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Economical Learning

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ECONOMICAL LEARNING

by

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INTRODUCTION

"Economizing in the smallest matters of learning, we shall save in the aggregate a large amount of time and useless expenditure of energy"Colvin

The great change in our economic life in the last decade has forced its demands for greater skill and more economical methods upon man in every walk of life. These demands have in part been met and satisfied, but much is left to be done by the present generation. Psychology will doubtless contribute toward greater efficiency and economy in every business and profession.

In education, the psychologists have made important discoveries; they have given us facts which, when properly applied, will help materially in making our educational system more efficient.

During the quarter of a century following 1870, psychology was studied as a pure science. The application to education was limited because of the scarcity of established facts. But in the latter part of the last century, as psychology accumulated a respectable amount of data, it pushed its field of application, particularly in education; for the educational psychologist realized, perhaps more than any other man in professional work, the great importance of the application of established facts, the importance of methods in harmony with these facts and with the

laws of human development, and the importance of economizing on the things apparently little, yet vast in importance in education and in life.

The leading contributors and contributions on problems in economical learning up to the present day are enumerated and discussed in the Historical Review which follows below.

The object of the experiments conducted in connection with this study was to get a solution to the problem. If a person has a definite number of practices or periods in which to acquire and perfect a habit or build up a new set of associations is it more profitable to put in one or two practices daily? Having a definite number of days in which to acquire and perfect a habit or build up a new set of associations is it more profitable to put in one or two periods daily?

This problem had suggested itself to the writer years ago, when he attempted to acquire the contents of a subject in less than half the time usually spent on it, and in so doing experienced great difficulty as well as partial failure.

It is difficult and in many cases impossible to get suitable and reliable subjects for experiments of the sort performed, for the work generally means tedious, fatiguing and uninteresting hours for them. It was my

good fortune to have a group of university students who were interested in the work and who worked hard and conscientiously.

An attempt was made to duplicate the experiment performed in our laboratory in various grades and schools, but for various reasons some could not give them; those who did obtained results corroborating our own.

Incidental to the main problem and arising in connection with our experiments, several interesting subsidiary problems have been considered; the data obtained are recorded in the Supplementary Section.

I am indebted to the subjects, who through their labors made the data herein recorded possible. To them I extend heartiest thanks, also to my wife for her assistance in reading and checking the records, and particularly to Dr. W. H. Pyle, whose activity in this field inspired me to make this investigation and who through his guidance, kindness, and fidelity has made the work possible, pleasurable and instructive.

SECTION I.

HISTORICAL REVIEW OF STUDIES ON THE LEARNING PROCESS.

A. The first really valuable study of the process^{1.} of learning was begun by Harter in 1893 when he attempted to solve and analyze problems arising in connection with acquiring the telegraphic language.

The first investigation extended over a period of almost a year. During this time he not only considered his own experience but made inquiries of other operators concerning their experience.

^{2.}
In co-operation with Bryan this study was continued for years with hundreds of students of telegraphy, operators and authorities on the subject.

The first extensive article appeared in 1897. The curves of improvement in sending and receiving messages obtained from records made by subjects contain a number of points of pedagogical and psychological significance.

The results summarized are:

1. In any process of learning, be it a study in language, composition, physics, chemistry, music, or checkers, there is a hierarchy of habits which need to be and have to be followed, step by step as it were, until the lower ones are automatized, when those of a higher order can be acquired.

1. Harter, Psychological Review, Volume IV, page 27.

2. Bryan and Harter, Psychological Review, Volume VI, page 345.

2. That it is not possible by any method to gain freedom in using higher units or processes until the lower ones have been reduced to the level of an automatism, and that it is best to practice at all times with the highest units possible.

3. That plateaus are merely pauses when the learner fixates and habituates that which he in part knows and struggles to reduce to the state, when higher and perhaps more complex units or processes can be attempted.

4. That effective speed and accuracy depend upon how simple or easy the processes are to the learner rather than with what readiness can he execute the process in consciousness.

B. Beginning in 1878 and extending over a period of more than ten years, Ebbinghaus performed extensive experiments on memory. The results of tests of interest to us in connection with this study are those he found when trying to obtain the most economical way of learning a subject for later reproduction. In these tests Ebbinghaus had two methods of procedure. For the first he used series of nonsense syllables which were repeated by the learner until they could be given back free of error. Immediately following, they were read over three times as many times as it had

1. Ebbinghaus, Über das Gedächtnis.

2. Ebbinghaus, Grundzüge der Psychologie, Zweite Auflage, page 657.

taken to learn them. After twenty-four hours they were repeated until a correct reproduction was given. The value of the first repetitions was thereby obtained.

In the second method again twelve syllables were repeated until a correct reproduction was obtained; then there were no more repetitions until the next day when they were repeated until given without error. This method was pursued for three days.

Ebbinghaus found that in the first case the syllables were learned in seventeen repetitions. In addition there were fifty-one repetitions, making a total of sixty-eight repetitions. After twenty-four hours, seven repetitions were necessary to get a correct reproduction.

In the second case for the first, second and third day, seventeen and one-half, twelve, and eight and one-half repetitions respectively were necessary for a correct reproduction. On the fourth day or twenty-four hours after the last repetition, only five repetitions were needed to repeat correctly. Thus sixty-eight repetitions in one day were not as good for later reproduction as thirty-eight repetitions in three days, or after the first correct reproduction the fifty-one additional repetitions in the first case were not as beneficial as twenty repetitions on the two succeeding days.

The gains of the second method of procedure over the first were first, in that thirty less repetitions were made, an immense saving, and secondly, in that only five repetitions as against seven repetitions were necessary for later correct reproduction.

Ebbinghaus explained these results on the grounds that fatigue set in, in the continuous practice.

1.

Jost, by way of verifying the results of Ebbinghaus, performed experiments of a similar character.

Subjects B and S using nonsense syllables, repeated lines thirty times in succession in one day, and in another test ten repetitions for three consecutive days.

