1}{4}$	156	7960	$49\frac{3}{4}$	217	8490	$41\frac{1}{2}$	158	5685
Series 6-10	$35\frac{1}{2}$	94	5465	$28\frac{1}{4}$	44	3765	$38\frac{3}{4}$	139	5760	$36\frac{3}{4}$	114	5815	$36\frac{1}{2}$	105	4070

Table XXIII

Time spent on each method by Group II

	Part	Whole	P. P.	D. R.	R. R.
Series 1-5	6440"	7975"	7425"	6340"	6620"
Series 6-10	5630"	5150"	4780"	4490"	5045"
Total	12070"	13125"	11205"	10830"	11665"

Table XXIV

Per cent of total time spent on each method by Group II, 10 series

	Part	Whole	P.P.	D. R.	R. R.
Series 1-5	18.5	22.9	21.3	18.2	19
Series 6-10	22.4	20.5	19	18.6	20.1
Total	20.5	22.2	19	18.5	19.8

Table XXV

Statistical findings in time for each individual of Group II, ten series

A comparison of time required for each method in the first and second rounds.

		Part	Whole	P. P.	D. R.	R. R.
Subject A	1	2070	1530	1265	1375	1370
	2	1230	1170	965	1020	1030
Total		3300	2700	2230	2395	2400
Subject B	1	720	1500	915	745	1170
	2	720	850	715	560	920
Total		1440	2350	1630	1305	2090
Subject C	1	1560	1500	1110	1380	1410
	2	1510	995	930	1095	1230
Total		3070	2495	2040	2475	2640
Subject D	1	1230	1020	2925	1620	1650
	2	1210	1145	1500	1025	1145
Total		2440	2165	4425	2705	2795
Subject E	1	870	1425	1210	1160	1020
	2	910	990	670	790	720
Total		1780	2415	1880	1950	1740

Table XXVI

Per cent of whole time that each individual of Group II gave to each method.

	Part	Whole	P. P.	D. R.	R. R.
Subject A	25.6	20.6	17	18.3	18.5
Subject B	16.5	28.1	18.5	14.8	23.7
Subject C	22.3	25.4	14.8	18	19.2
Subject D	16.9	15.1	30.9	18.9	19.5
Subject E	18.2	24.8	19.2	20	17.9
Average	19.8	22.8	20.08	18	19.7

Table XXVII

Number of errors made by each subject of Group II in the various methods

Subject A	60	124	25	22	25
Subject B	20	39	12	10	15
Subject C	87	93	27	42	48
Subject D	48	96	100	40	42
Subject E	56	139	32	32	26
Total	251	541	196	146	156

Table XXVIII

Number of errors made in each method by Group II.

Series 1-5	139	330	121	92	100
Series 6-10	112	211	75	54	56
Total	251	541	196	146	156

Table XXIX

Per cent of errors in each method

19.4	41.9	15.1	11.3	12.1
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Table XXX

Statistical findings in trials for each individual for Group II, ten series.

A comparison of trials required for each method in the first and second rounds.

		Part	Whole	P. P.	D. R.	R. R.
Subject A	1	10	9	$8\frac{1}{2}$	8	$4\frac{1}{2}$
	2	7	6	$7\frac{3}{4}$	$7\frac{1}{2}$	$7\frac{1}{2}$
Total		17	15	16	$15\frac{1}{2}$	12
Subject B	1	5	8	$7\frac{1}{2}$	$5\frac{3}{4}$	7
	2	$4\frac{1}{2}$	5	$7\frac{1}{2}$	$5\frac{3}{4}$	$5\frac{1}{2}$
Total		$9\frac{1}{2}$	13	15	$11\frac{1}{2}$	$12\frac{1}{2}$
Subject C	1	$7\frac{1}{2}$	8	$9\frac{1}{2}$	$8\frac{3}{4}$	11
	2	$9\frac{1}{2}$	5	$8\frac{1}{4}$	$7\frac{1}{2}$	$8\frac{1}{2}$
Total		17	13	$17\frac{1}{2}$	$16\frac{1}{2}$	$19\frac{1}{2}$
Subject D	1	$7\frac{1}{2}$	6	18	$9\frac{3}{4}$	$8\frac{3}{4}$
	2	$6\frac{3}{4}$	7	$10\frac{1}{4}$	$7\frac{3}{4}$	7
Total		14	13	$28\frac{1}{2}$	$17\frac{1}{2}$	$15\frac{3}{4}$
Subject E	1	$5\frac{3}{4}$	10	$8\frac{3}{4}$	$9\frac{1}{4}$	$7\frac{3}{4}$
	2	$6\frac{1}{2}$	8	$7\frac{3}{4}$	7	$7\frac{1}{2}$
Total		12	18	$16\frac{1}{2}$	$16\frac{1}{4}$	15

Table XXXI

Trials made on each method by Group II.

	Part	Whole	P. P.	D. R.	R. R.
First round series 1-5	35½	41	51½	41½	39
Second round series 6-10	34	31	41½	35½	36
Total	69½	72	93½	76½	75

Table XXXII

Per cent of trials by each method, Group II.

	Part	Whole	P. P.	D. R.	R. R.
First round series 1-5	17	19.6	24.8	19.9	18.7
Second round series 6-10	19.1	17.4	26.5	19.7	20.2
Average	18.0	18.6	26.7	19.8	19.4

Table XXXIII

Per cent of his whole number of trials that each individual made on each method, Group II.

	Part	Whole	P. P.	D. R.	R. R.
Subject A	22.4	19.9	21.3	20.3	16.2
Subject B	15.4	21.1	24.4	18.7	19.5
Subject C	20.4	15.6	21.0	19.5	25.4
Subject D	15.8	14.7	31.9	19.7	17.9
Subject E	15.4	23.8	21.2	21.0	19.3
Average	17.9	19.0	24.56	19.8	19.2

Table XXXIV

Gains of Group II

	Part	Whole	P. P.	D. R.	R. R
Trials round 2 over 1	$1\frac{1}{2}$	10	$9\frac{1}{2}$	$6\frac{1}{2}$	3
Errors round 2 over 1	27	119	46	38	44
Time in seconds round 2 over 1	810	2825	2645	1850	1575

Table XXXV

Gains of round 1 to 2, 2 to 3, Group I

	Part	Whole	P. P.	D. R.	R. R
Gains of trials round 2 over 1	$15\frac{1}{2}$	30	$3\frac{3}{4}$	$5\frac{1}{2}$	$7\frac{1}{2}$
Gain of errors round 2 over 1	45	558	28	54	93
Gain in seconds round 2 over 1	3763	4495	1854	1443	1630
Gain of trials round 3 over 2	$8\frac{3}{4}$	6	$5\frac{3}{4}$	$5\frac{1}{2}$	$5\frac{1}{2}$
Gain of errors round 3 over 2	83	93	16	46	12
Gain of time round 3 over 2	2310	1920	1450	40	2625

Table XXXVI

The following comparison of errors which accrued to the whole and direct repetitive method for each subject of Group II are taken from Table XXVII.

Subjects	Errors in whole method	Errors in Direct Repetitive method	Comparison
A	124	22	5.6 to 1
B	89	10	9.0 to 1
C	93	42	2.2 to 1
D	96	40	2.4 to 1
E	139	32	4.3 to 1

Table XXXVII

Comparison of the errors of the whole and direct repetitive methods by rounds.

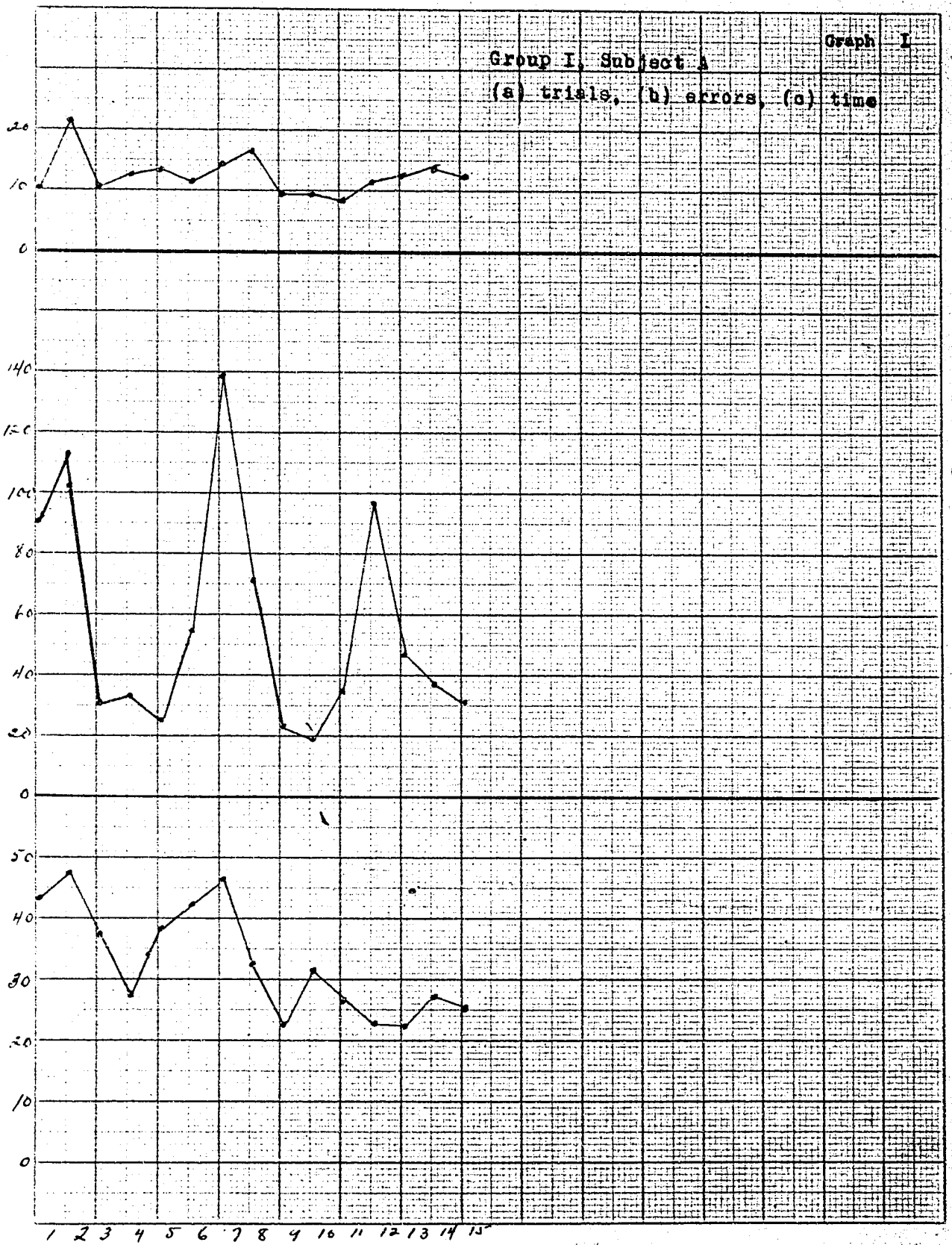
	Whole method	Direct Repetitive	Comparison
Round I	330	92	3.5 to 1
Round I	211	54	3.9 to 1

The following are the syllables used in the experiment:

kex	gox	daf	jix	nos
xak	teg	qub	neg	cik
vuv	jun	pov	pij	puv
lig	sen	feo	maf	bej
toz	kac	gis	lub	gat
nus	puz	meb	koz	xud
mon	qam	nij	ven	zaf
sig	noj	jon	tam	sez
qel	lek	kuj	fuq	voc
pab	mif	laq	pez	tib
zep	vot	tef	qak	dom
mav	xux	sef	nuv	qez
bis	bek	vig	jep	fup
lup	zal	zut	nax	pav
coj	dos	xod	los	nug
jid	ciq	diz	kiq	gan
kon	gac	ces	zod	kez
gec	fum	dax	kan	liv
duf	kip	kec	jum	jaq
fax	jed	fon	buf	moq
nes	mul	guj	gol	sij
fid	kaq	jaf	cag	kov
det	pex	pux	dej	jit
pib	nav	nom	jik	tog

buk	xem	xug	tos	sek
noc	laj	kos	jik	gax
cam	zim	xag	vux	tel
mib	kuc	jiq	geg	fut
lez	bop	zek	xav	vom
kax	gix	bij	duj	cis
juv	joz	gep	fac	dov
dep	cuq	fal	zex	xun
gos	das	cok	cof	beq
fiq	fet	dus	biz	zap
puđ	mek	zom	kom	jez.
doq	baz	lut	xit	vam
qaf	nid	mav	luj	kib
cin	zux	xil	vel	tul
bep	pon	nem	mas	lod
zam	xov	vek	sux	qik
seg	qum	piz	tav	muc
xul	vit	qob	nep	pej
tij	saq	suf	piq	naf
vok	tep	taj	qos	soq
fut	ceb	bup	zon	xen
val	sig	qan	pub	nim
tuk	dif	caq	buj	zis
gav	qen	pum	noq	mel

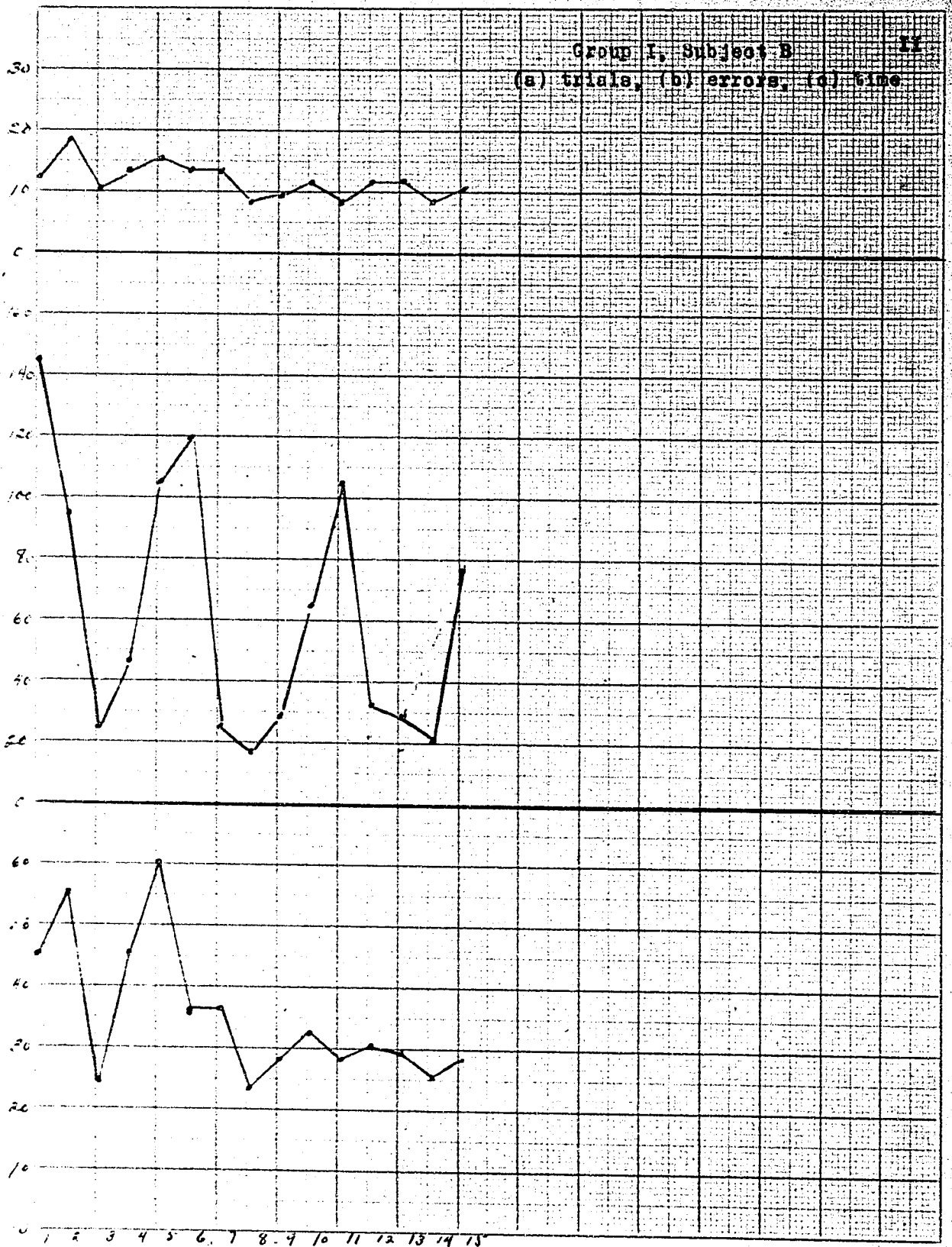
poq	mej	baj	xip	sep
dib	bak	nux	lek	gaf
qup	nif	cek	zoq	tiq
cef	zug	mov	kad	fuj
sab	pos	dil	fuv	vos
zuv	vid	kep	zug	xut
bac	xoc	liq	cax	dof
tes	saz	fom	gof	cib
xox	tek	jan	dez	zav
vix	qug	guz	fis	bez
fuf	cel	qec	fak	hek
sov	poj	paz	bef	taz
gaj	div	duz	puq	suv
qid	mev	siz	sac	kol
jek	dib	col	xub	piv
nam	fem	vud	nop	got
pel	jon	toc	qas	lum
kim	gip	xaf	tix	nev
nun	kug	bik	sev	jis
lov	lat	zeg	vox	maq
tup	quk	fas	cig	veb
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Kuf	guc	gev	doj	lep
vaq	saf	qok	qib	xic



(a)

(b)

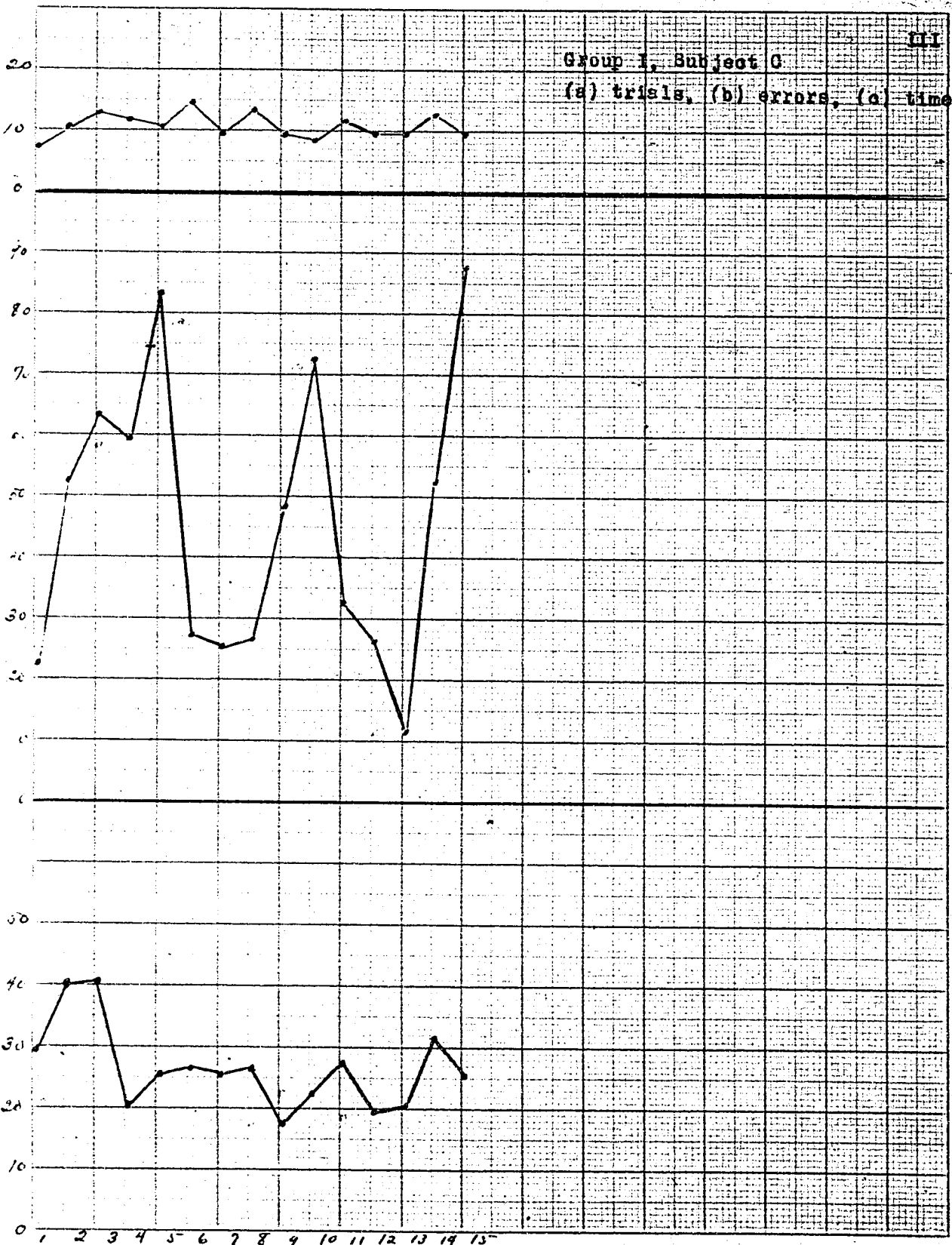
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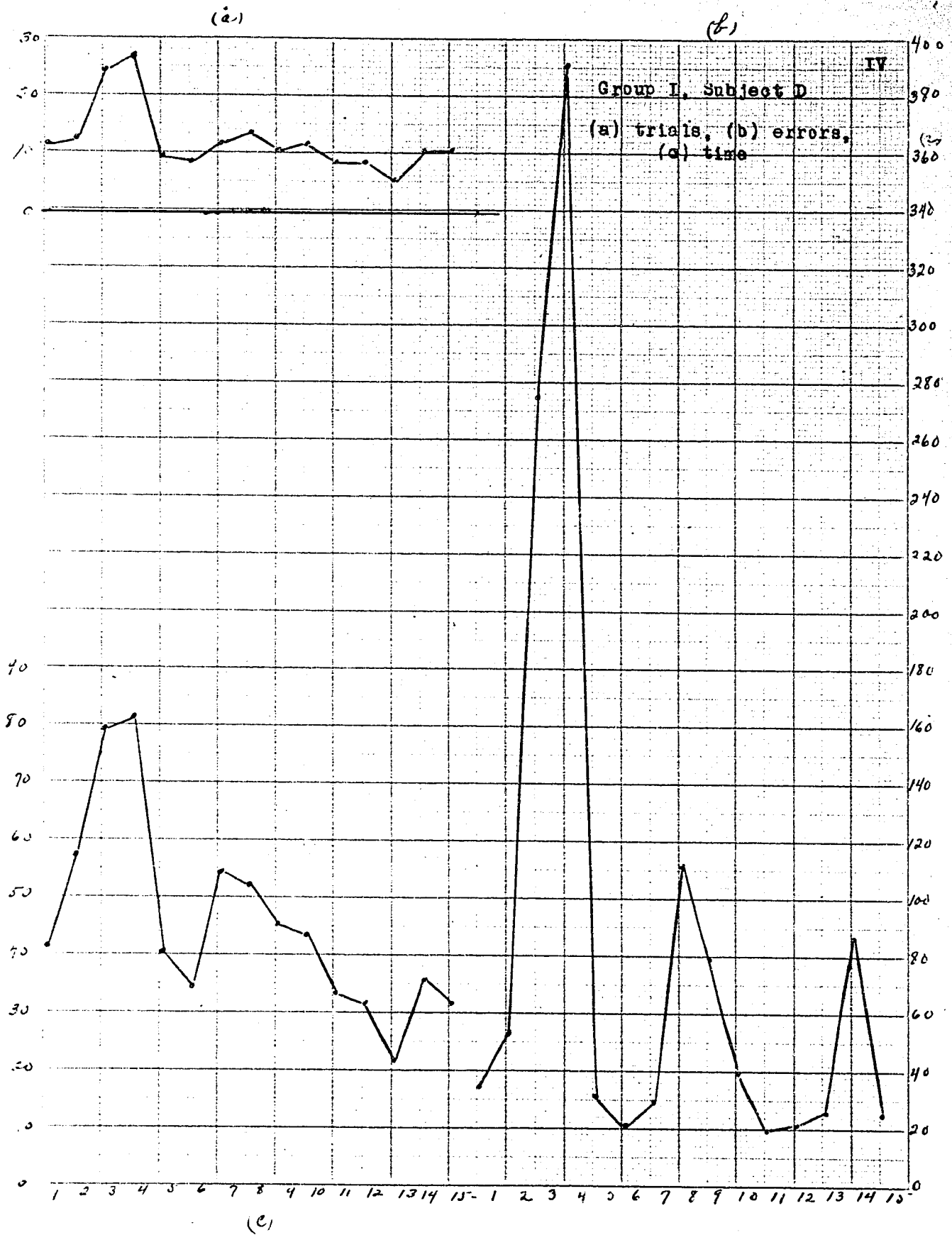
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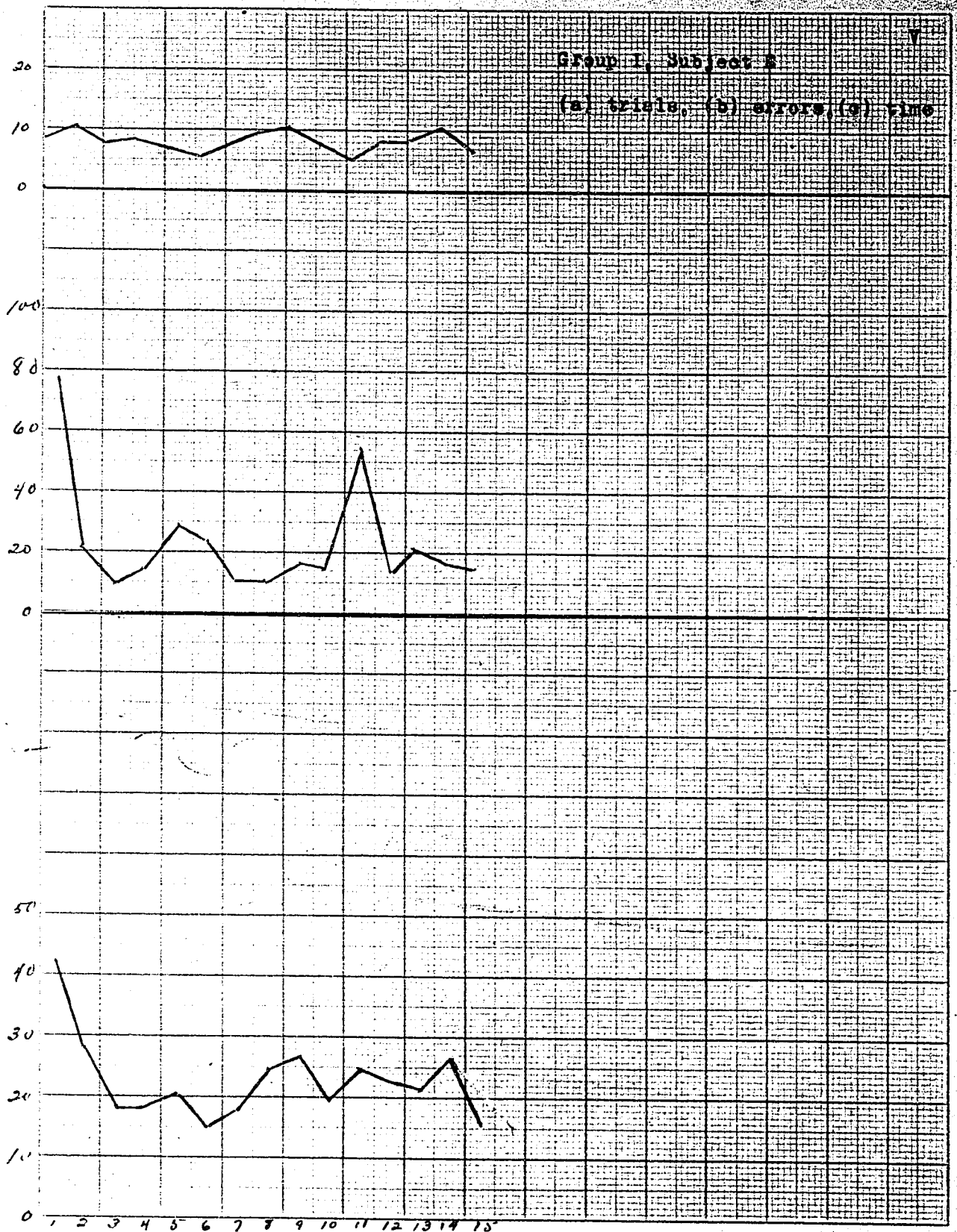