The method of procedure with the C or "Cumulationsreihen" was to read the syllables over once, then rest five minutes, then another reading and rest, etc. to the end.

With the V or "Verteilungsreihen", there was a reading and then a rest of three minutes, another reading and rest, etc., until ten such repetitions were made. The same was done on the two succeeding days.

He found the following results: With subject B on the C series it took six and one-half repetitions for a correct reproduction after twenty-four hours; on the V series it took five and one-half repetitions, a difference of one,

1. Jost, Zeitschrift für Psychologie der Sinnesorgane, Volume 14, page 436.

in favor of the last method. With subject S on the C series it took eleven and one-half repetitions, and on the V series nine & seven-tenths repetitions,- a difference of one and eight-tenths in favor of the last method. In both cases decidedly in favor of distributing the repetitions over more days.

Continuing the investigation along the line of the former experiment, Jost again using series of nonsense syllables had subjects repeat them four times daily for six days, eight times daily for three days, and twice daily for twelve days, and found that for later reproduction the four repetitions daily for six days were better than the eight repetitions daily for three days and the two repetitions daily for twelve days better than four repetitions daily for six days.

Jost agrees with Ebbinghaus that fatigue in the V series test enters to affect the results, but not in such a measure as to bring about the results obtained. He believes and has data to substantiate his belief, that it is not so much fatigue as it is inattentiveness. The inattentiveness of the last repetitions of a long series of repetitions causes them to have a very small and in some cases a negative influence.

1.

C. Swift in his book, "Mind in the Making", devotes

1. Swift, Mind in the Making, Chapter VI.

a chapter to the psychology of learning. In this chapter he designates three types of learning:

1. Physical, the acquisition of skill in any complex act.
2. Physical and mental, the acquisition of skill, as in typewriting.
3. Mental, the acquisition of knowledge in beginning any language.

Tests covering these types were made in ball tossing, typewriting, and learning a language.

(A) In the ball tossing test there were six subjects. The daily plan consisted of ten series, a series being until a catch was missed. Catches were recorded, and data, as to the method pursued. After a series a subject rested as long as he deemed necessary and then proceeded. There was no practice between series. Subjects were unfamiliar with what was attempted. Practice lasted from a few minutes at first to several hours later. The subjects knew their score as well as the score of others. The left hand was tested in the first practice and again later to get the effect that the training of the right hand might have upon it. The tests continued until catches on an average were over one hundred for each series.

The factors that influenced the scores were the weight of the balls, their weight 132 grammes being probably too great; the height of the room, it not being high enough

in the early practices; the physical condition of subjects; wild throwing or throwing the ball out of reach and method of trying to avoid collisions.

The curves constructed had these characteristics in common:

1. Progress was at first slow, then rapid;
2. There was great irregularity of advance;
3. The number of low throws continually decreased.

Swift, unlike Bryan and Harter, found not a few but many plateaus, varying with different individuals.

The conditions that influenced the learning were:

1. Physical condition, resulting from proper or improper exercise;
2. Lowered vitality, often not known to the subject;
3. Off days, which were at times overcome by warming up;
4. No uniformity of effort, that is, some relaxed and, even when they did not do that, they could not do equally well at all times;
5. Lack of energy due to waning interest;
6. Lack of confidence, at other times overconfidence;
7. Methods of throwing the balls.

Summary

1. Good methods and proper guidance are most essential in the early stages of the learning process.

2. In learning a complicated process we progress by sections.

3. In avoiding errors there in adaptation more subconscious than conscious.

4. Warming up is usually necessary.

5. Attempts to spurt were found ineffective, the special effort interfering with success by bringing the process too strongly into active attention.

6. Steady and calm intensity made for progress.

7. Co-operation of all muscles of the body is necessary.

8. Good catches left traces in the nervous system and gave a pleasurable feeling which facilitated similar repetitions.

9. Fatigue hinders the entire process.

10. General arm movement remains in consciousness but finger movements not.

In connection with the test Swift gives us some interesting data on the effect of right hand training upon the skill of the left. The subjects were all tested with their left before practice with the right hand began, and again later. He found that the first day's test was higher than the preliminary test, that the left hand curve was similar to the right hand, that subjects made a better score with their left hand on the first day of regular practice than they had been able to do with the right hand, that skill of the right hand helps the left hand to get a hold of method

of procedure in about one-third the time required by the right hand.

(B) In the experiment of learning to typewrite, Swift himself acted as subject. The test lasted one hour a day for fifty days. The writing was from copy and after every practice introspections were made.

Summary and results:

1. In learning to typewrite there is in the early stage a rapid rise due to the ease with which a few imperfect co-ordinations and associations are made.

2. The drop at a certain time in the learning curve was due to harder copy, but at times in a process no reason can be given for an apparent retardation.

3. The period of enjoying the practice corresponds with the first rapid rise.

4. Mental depression caused by monotony and drops occurred at the same time.

(C) The third study consisted of a study of Russian by Swift. It lasted from March the thirteenth to June the fourteenth, thirty minutes daily for study followed by fifteen minutes test of ability to read.

The preliminary preparation consisted of two hours' study of the Russian alphabet. From introspections and results from day to day Swift summarized as follows:

1. There were three ascents and four plateaus. During the plateaus there was progress not from a visible

point, but as far as automatization was concerned

2. Automatization was not continuous but rather by irregular leaps

3. Periods of monotony were important factors in the learning; they alternated with periods of pleasure and assisted in prolonging the plateaus.

Conclusion and General Summary

Swift found that the factors of chief importance and common to the several types of learning were:

1. The effect of physical condition, - and how much it enters is often almost impossible to determine, but where it has been positively determined that the physical condition of the body was not the best, the results of work attempted have been correspondingly low. Poor physical condition of a subject shows up most in persons who are older and have the will power to apply themselves. The first result is loss of nervous control over the small muscles which aid in whatever is attempted so that in processes other than those where physical operations enter, it means that the last, most complex, and highest stages of learning at which one has arrived leave us and we are obliged to use habits of a lower type.