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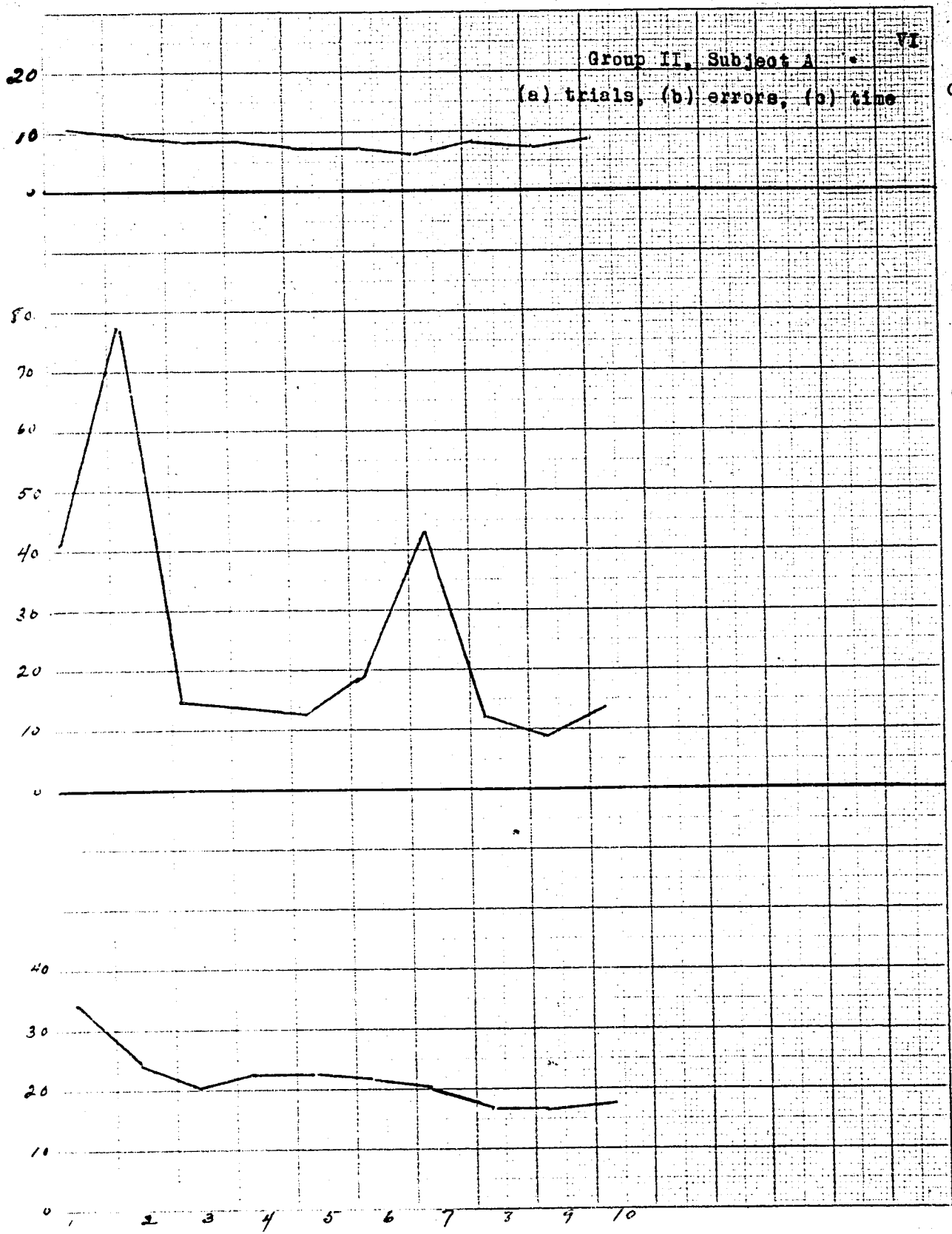




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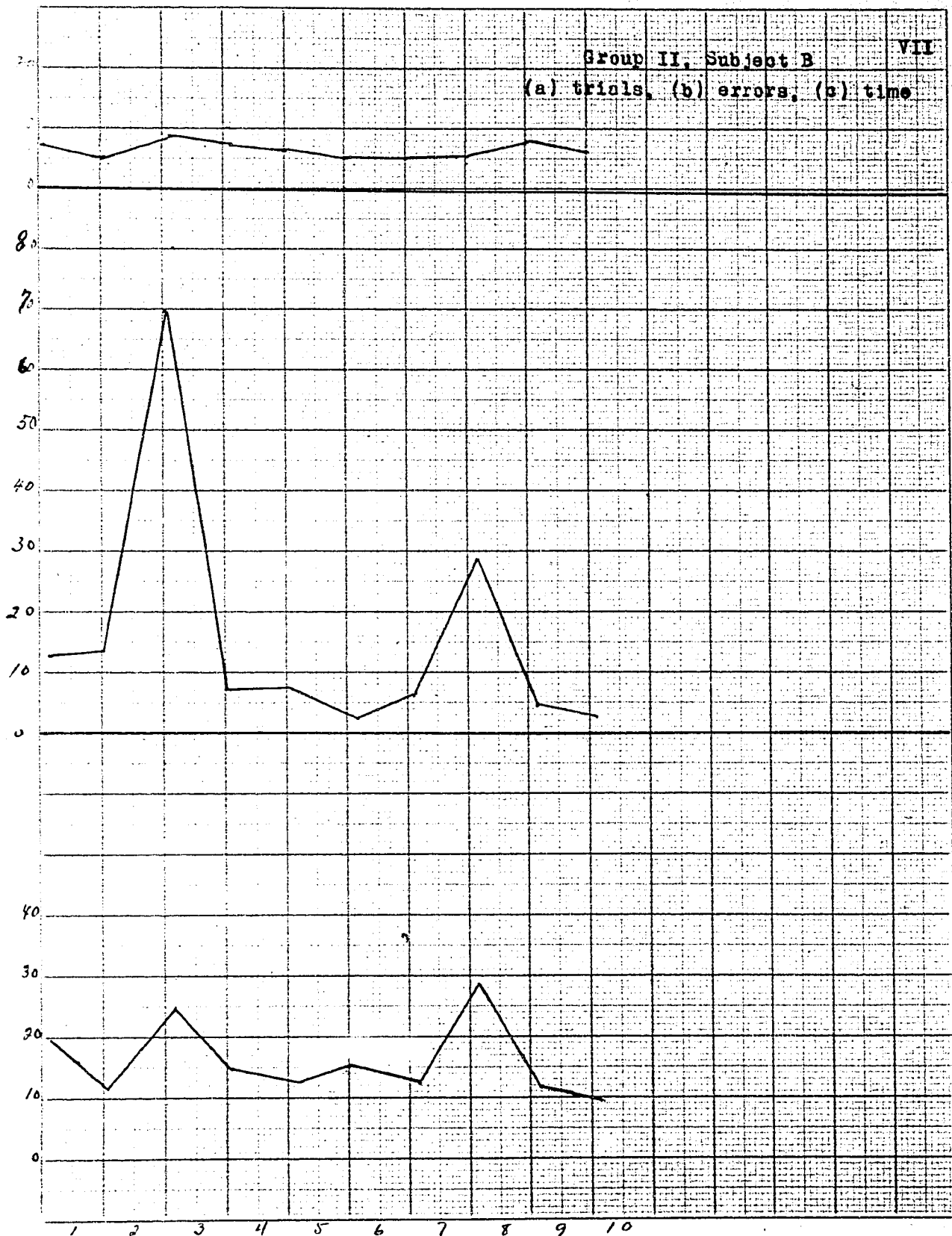
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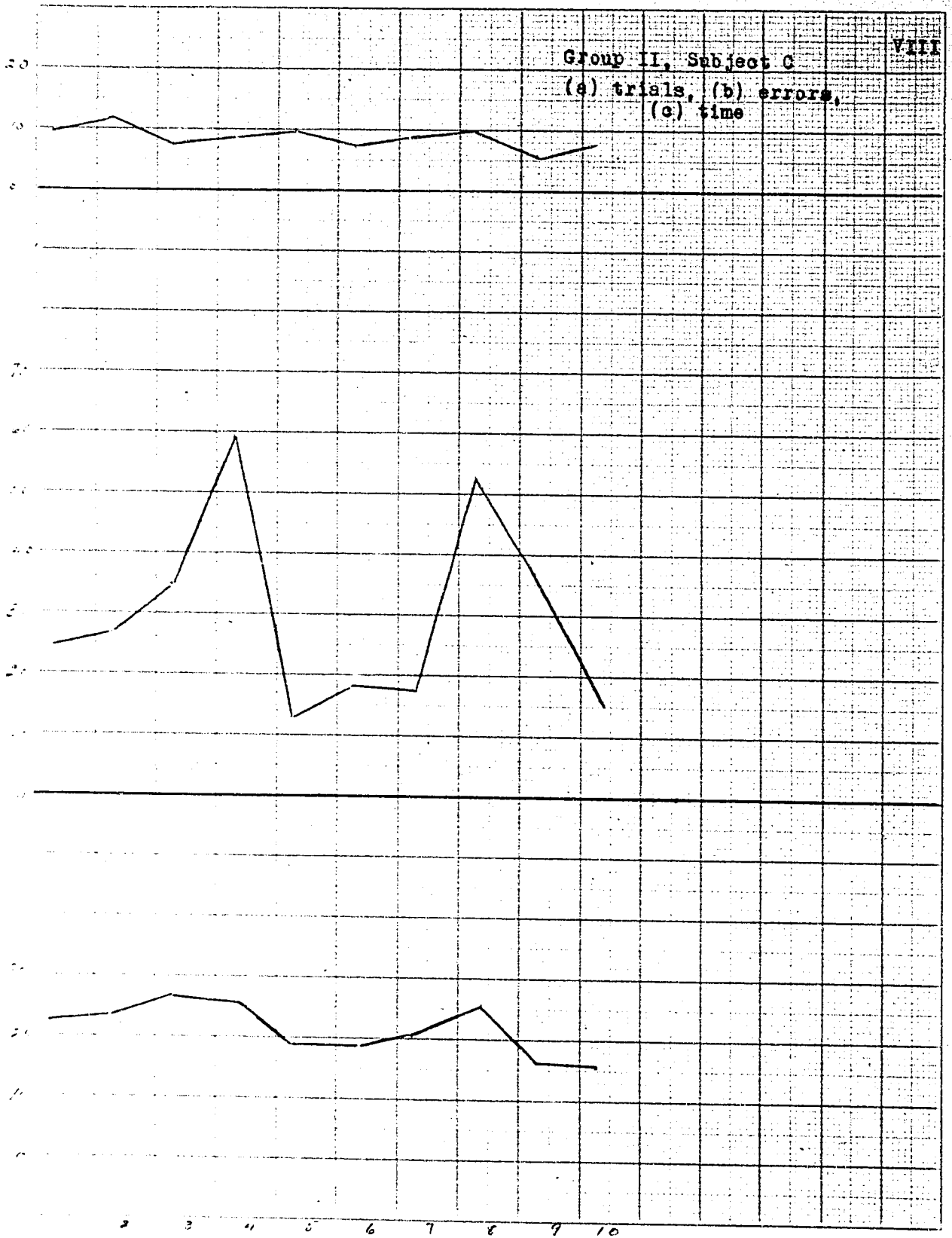