2. Progress in learning is not continuous, but by leaps or in sections. It is a gradual and irregular growth from mental uncertainty and confusion to a condition when we do things with automatic certainty. The advances at

times are great, and the learner may drop back, but in a short time has no trouble in keeping up to the mark previously obtained.

3. The periods of no progress or plateaus are numerous and important. They are the periods of arrest when habits of a lower order are perfected and habits of a higher order take their place. The higher order habits do not come to the surface strongly in early stages, but they are making their way towards automatization all the while. Plateaus are active periods in automatization. After processes have become automatized the learner takes on new courage and the forward step is taken. These plateaus are significant; they tell us that enough has been attempted for the time being, and that the mind needs time for adjustment. Serious prolongations are often due to poor previous preparation on the part of the pupil, poor method on the part of the teacher, ill-suited subject matter.

4. Monotony is one of the elements that hinder in learning. Subject matter that was at first easy later becomes harder, the thing partly learned will have to be relearned and hence the first plateau. The material introduced during all this time causes the learner to become less confident and hence make no apparent progress. By special effort, such as a desire to beat our previous record, we raise ourselves out of the first time and place of no progress. The new methods of improvement are usually hit upon unconsciously

but survive because of a conscious reason.

5. Movements that contribute to the success of that which we are striving to do results in organic contentment which heightens the neuro-muscular tone and favors their repetition, resulting in automatization and success.

6. Fatigue is disastrous to the finer acquisitions which characterize growth in skill and knowledge.

7. Practice should not be carried to the point of fatigue, but should cease while the learner is still fresh and enthusiastic. If carried beyond this, the fatigue point, study tends to delay progress by starting erratic impulses that end in confusion.

8. Equivalent results are not obtained from equal amounts of work. At times great efforts produce only small results; at other times the returns seem to exceed the effort. This is probably due to failure to organize at certain periods which, when organized at another time, yields greater results. This organization may have taken place when no progress was being made.

9. The periods of no progress are oppressive, but sudden in their disappearance. The learning and automatization connected with or acquired during those periods is largely subconscious.

10. The advance that can be seen is very slight; time and steady work bring about the growth in power to understand relations, which constitutes a great part of the improvement.

D. Some very interesting and suggestive studies of various phases of development and learning were made by a class in psychology under the direction of their instructor, E. A. Kirkpatrick, during 1908. Practically every one of these studies acquaints us with some special problem well worth consideration, but only those bearing more directly on the learning process will be reviewed here.

(A) "The Curve of Learning", consisted of a series of experiments performed on children, normal school students, and two older persons. The object was to get data for the construction of a curve of learning.

The test consisted of substitutions of a group of twenty letters of the alphabet. The letters had as their equivalent some other letter, as a = x, c = f etc. Subjects were given test sheets on which were series of ten rows of letters differently arranged in each group or line and the subjects were to make the substitutions, in accordance with the key.

Curves were constructed showing the results of different methods of the test, as once, twice, or four times a day, and the progress of the different subjects.

The factors found to influence the progress of the curve most were; physical condition of subject, temperature of the room, interruptions, mind wandering, hurrying, fatigue, and attempted spurts.

1. E.A. Kirkpatrick, Studies in Development and Learning, Archives of Psychology, 1909.

Results:

1. The greatest gains in the learning process were made in the first practices.
2. Morning practices were more beneficial than afternoon practices.
3. Children worked slower at first than adults, but their gains were greater. Adults' gains were more uniform.
4. Short and frequent periods of practice proved more valuable than extended ones.

(B) Fatigue in Habit Formation: This experiment was conducted in very much the same way as the foregoing one. The same test sheets and keys were used.

Results:

1. As fatigue increases, the rate of improvement decreases.
2. There was great irregularity in the records when several tests were given at the same time.
3. As a rule there was less improvement in the afternoon than in the forenoon.
4. A single test in the grades showed a fatiguing effect.
5. Poor records were made after a drawing lesson, indicating that fatigue is local, not general, and mainly motor.

(C) Ways of Learning Visual Forms: Pupils of the first, third, sixth, eighth grade, and students of the normal were given five meaningless figures based on geometrical forms. The subjects were asked to study these figures for ten minutes; no method of study was suggested. At the end of ten minutes the figures were removed and the subject instructed to draw them. The following questions were asked:

1. How did you learn the figures?
2. Did you, while studying, move hand or body in a way corresponding to the shape of the figure?
3. Did you make associations with familiar objects?
4. Did you study the figure in parts or as a whole?

From results obtained, the following classifications were made:

1. Those who use the hand or part of the body.
2. Those who associate figures to be learned with some familiar figure.
3. Those who learned by wholes.
4. Those who learned by parts.

The results indicated the following:

1. Nearly all subjects used several methods, some all of them.
2. Normal students remembered by association.
3. Children learned by wholes.
4. Eighty per cent of children of the lower grades used the motor element, while hardly half that number in the normal student group did.

5. The motor element was not a great help in remembering after a lapse of several days.
6. A large per cent of students getting high grades in the test both in general and detailed appearance used the combination of methods.
7. Normal school students got best results from studying as a whole, then associating and analyzing.
8. Third grade children got the best results from studying as wholes, then tracing.

(D) Methods of Learning Visual Forms: This experiment had as its object the testing of methods of pupils of different grades when learning different figures. Three tests were given to the pupils of the second, fourth, sixth, and eighth grades. The first method was to ask pupils to study the figure in any way they wished; the second, to look at the figure then look away and image it; the third, to draw the figure on the desk with the hand. In each test four minutes were given to study, then a reproduction was made. The papers were graded as to general form and details.

Tables on details show great improvement from the second to the fourth grade, no changes from the fourth to the sixth grade, and again a change from the sixth to the eighth.