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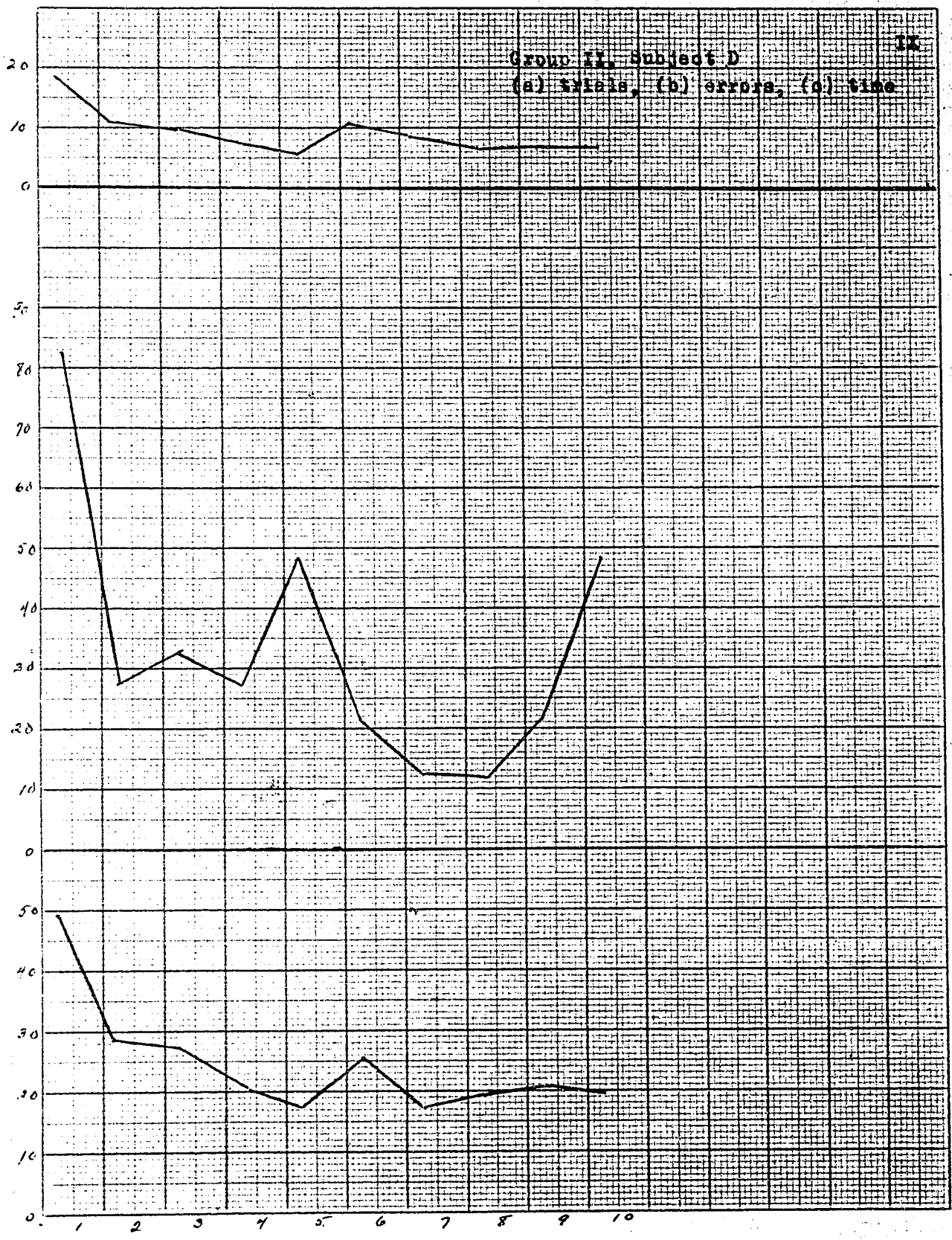




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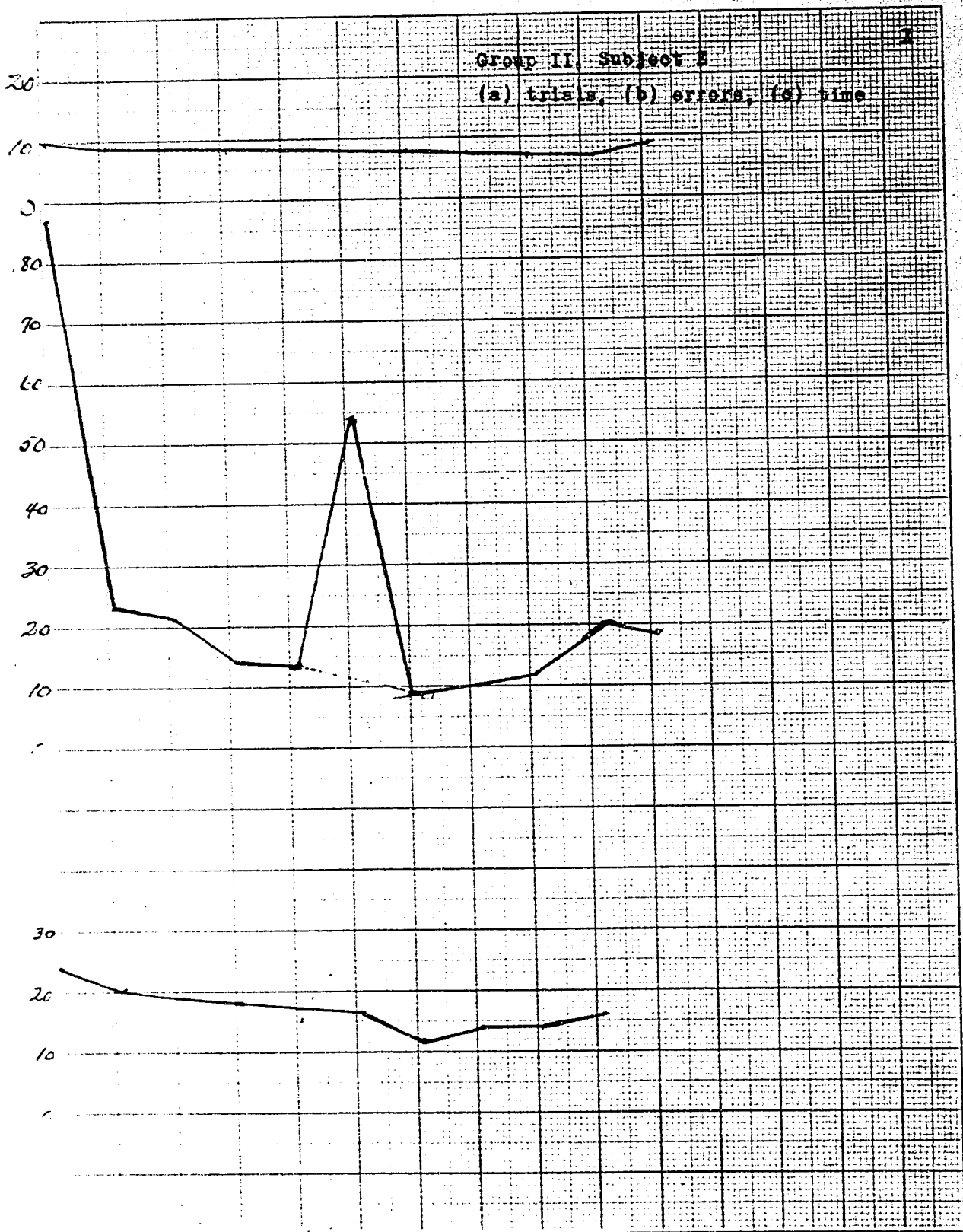
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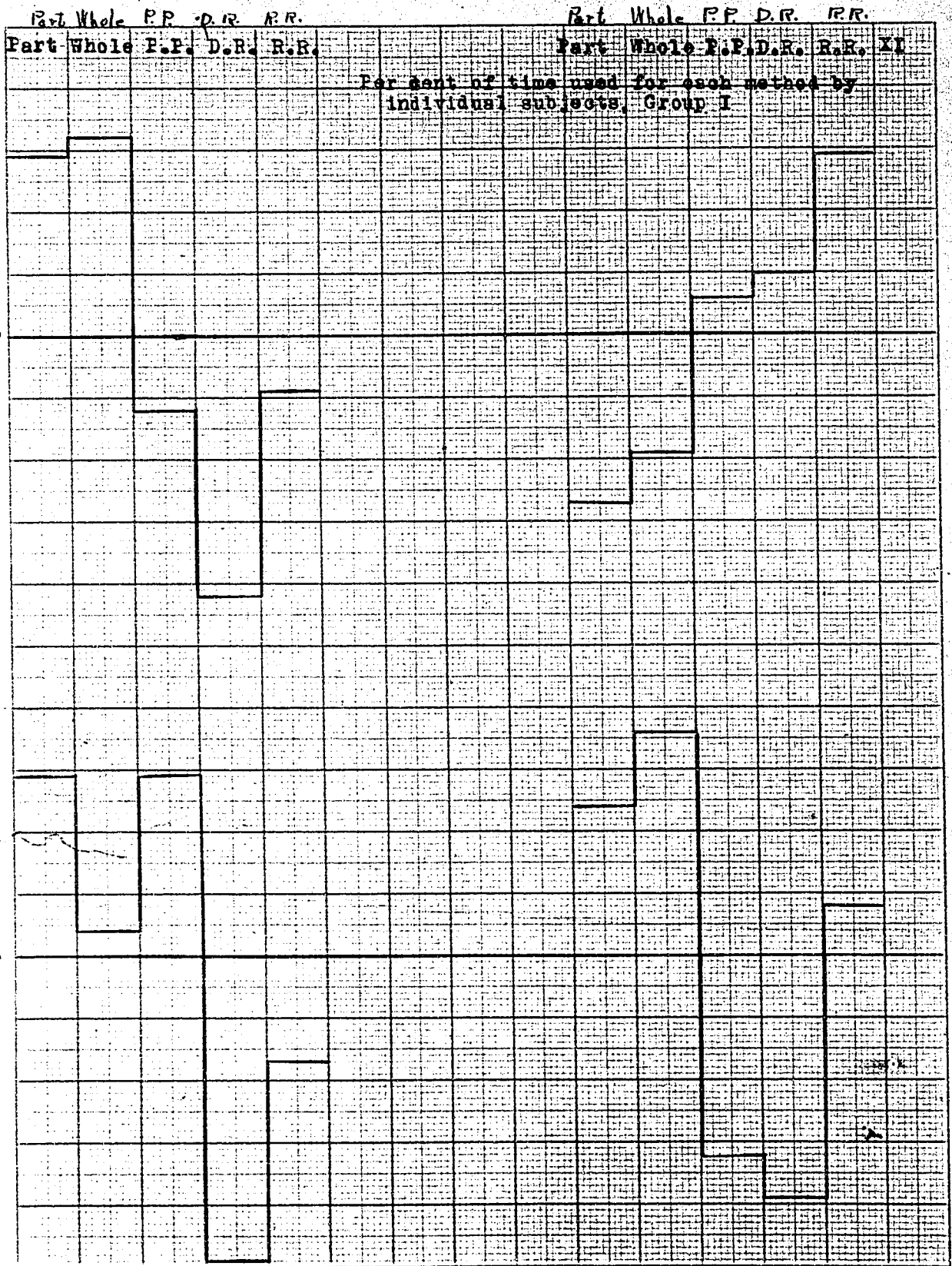