Tables on general form show that there is gradual improvement. Younger children get the general form almost

as well as do older ones, which is not the case when considering details.

The results as to methods were:

1. Motor method gave the best results particularly as concerns details.
2. Motor method proved best for the second grade.
3. In the fourth and sixth grade the imagination method was best.
4. The best results were obtained where some specified method was pursued.
5. The difference in favor of motor test was slight.
6. If small children who are learning to read speak the words, they learn more readily.
7. No specified method should be given to class as a whole, as individuals differ, but methods of learning should be suggested.

E. An extensive and, as far as is known to the writer, the most critical study of any learning process was made of ^{1.} learning to typewrite by W. F. Book.

With eleven subjects, three regular learners, three professional typists, four beginners and one expert, he spent periods ranging from several days for some to eighty-six and one hundred seventy-four for those working longest, in an attempt to get first hand the psychology of skill as it manifests itself in such an acquisition.

1. W. F. Book, Psychology of Skill, University of Montana Publications, 1908.

The tests, preceded by a short practice, lasted one-half hour daily.

Those subjects who learned by the Sight Method used a test sentence at intervals in their writing from copy; those who learned by the Touch Method used the test sentence only.

The object of the study was to obtain for each learner a practice or learning curve representing his progress and an explanation of the same from personal introspections and objective records.

The study attempted to determine all that took place on the conscious side in learning to typewrite, the habits learned and acquired, what gave rise to these habits, how they developed and what factors entered to help or hinder their development.

In order to keep or get an exact record of what the subject did while at the machine, electrical connections between the typewriter used and a Deprez marker were made, thus the striking of a key, the moving of the carriage or spacing would be recorded.

The number of times a subject had to look at the copy and the time for retaining it were likewise obtained by means of a switch key attached to a marker.

It was soon found that these results were not sufficient to check the introspections and account for the various problems coming up, particularly the fluctuation in work from

minute to minute or day to day, so a pulse record was taken. This was accomplished by means of tambours placed on the temporal artery and thus a measure of the fluctuation of effort was obtained. As a standard or norm of the subject's pulse rate his pulse record was taken each day after being seated and rested for a while.

At regular times a kymograph record was taken of twenty repetitions of the test sentence. The learners were kept ignorant of their scores.

After each practice, introspections were recorded and these were supplemented by answers to questions asked by the experimenter.

Extended introspections were made every ten days when the subjects wrote for several hours; special points were worked on and were not given up until solved. A copy of the problems to be worked out was placed before the subjects during these periods, but no questions were asked.

From the results obtained learning curves were constructed and the following established and verified:

1. That for all subjects there was a rapid and continuous rise in the earliest stages followed by a slower advance;
2. That there were daily variations without any apparent causes;
3. That there were periods of non-improvement or breathing spaces lasting eight to ten days where the learner often fell below his previous record;

4. That certain individuals had longer periods of non-improvement or plateaus than others;
5. That breathing places appear at no special or regular time, but that plateaus appear when the subject has reached a certain level of attainment;
6. That critical stages come to all of the learners, barely noticed by some, while others could not get past them for days.

Analyzing the process of learning, Book found that there were two groups of habits; habits of manipulation and habits of control.

Habits of manipulation consist of numerous simple and complex habits which merge into each other to form still higher complexes by a process of short circuiting. This short circuiting consists of dropping or combining certain operations at first necessary and hard in themselves, but later such that they can be omitted or done in one act. Through this process of elimination and recombining, direct, useful and the most economical habits were acquired.

In the earliest writing he found the following steps;

1. Getting the copy.
2. Spelling or thinking of each letter made.
3. Mentally locating it on each key.
4. Getting the proper finger on the key.
5. Pronouncing the letter or initiating the final letter making movement.

Improvement in these steps came through short circuiting. The steps at first separate and distinct, became easier, and eventually the sight of the letter brought on the movement by which the proper key was struck. The fusion of the steps took place somewhat in this manner, for example, for steps one and two; the getting of the copy, which consisted of the spelling out of words, in a short time came to be the momentary and almost unconscious sight of the letters, whereupon location upon the keyboard followed, the second step, being literally dropped. In similar ways the other steps combined until the entire five steps became one automatic action, the sight of the letter setting the psychophysical organism to going and keeping it going until the letter had been recorded.

The habits of control or habits of a strictly psychic nature consisted of:

1. Learning to short circuit or the acquiring of the most advantageous and most economic way of mastering the subject. Three facts observed in regard to short circuiting were:
 - (a) New adaptations were made unintentionally,
 - (b) Progress or forward steps came only as a result of great effort,
 - (c) Less and less short circuiting took place as the subject approached perfection.

2. Learning how to meet difficulties.
3. Acquiring and maintaining a favorable attitude of feeling
4. Keeping attention focussed on the work in hand
5. Learning how to economize effort.

Special habits of typewriting were developed and perfected in a definite manner as follows:

1. Earliest associations were formed from associations and activities previously acquired,
2. At first the learner's attention and efforts were not applied in a direct and economical way,
3. Many non-usable associations were called up in the attempt to succeed.
4. Through special effort, elimination and recombination the most direct method of work was obtained
5. Many habits entered, but were eliminated, others modified and merged into others survived, thus forming the higher groups which were further recast to form still higher complexes.

Special habits of manipulation grew and developed simultaneously, that is,

1. Elementary habits were not completed until the formation of higher order habits entered
2. Development of the higher and the perfection of the lower habits took place during the entire process

3. Lower order habits were developed in and through the higher, the final development of the higher depending upon the degree of perfection of the lower
4. Final perfection was slow and gradual.

Factors that entered into the learning and that served to hinder the growth and development of habits were:

(1) Daily Relearning and Warming Up.

Some of the skill acquired from day to day was forgotten and the associations did not work as promptly and easily. To bring about former ability, warming up and relearning were daily necessary. It was found that with the warming up, came increased pulse and that before work was profitable at maximal effort, this had to be done. After the subjects had relearned and warmed up they were able to push to a higher plane of work.

(2) Fluctuation in Attention and Effort.

There were three groups of Fluctuation.

- (a) The regular fluctuation at the beginning and ending of a practice, and the irregular fluctuation which took place anywhere in the practice. These sometimes lasted for several days, explainable only by some fatigued condition of the subject;
- (b) Variations from day to day, as indicated by introspections, observations, kind and number of errors and pulse curves. These variations were accompanied by lack of incentive, changes in the learner's attitude, changed physical con-

dition, relapse to older or lower methods of work and inability to control the defects in efficiency.

- (c) Regular and irregular lapses which occurred at different stages of practice. The irregular lapses or breathing places came at any time when anything retarded success temporarily, and were overcome by some special effort or incentive. The regular lapses came at a stage of advancement when a special habit or group of habits was being perfected and when attention drifted from the work as a whole or the details had become automatic and were slighted because it was harder to center attention on them. These periods prolonged, Book calls the critical stages because: (a) The learner is liable to take in foreign matter instead of pushing on; (b) He may go too fast, neglecting the perfection of details.

(3) Fluctuation in the Feeling and Attitude.

More mistakes were made when there was a lapse of attention and effort. The mistakes affected the work by increasing the fluctuation of errors and by affecting negatively the learner's attitude and ability to do.

Conclusions and General Summary.

1. There is a close correlation between the learner's ability to do and learn and his general affective tone and attitude.
2. Fluctuations in attention and effort are the causes of the variations in the learning curve.
3. Fluctuations are unavoidable.

4. The lapses in attention and effort which occur at the breathing places can be eliminated.
5. The feeling aroused one day or during one practice goes to form the attitude or mood with which the learner starts his next practice.
6. At critical stages hindering associations tend to develop in masses.
7. Periods of rest allow the growth of proper habits and at times are more beneficial than practice.
8. All specific habits and associations involved in the mastery of anything should be carefully perfected.
9. Habits of a lower or primary order should be rapidly outgrown and replaced by habits of a higher order.
10. The learner should practice with the highest order habit at his command.
11. Habits of accuracy and speed in typewriting, while they may be practiced at less than the maximal ability should be practiced together at their maximum in order that they may be learned in their final and exact setting.
12. The learner's equilibrium of efficiency varies for different periods of practice, that is, at times he may be working far below his capacity; at other times, above, due to attending incentive or lack of incentive.
13. The hygienic condition of the nervous system affects the number, length, succession and seriousness of the irregular lapses in attention and effort.

14. The fluctuation in efficiency can be controlled easiest by improving the subject's general neural tone through sleep, rest, exercise, food, change of attitude or change of weather.
15. The learner can do nothing by an act of the will to control the attention and effort.
16. Forward steps are made unconsciously.
17. Adaptations are made with little conscious help, and during a time when attention and effort are spontaneous and vigorous.
18. When all conditions are favorable the forward step in the learning is made.

1.

F. Dearborn in connection with classes in educational psychology, performed several experiments in learning in 1910. The object of his experiments in general was to throw some light on the process of learning; his greatest contributions, however, are suggestions as to methods of procedure.

1. Trial and Error Method.

In this experiment the subject was directed to trace the outlines of a star by looking in a mirror. The figure of the star, the hand and arm used were hidden by a screen and the tracing was done by looking at the reflection in an upright mirror. The subject followed the line, and

1. Dearborn, Journal of Educational Psychology, September, 1910.

when he got off, he immediately returned to it. The star was printed at an angle such that no lines were parallel or perpendicular to the base line of the mirror. The most difficult lines were the slanting lines. After a short time most subjects learned to trace readily.

To demonstrate that this ability to draw a star in a certain position had not resulted in a general acquisition of the difficult strokes he gave them a figure having no outline but having a central point and numbers around and away from it. When directed to draw the strokes from the center to numbers outside, they failed.

Another way to carry on this test, as Dearborn suggested, is to trace half of the star in the first test with the left hand, and then after considerable practice with the right hand, finish it with the left. Again by having part of the class omit the right hand practice and then finishing out the star, will give some indications of how much of this transference of training is due to the repetition or second trial and how much to other factors.

2. Practice Experiment.

In this test, blanks were used on which were lines of connected prose which the subject spelled out, using numbers in place of the letters in the words. The learning of the equivalent of the letters was through actual use.

The purpose of the test was to make as many substitutions as possible without error in a given time.

The initial and one test toward the end of the practice were done in the class, the rest outside. The curves of the different individuals do not point to any conclusions, they merely indicate what different individuals can do.

In another part of the test a class was divided into two groups, one group practicing at intervals of twelve hours, the other at intervals of twenty-four hours. The group practicing every twenty-four hours continued for fifteen days, the division practicing every twelve hours, eighteen days.

The results obtained show that once a day practice for ten minutes is productive of greater progress than twice a day for five minutes.

3. Practice Experiment in Memory.

In this experiment the object was to find the minimum time necessary to learn, so that they could be recalled, the English equivalents for German and French words.

There were twelve subjects, the experiment lasted twenty days, and from thirty to fifty unfamiliar words in German or French were committed daily. The same plan was pursued with memorizing familiar poems or phrases.

The time of the first and lowest record, the gain in minutes, the gain per cent and the total number of words learned as well as the total time expended were recorded.

It was found that there was a gain of from fifty-three to sixty-two per cent between the initial and final

practice, and a transferred effect of practice between time before practice and time after practice of from seven to thirty-three per cent.

Conclusions.

The permanence of retention is not claimed for such memorizing, but in view of the fact that words can be relearned much quicker than learned when new, it speaks in favor of memorizing material which might be used in later studies and work.

The main results of the experiment are that it shows that it is more economical to commit to memory after a high level of practice efficiency has been reached.

1.