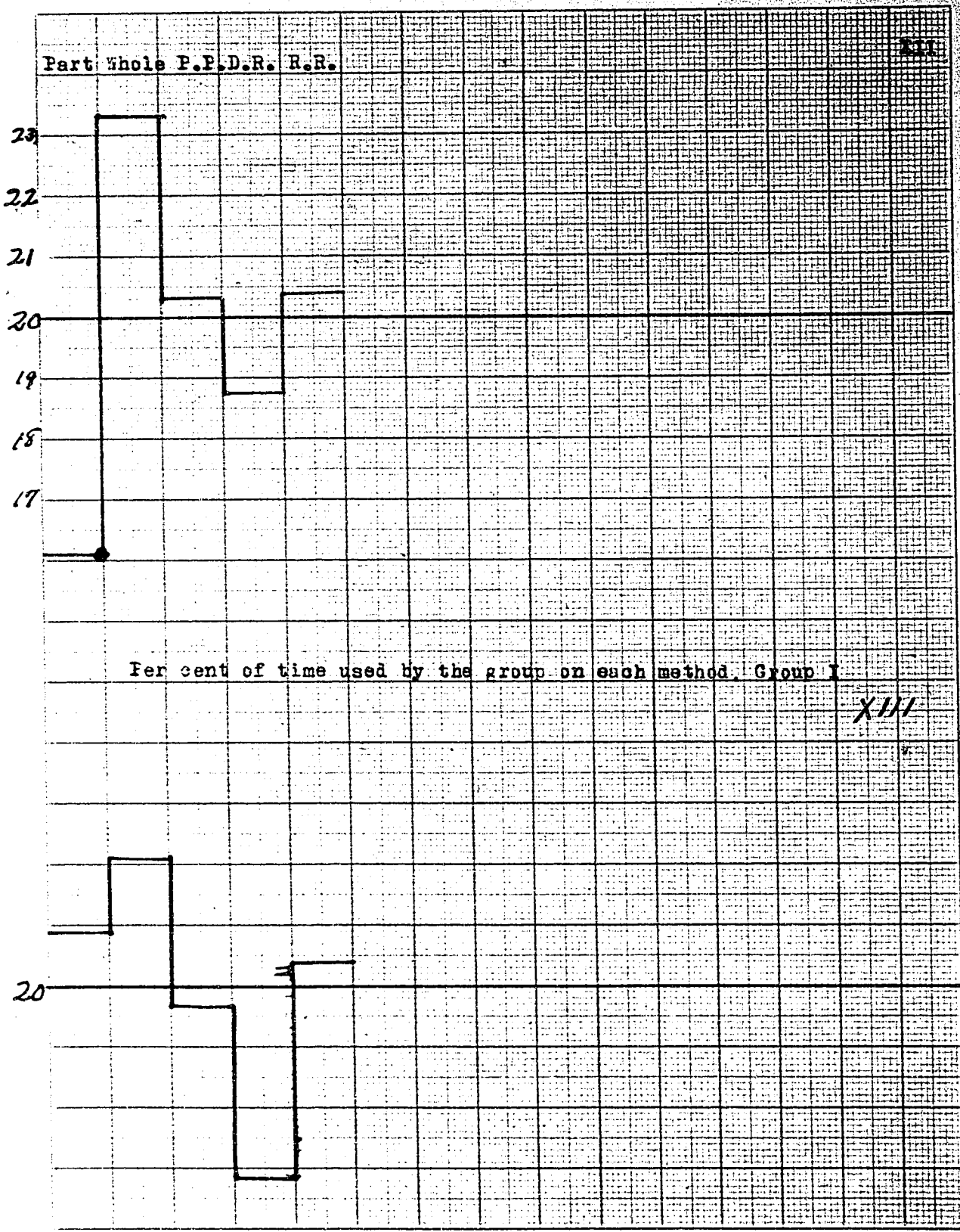
(a)

(b)

(c)







Part Whole P.P. D.R. R.R.
 Part Whole P.P. D.R. R.R.

XV

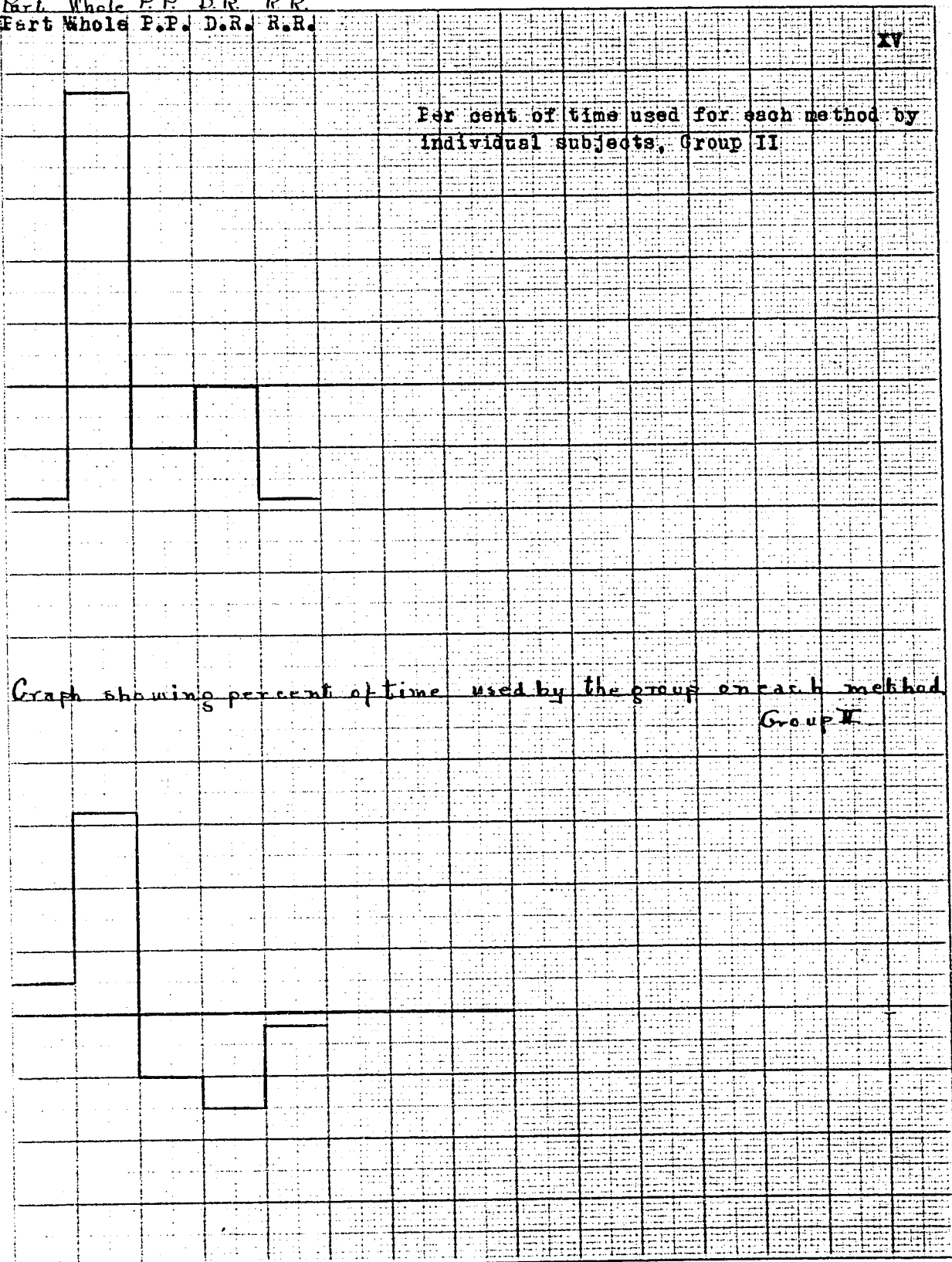
Per cent of time used for each method by individual subjects, Group II