G. Starch in the past year tried to verify the results of Ebbinghaus, Jost and others, and also find out whether what they found held when longer periods were employed. He had forty-two students in groups, on different phases of the problem. In group one, there were twelve students; in group two, fourteen; in group three, nine; in group four, seven.

The learning process consisted of substituting a number for each letter of the alphabet.

A keyboard of the letters and numbers was at the top of each of the blanks used. On the blanks were prose sentences and using the keyboard the subjects were required

to substitute in the proper space a number for each letter.

To determine the relative advantage of different periods he had group one work twice a day ten minutes for six days; group two, once a day twenty minutes for six days; group three, every other day forty minutes for six days; group four did the entire task in one continuous sitting.

The time was one hundred and twenty minutes. The subjects worked at the same time daily, and those working twice a day at intervals of at least five hours.

Curves were plotted and they indicate that shorter and more numerous periods are better than the longer periods.

Starch found the ten minute periods the most productive; the twenty minute period seemed almost as good, while the forty minute or the continuous period were far below the shorter periods.

Starch concludes that still shorter periods would not be advantageous, as the time needed for warming up would offset what gain there might be. In support of this he refers to the advantage of the ten minute group over the twenty minute group which is not as great as the gain of the twenty minute subjects over those working forty minutes.

The reasons why the short period groups gain so much more than the longer period groups are, he thinks, that they start and work with greater concentration and because, during the periods of rest new associations become settled and fixed, making them ready and helpful in the next practice.

H. (A) The latest and perhaps most valuable results, from a pedagogical point of view, obtained from psychological research have come from the laboratory of Dr. W. H. Pyle¹ of the University of Missouri.

In the second semester, 1909-1910, the problem, What is the most economical unit for committing to memory? was taken up and experiments performed covering a period of six months.

With a number of subjects, and acting as a subject himself, units ranging from five to two hundred and forty lines were committed. Only one subject did consistent and systematic work, and hence only his record and results are considered.

The material used was Longfellow's translation of Dante's Divine Comedy. The method was to read the poetry aloud, the learner repeating any part from the beginning as soon as he could. When unable to proceed the unit was read out to the end. Units of sixty and more lines were read entirely through as many times as was possible at one sitting, for several successive days, as they could not be learned in one period of forty or fifty minutes.

By the part method the unit was learned by dividing it into parts and then learning them separately.

It was found that, irrespective of length of unit taken, even the longest attempted, two hundred and forty lines,

1. Pyle, W.H. Journal of Educational Psychology, March, 1911.

that there was a gain of from 11 per cent for the shorter, to 20 per cent for the longest unit in favor of committing by wholes. It was further found

1. That fatigue sets in at the end of forty to fifty minutes when it is a loss of time to try to memorize.
2. That the associative connection between the divisions of a unit, while at times verbal, more frequently consists in meaning.
3. That the greatest hindrances in memorizing by the part method were

(a) Associating the last line of a division with the first of that division instead of the first line of the next division,

(b) The loss of time by this method was mostly due to the extra time required to get or fix the divisions together.

1.

(B) During the following year, Dr. Pyle carried on experiments to determine,

1. What length of period is best when one has an absolute amount of time.
2. What is the best interval between practice periods.

In the first part of this work four subjects were given a devised alphabet and using those characters to represent English letters they transcribed from a monograph.

1, Pyle, W.H. Journal of Educational Psychology, March, 1913.

All worked daily for the same number of days, thirty minutes daily; this constituted the control experiment. In the second part, or experiment proper, one subject worked fifteen minutes, one thirty, one forty-five, and the other sixty minutes daily for seventeen days.

Comparing results on the basis of average speed the greatest improvement was for thirty minutes, and least for fifteen, and sixty minutes; on the basis of final speed, the forty-five minute period proved better than the thirty minutes, but the sixty minute period was no better than the thirty minutes.

Considering the same problem when all subjects put in the same number of hours and distributing the time in shorter or longer daily periods of fifteen, thirty, forty-five or sixty minutes, it was again found that whether figured on the basis of average speed or initial speed with the final speed, the thirty minute periods gave the best results.

The question, What is the best interval between practice periods? was worked out with ten subjects. The material and method were similar to those in the foregoing discussion.

Following a check experiment, the experiment proper of sixteen practices was taken. In this, five subjects worked daily for thirty minutes and five for the same length of time on alternate days. Results show that comparing the subjects in pairs or in groups, there is in every case a gain for daily practices.

SECTION II.

If a person is acquiring and perfecting a habit or building up a new set of associations and has a definite number of practices in which to do it, is it more profitable to practice once or twice daily?

Having a definite number of days in which to acquire and perfect a habit or build up a new set of associations, is it more profitable to put in one or two periods daily?

The historical review of the preceding Section indicates the nature, extent, and results of experiments directed toward the solving of problems or questions in economical learning prior to nineteen hundred and twelve.

The first series of experiments, conducted in connection with the writing of this thesis, was begun on the second of October, nineteen hundred and twelve, and continued to November twenty-second. The second series began February seventeenth, nineteen hundred thirteen, and lasted till March the twenty eighth.

All the experiments were performed in the presence of the writer, and the object primarily was to get definite and reliable data in answer to the questions stated above.

Between the First and Second experiment, and after the Second, experiments were performed on a number of other problems in economical learning, considered in Section IV. The results recorded there may not be final, yet they are evidence of answers as indicated.

EXPERIMENTAL.

(a) First Experiment.

The experiment recorded in this Section was with six University students acting as subjects and was conducted in the following manner.

The subjects were given twenty minutes in which to learn a devised alphabet after which they were asked to copy words from a monograph on educational psychology.

Loose-leaf paper and pencils were used and nothing was allowed to interfere with the subjects during the practice.

The length of each practice period consisted of three ten-minute periods. At the end of the ten minutes a signal was given, when the subject made a mark to record each successive ten minutes work.

Before starting on the daily practice the subjects recorded their physical condition, dated and numbered an approximate number of sheets of paper, and opened the monograph to the place from which copy was to be made.

At the appointed signal, which was the clicking of the stopwatch, the alphabet was turned face up and the writing began.

At the conclusion of the practice the subjects recorded their introspections. These introspections, while they cast some light on the mental process of each individual, are not incorporated in this discussion.

The entire experiment consisted of three parts, for each part a new alphabet (page 40) was used, and, with the exception of not having the subjects first study the alphabet twenty minutes and then write, but having them begin to write in the initial practices in Part III, the same conditions were maintained throughout.

The alphabet, a copy of which was placed with each subject, consisted in the main of unfamiliar characters and after writing began was kept in view so that the writer could refer to it as occasion demanded.

The subjects, all of average ability and school standing, reliable and conscientious were Mabel Schleef, Senior in Education; Belle Mayer, Junior in Education; Mabel Berryman, Senior in Arts and Science; Margaret Carney, Sophomore in Arts and Science; Eulah Lyon, Senior in Education; Mildred Norris, Senior in Arts and Science.

In the discussions following the initials will frequently be used in referring to those taking part in the experiments.

The subjects were instructed not to write or discuss the alphabet in any way with any one, and to banish it from their minds if it came up at any time outside of their practice.

While the test was in progress, they were at times kept ignorant of their records; at other times, when it was

ALPHABETS.

I.
 a = /
 b = $\frown$
 c = $\smile$
 d = —
 e =)
 f = ==
 g = A
 h = $\forall$
 i = (
 j = #
 k = ∇
 l = λ
 m = $\wedge$
 n = $\vee$
 o = $\dagger$
 p = δ
 q = ℓ
 r = σ
 s = $\surd$
 t = t
 u = ϵ
 v = 3
 w = +
 x = $\hbar$
 y = Ψ
 z = Δ

II.
 a =)
 b = —
 c = $\neg$
 d = $\perp$
 e = (
 f = $\neg$
 g = |
 h = L
 i = $\frown$
 j = $\neg$
 k = $\neg$
 l = L
 m = J
 n = /
 o = o
 p = \\\br/>
 q = $\surd$
 r = $\neg$
 s = >
 t = <
 u = $\smile$
 v = $\vee$
 w = $\wedge$
 x = +
 y = ==
 z = —

III.
 a = o
 b = +
 c = 9
 d = $\triangleright$
 e = /
 f = <
 g = ==
 h = γ
 i = t
 j = —
 k = $\pm$
 l = 8
 m = X
 n = π
 o = ϵ
 p = ϕ
 q = —
 r = $\sqsubset$
 s = 7
 t = $\sqsupset$
 u = 4
 v = $\triangleright$
 w = T
 x = $\times$
 y = $\neg$
 z = $\vee$

thought necessary to keep up interest, they were advised of their own standing as well as the standing of others.

The physical condition of the subjects was excellent, however, headache, colds, and changeable attitude towards the exercises entered sufficiently at times to cause perceptible fluctuation.

In Part I, all subjects, S, M, B, C, S, and N, worked once a day, S, C, and M, from eight to nine in the forenoon, and L, B, and N from nine to ten, all under identical conditions. This test extended over a period of nine days and served as a check and index of the speed and ability of the subjects.

In Part II, S and C worked twice a day for fifteen days, M and L once a day for nine days, and B and N twice a day for four and one-half days. When there was one practice daily the practice came from eight to ten in the forenoon, the second practice for any day from four to five in the afternoon.

In Part III, S, M, and B worked once daily, C, L and N twice daily for fifteen days.

The method of calculation applied to the data obtained is to divide the number of seconds in one period by the number of words written during one period. This gives the number of seconds required to write one word and is used in computing the average for the entire experiment.

In considering the first part of the problem, the term practices will be used, for the second part periods; in either case it means the length of an application.

In every comparison the data will be considered by taking the subjects in groups of once a day as over against twice a day.

Part I, in which all subjects worked once a day, is used as check upon Parts II, III, and with Part II upon Part III. Part II is used as check on Part III. In using these parts as checks the groups are made up of subjects who have taken the same number of practices and according to a certain method. That is to say, the groups are made to be as equal as is possible, and what difference exists by virtue of different ability is overcome through the application of their relative ability in the control or check experiment.

A. Table I gives the records of the number of words for the subjects for each day in Part I, and the average of the groups working once or twice a day in the next part of the experiment or Part II.

Table II gives the number of periods, the time of practice, the daily records of subjects, the method pursued, and the average of the groups in Part II.

Applying the methods of calculation previously mentioned to the records obtained and summarizing from Tables I and II, we have results as indicated in Tables III, IV, and V.

In Table III and all other tables similarly arranged, No. of P. stands for the number of practices or periods in the experiment; Ave. of E.Ex., for the average time in seconds that it took to write one word throughout the experiment; Av. of I.3 P., for the average time in seconds required per word in the first three practices; Av. of F. 3 P., for the average time in seconds required per word in the last three practices; Gain % F/I, for the gain of the average of the final three practices over the average of the initial three practices. In all cases where tables are marked (a) and (b) the part marked (a) applies to the first part of our problem, (b) to the second part.

From Table V we have in answer to the first part of our problem for the average of the entire experiment 5.3% in favor of once a day practices; for average of the final three practices 20%, and for the gain per cent of the final three practices over the initial three, 28.9%.

In answer to the second part, for the average of the entire experiment it favors two periods a day by 21.1% for the average of the last three periods 30.9%, and for the gain per cent of the last three periods over the first three, 22.7%.

TABLE I.

Record of Part I.

<u>Daily Group</u>			<u>Twice Daily Group</u>				
<u>Mayer</u>	<u>Lyon</u>	<u>Average</u>	<u>Norris</u>	<u>Berryman</u>	<u>Schleef</u>	<u>Carney</u>	<u>Average</u>
130	156	143	121	101	96	182	125
154	121	138	105	113	110	152	120
174	145	160	164	172	153	162	183
200	155	178	160	201	206	226	198
229	211	220	211	205	254	253	231
263	214	239	226	235	304	290	264
296	288	292	260	281	329	311	292
343	349	346	279	294	360	352	321

TABLE II.