1

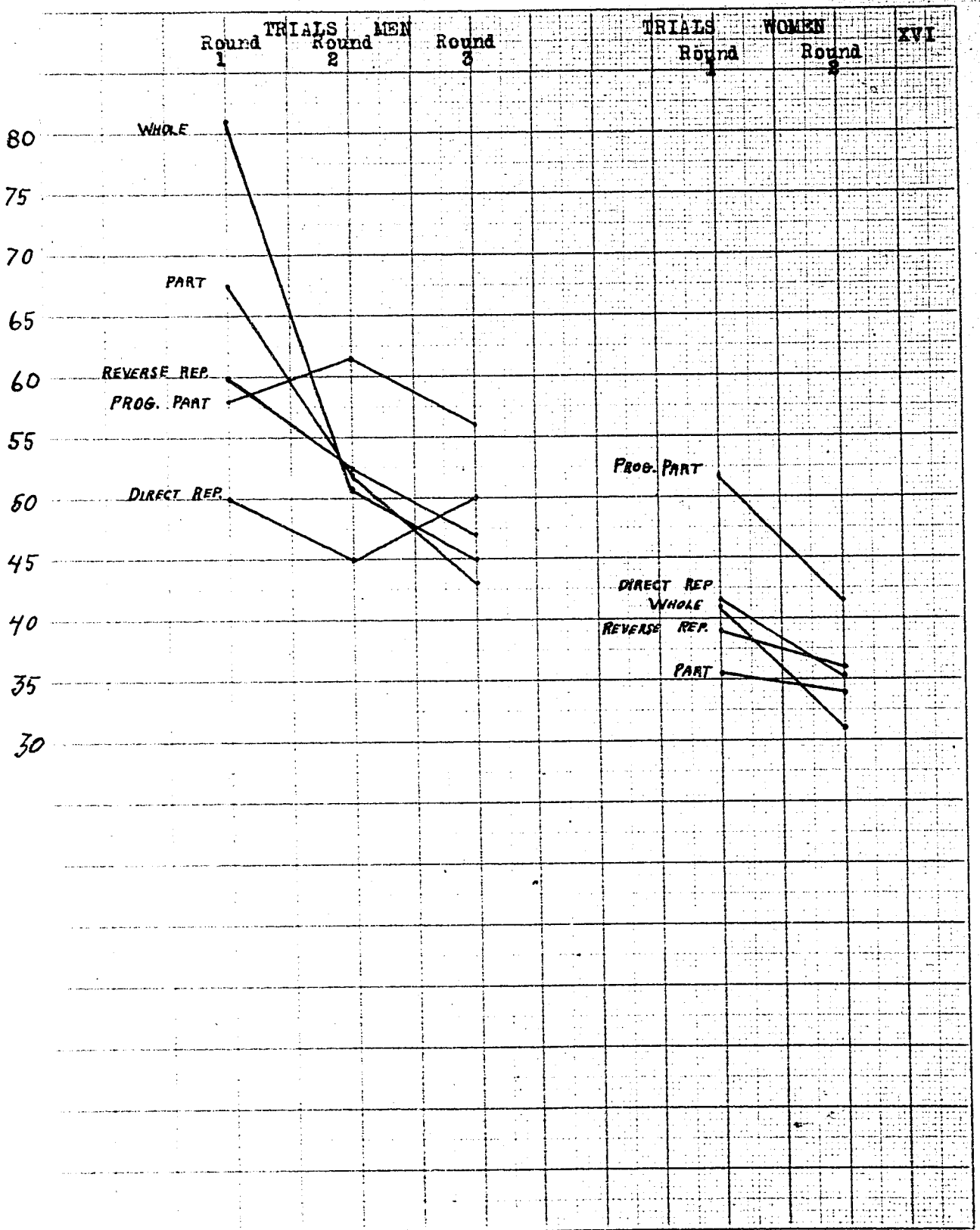
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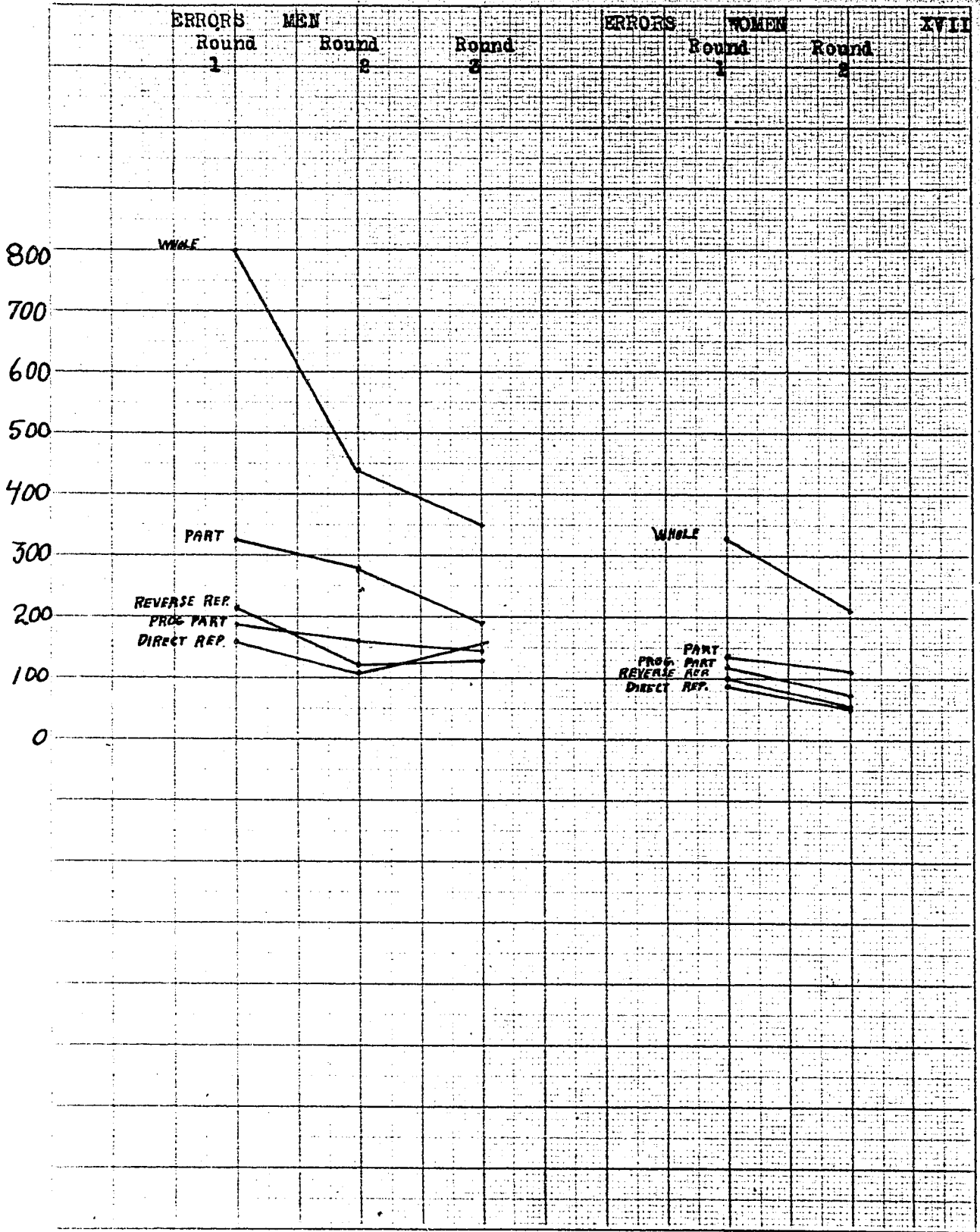
Graph showing percent of time used by the group on each method Group II

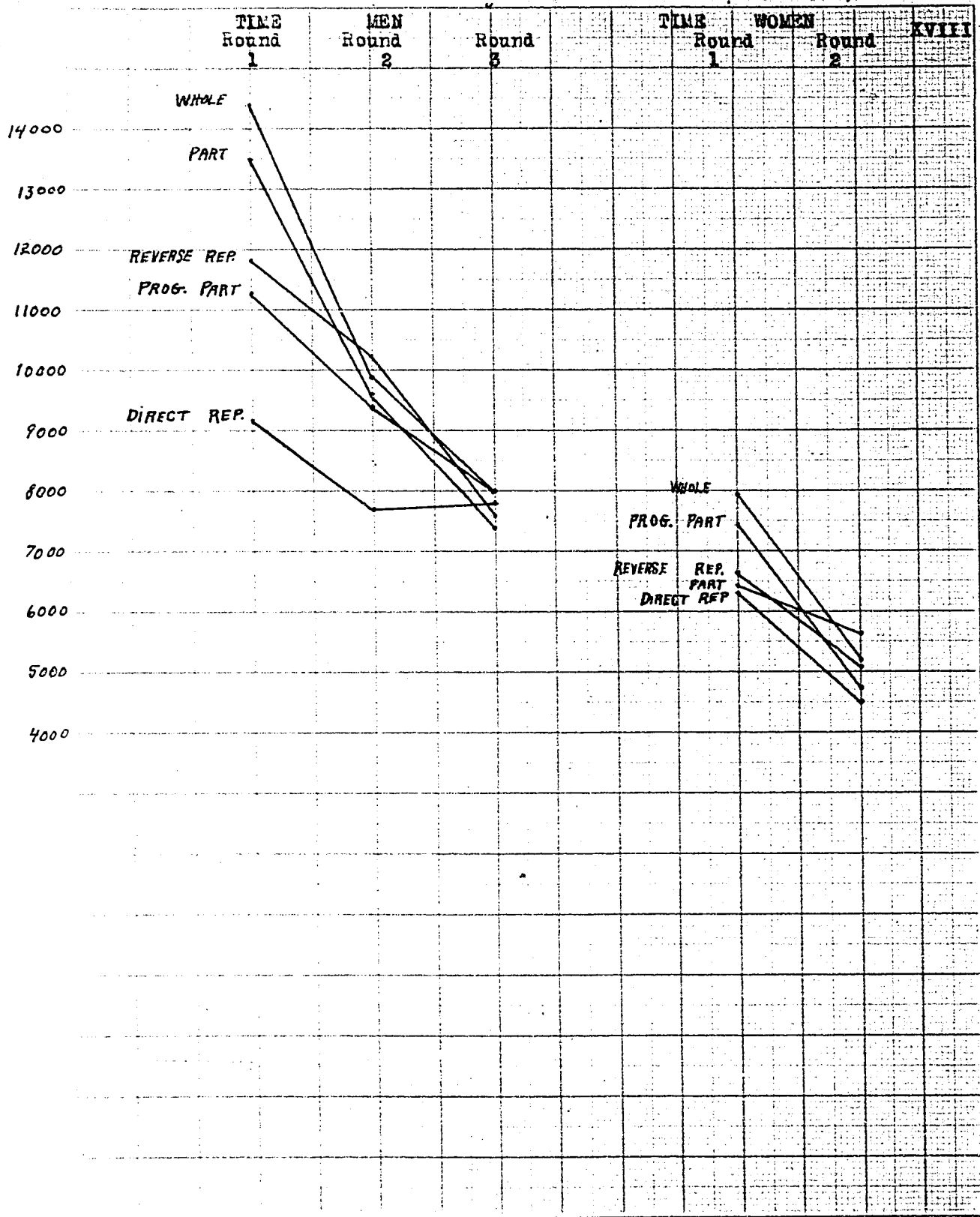
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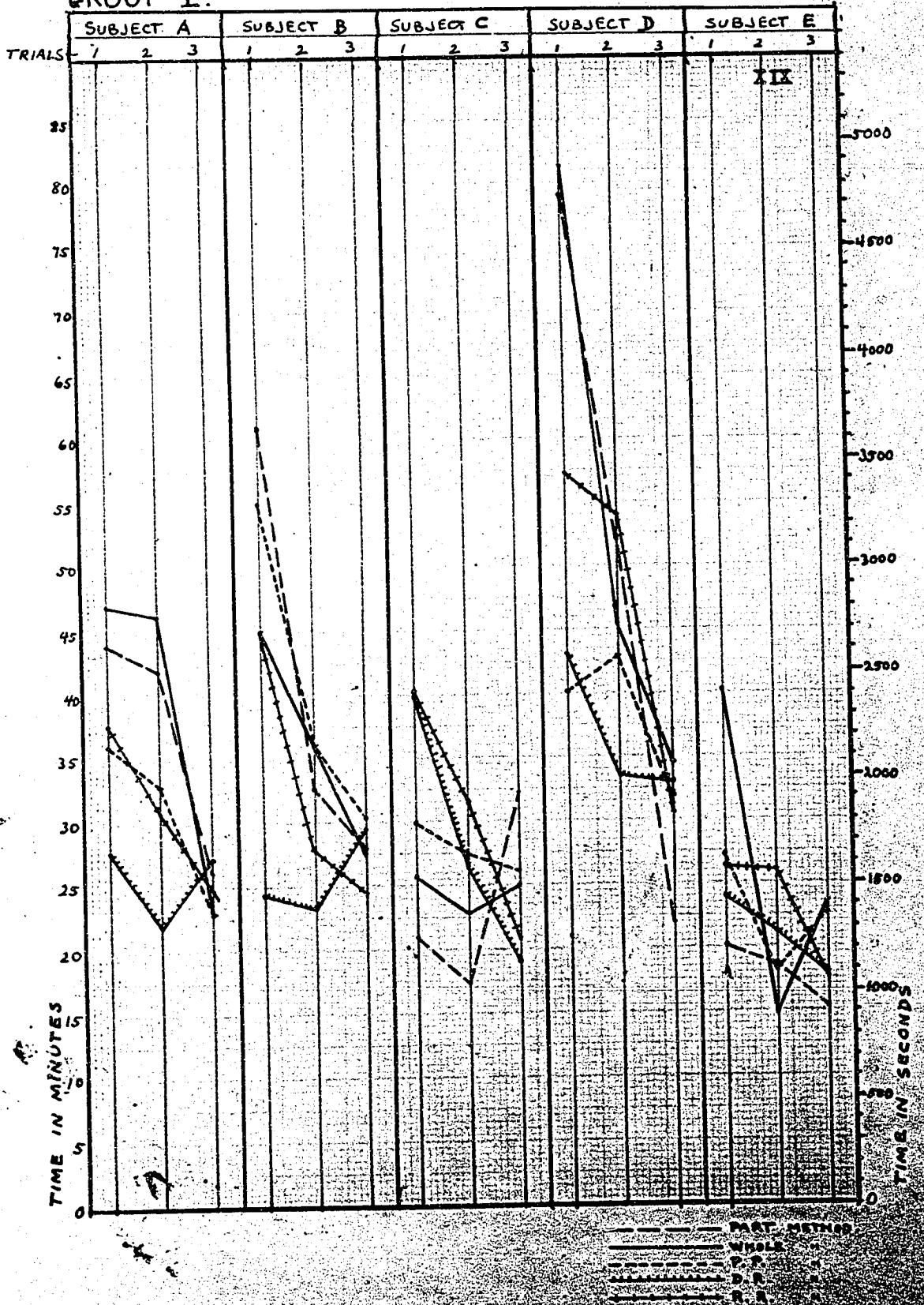
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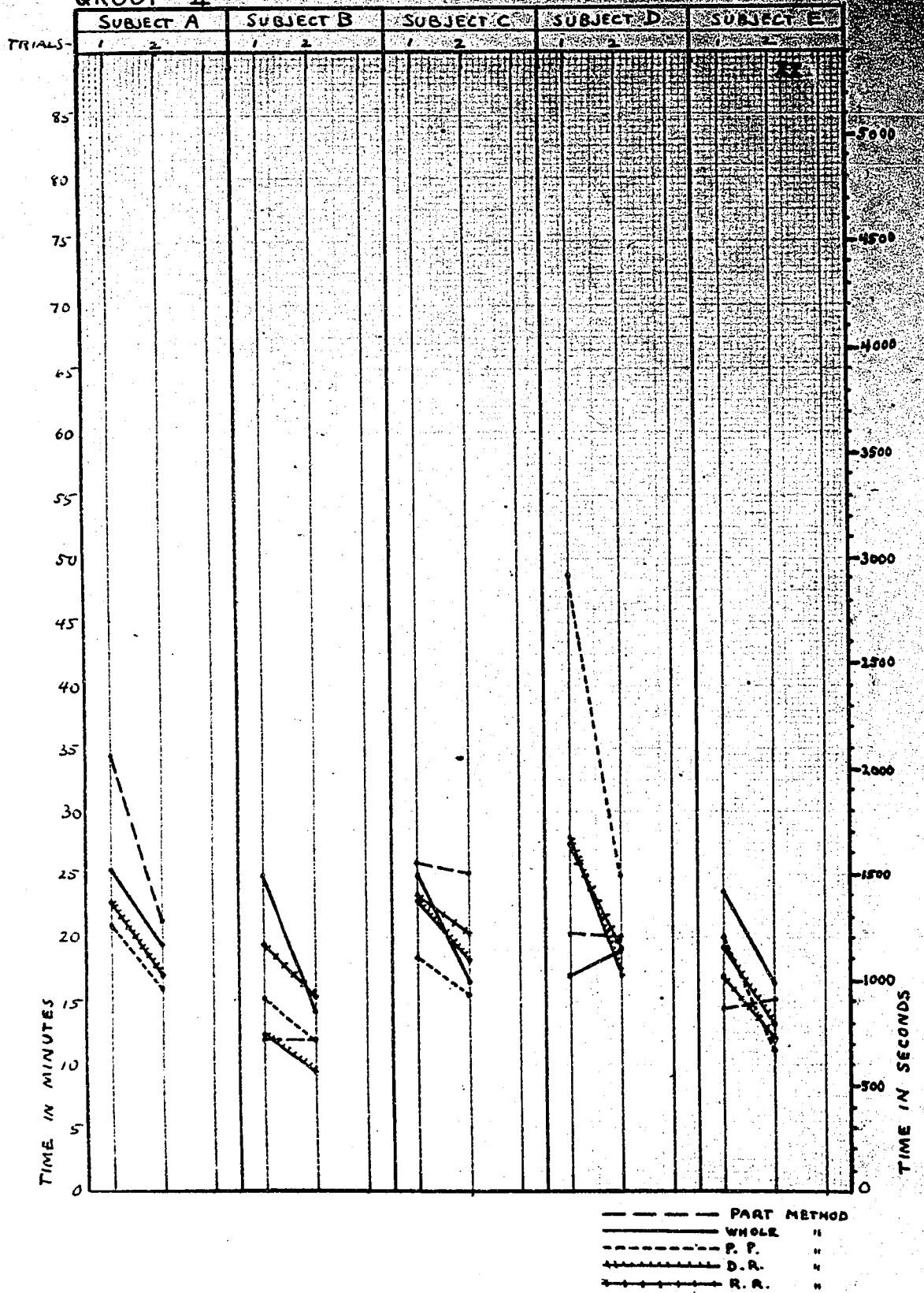
GROUP I.

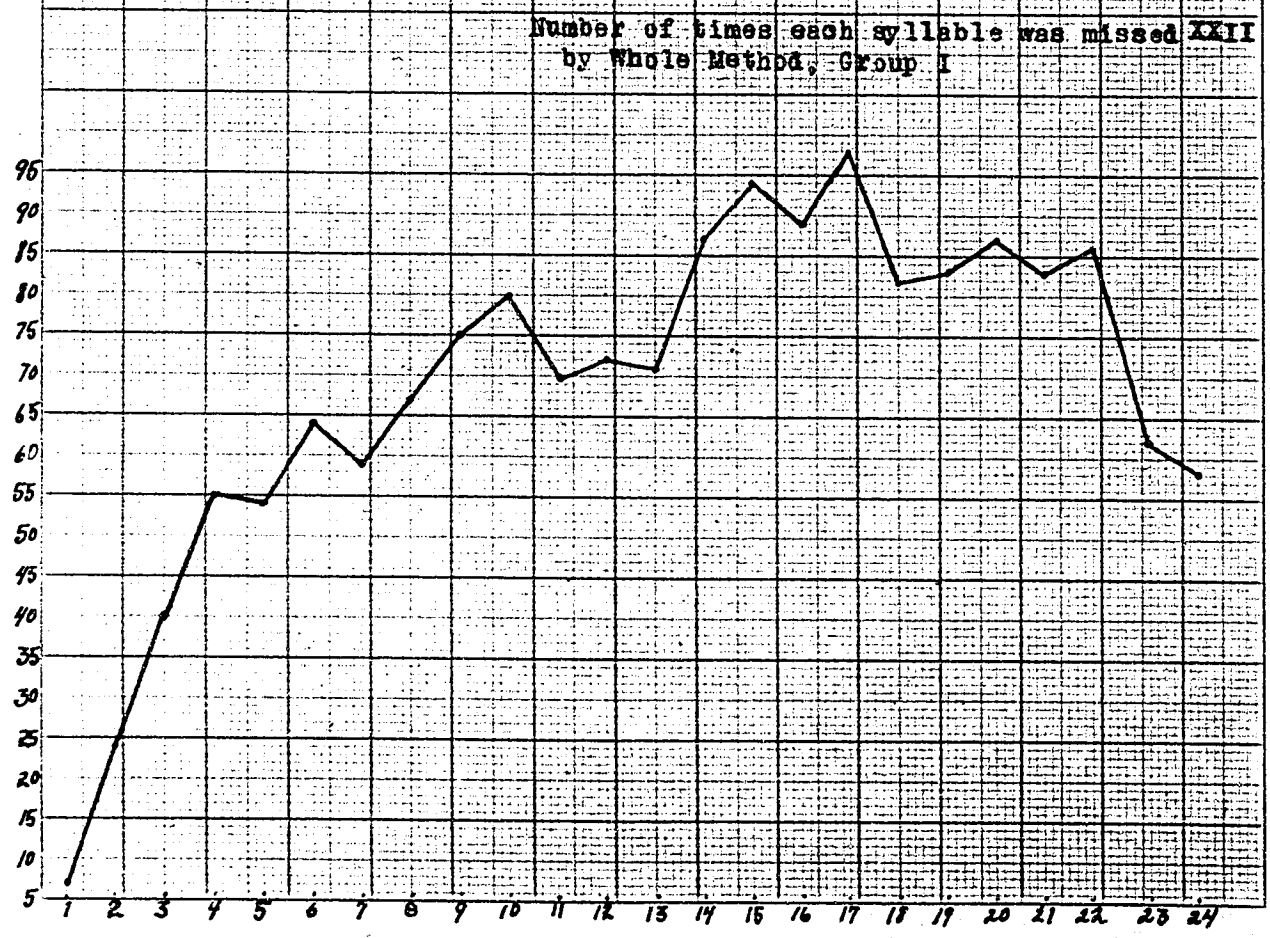
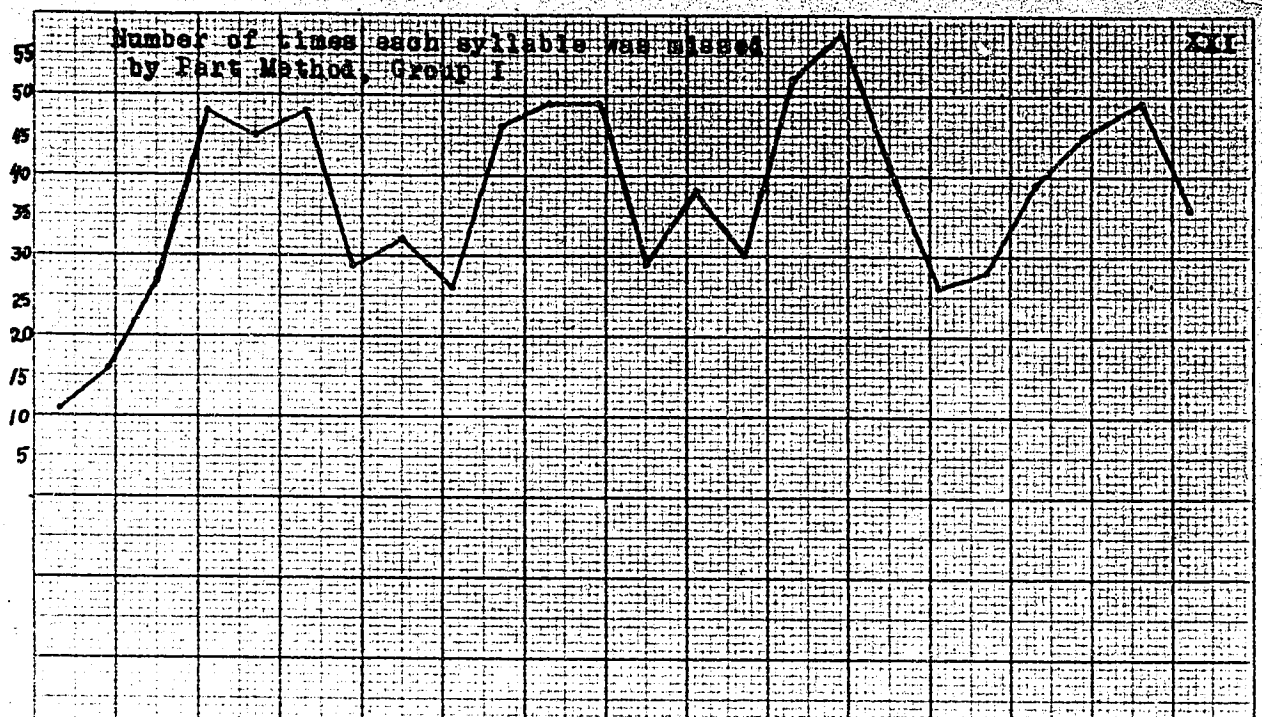


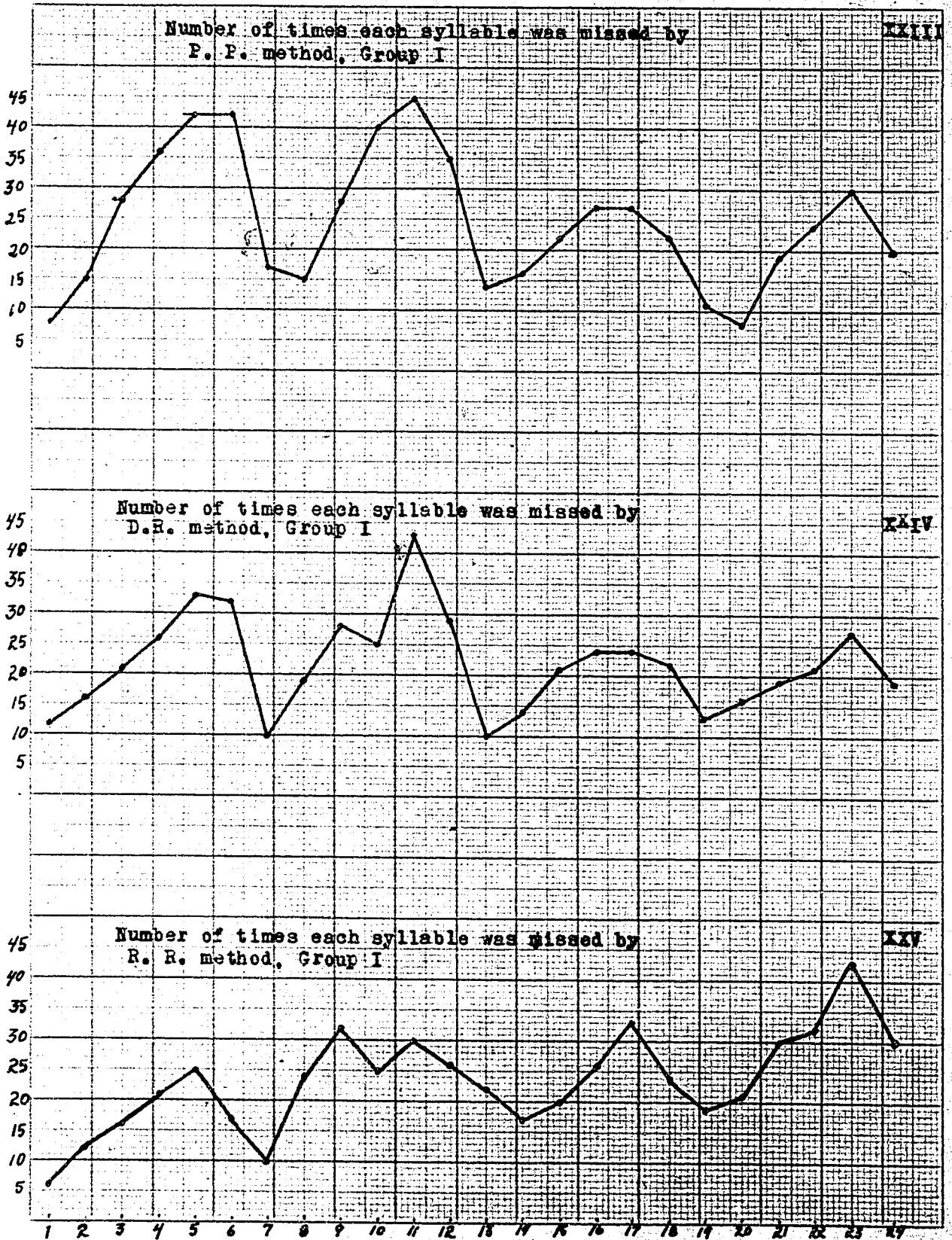
XIX

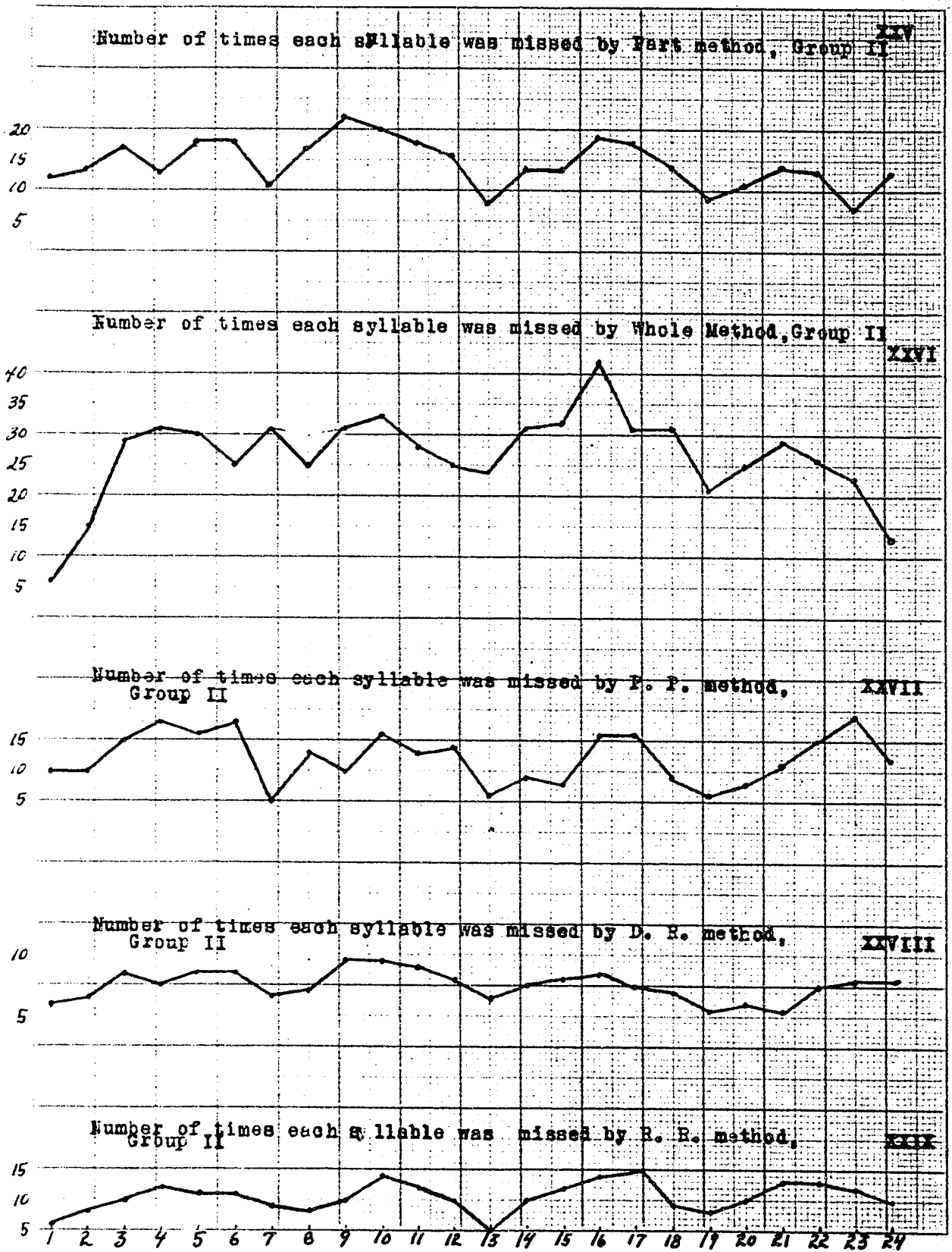
PART METHOD
 WHOLE
 P.P.
 D.P.
 R.A.

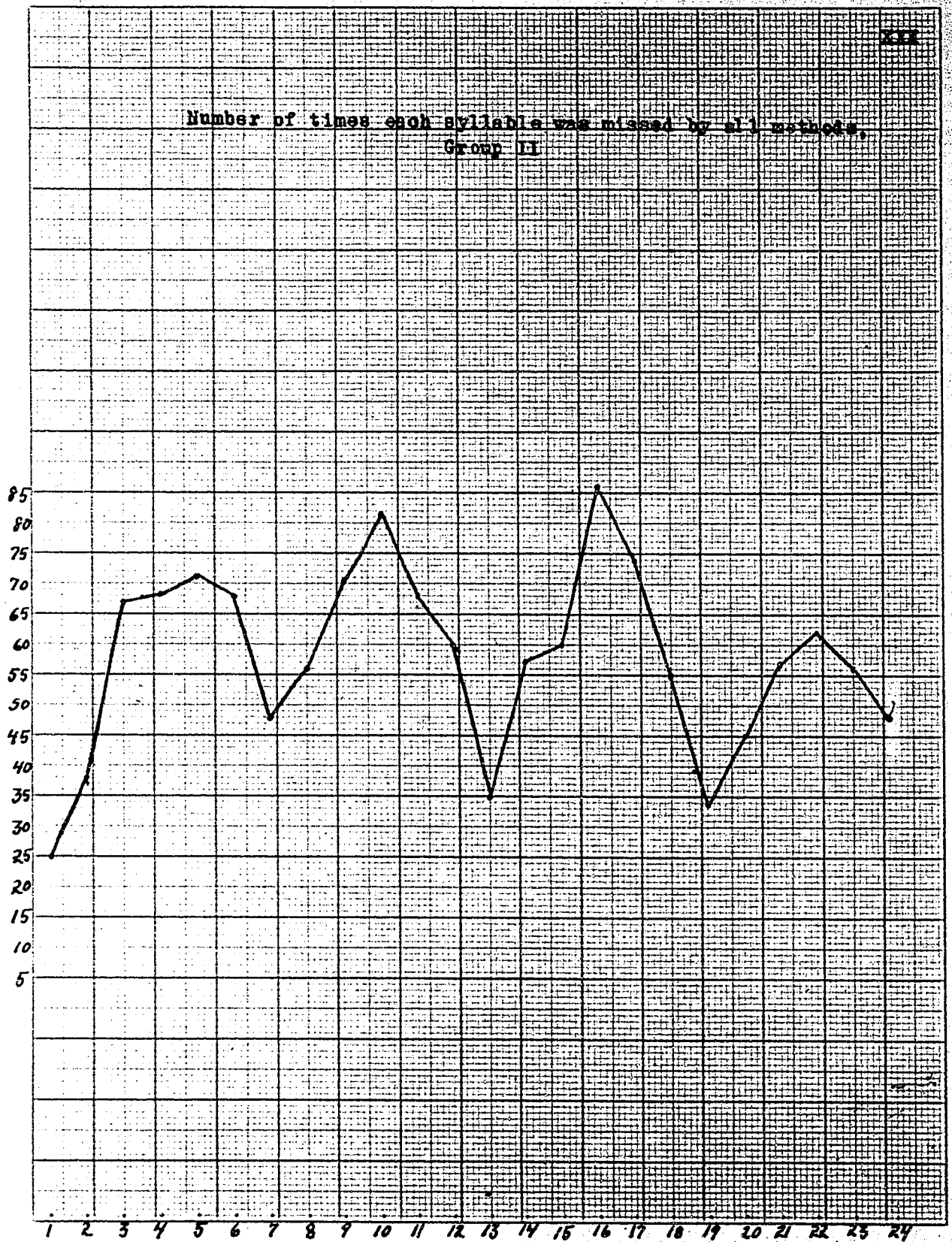
GROUP II



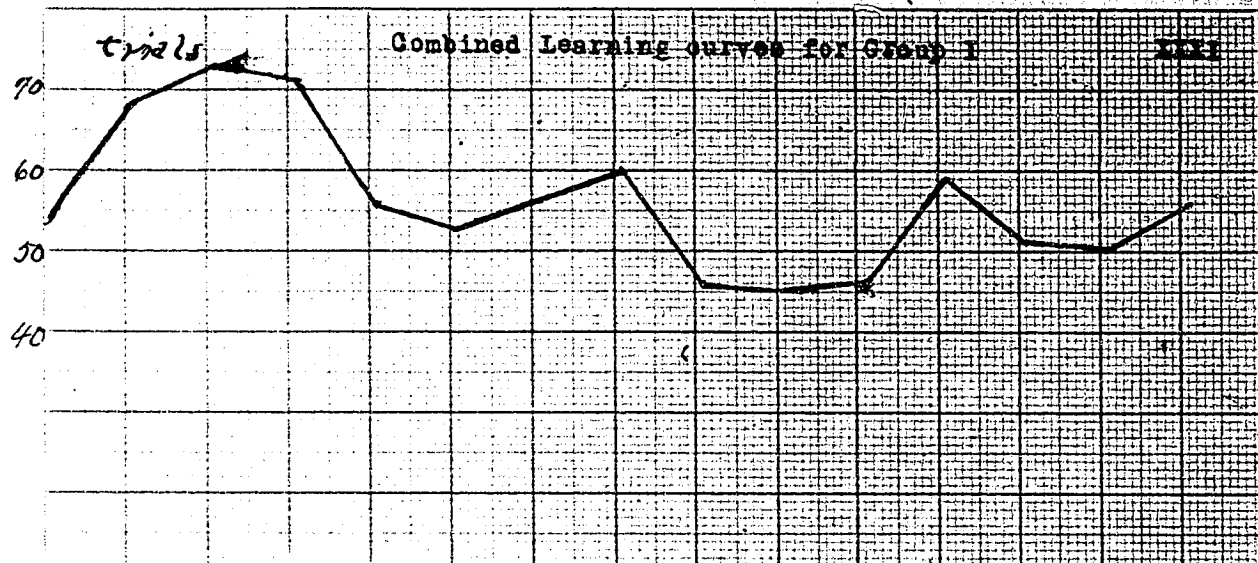








XXX



Learning Curve for Group 1

EX-111

time