Record of Part II.

	<u>Daily</u>			<u>Twice Daily</u>				
	<u>Mayer</u>	<u>Lyon</u>	<u>Average</u>	<u>Norris</u>	<u>Berryman</u>	<u>Schleef</u>	<u>Carney</u>	<u>Average</u>
P.M.				147	148	163	146	151
A.M.	133	180	157	217	169	240	213	210
P.M.				206	181	238	211	210
A.M.	167	239	203	225	204	237	195	216
P.M.				222	219	267	211	230
A.M.	188	251	219	256	256	276	248	259
P.M.				241	240	320	276	270
A.M.	234	294	264	315	289	335	359	325
P.M.						356	335	346
A.M.	246	303	274			386	357	372
P.M.						403	332	368
A.M.	273	309	291			465	410	438
P.M.						446	407	427
A.M.	328	382	355			476	465	471
P.M.						472	458	465
A.M.	330	396	363			481	496	489

TABLE III.

Daily Group

<u>Part I.</u>	<u>Mayer</u>	<u>Lyon</u>	<u>Average</u>
No. of P.	8	8	
Av. of E.Ex.	8.9"	9.9"	9.4"
Ave. of I.3 P.	11.9	12.9	12.4
Av. of F. 3 P.	6	6.6	6.3
Gain % F/I	49.6	48.8	49.2

Twice Daily Group

	<u>Schleef</u>	<u>Carney</u>	<u>Norris</u>	<u>Berryman</u>	<u>Average</u>
No. of P.	8	8	8	8	
Av. of E.Ex.	9.9"	8.1"	10.5"	10.3"	9.7"
Av. of I.3 P.	15.6	10.9	14	14.7	13.8
Av. of F.3 P.	5.5	5.7	7.1	6.7	6.3
Gain % F/I	64.8	47.7	49.3	54.4	54.1

TABLE IV

Daily Group

<u>Part II</u>	<u>Mayer</u>	<u>Lyon</u>	<u>Average</u>
No. of P.	8	8	
Av. of E.Ex.	8.3"	6.5"	7.4"
Av. of I.3 P.	11.3	8.2	9.8
Av. of F. 3 P.	5.9	5	5.5
Gain % F/I	47.8	39.3	43.5

Twice Daily Group

(a)	<u>Schleef</u>	<u>Carney</u>	<u>Norris</u>	<u>Berryman</u>	<u>Average</u>
No. of P.	8	8	8	8	
Av. of E.Ex.	7.2"	8.2"	8.2"	8.6"	8.1"
Av. of I.3 P.	8.7	9.7	9.7	11	9.5
Av. of F.3 P.	5.8	6.3	6.8	7.3	6.6
Gain % F/I	33.3	35	30	33.6	33

(b)	<u>Schleef</u>	<u>Carney</u>	<u>Average</u>
No. of P.	16	16	
Av. of E.Ex.	5.7"	6.4"	6"
Ave. of I.3 P.	8.7	9.7	9.2
Av. of F. 3 P.	3.8	3.8	3.8
Gain % F/I	56.3	60.8	58.6

TABLE V.

Comparison between I and II.

Part I.	Daily	Twice Daily	In favor of Daily	In favor of Twice Daily
Av. of E.Ex.	9.4"	9.7"	3.2%	
Av. of F.3 P.	6.3	6.3		
Gain % F/I	49.2%	54.1%		10%

Note: The per cent in favor of either daily or twice daily is found by taking the difference between the records of the groups and then finding what per cent that difference is of the record of the once a day group.

Part II. (a)	Daily	Twice Daily	In favor of Daily	In favor of Twice Daily
Av. of E.Ex.	7.4"	8.1"	5.3%	
Av. of F.3 P.	5.5	6.6	20%	
Gain % F/I	43.5	33	28.9	

Note: The per cent in favor of either group is obtained by applying the ratio existing in the check experiment to the record of the daily group in the experiment proper. The record to be attained by the twice a day group will be X. The per cent that the difference between X and the actual record of the twice a day group is of X, is the gain per cent.

Part II. (b)	Daily	Twice Daily	In favor of Daily	In favor of Twice Daily
Av. of E.Ex.	7.4"	6"		21.1%
Av. of F.3 P.	5.5	3.8		30.9%
Gain % F/I	43.5	58.6		22.7

Note: In (a) the comparison is made for the same number of practices; in (b) for the same number of days, the twice a day group putting in twice as many periods.

Represented by a graph in which the number of words written in a period is represented on the vertical axis and successive practices on the horizontal line, we get curves as given on Plate I. The curve at the right is the control experiment, the one furthest to the left, the experiment proper. The black line represents the progress of the daily group, the green line the twice a day group. The lower green line is the record of an equal number of practices by the twice a day group as compared with the once a day, the upper green line, the record of an equal number of days by the twice a day group as compared with once a day.

LEARNING CURVES FOR PARTS I AND II

SUCCESSIVE PRACTICES

PLATE I

B. Taking up and comparing Parts I and III we have Table VI, which groups the subjects and their records in Part I into once a day and twice a day subjects as they appear in Part III or Table VII.

Applying the same method to this data that was applied to the data in A we get Tables VIII, IX and X.

In answer to the first part of the problem we get from this table that there is a gain of 9.2 per cent for once a day practices when taking average of the entire experiment, 5 per cent when taking average of the last three practices, and 5.3 per cent when taking gain per cent of the final three practices over the initial three practices.

In answer to the second part of the problem, there is a gain of 13.2 per cent for the average of the entire experiment in favor of putting in two periods, likewise a gain of 20 per cent on the average of the last three periods, and a gain of 29.7 per cent on the gain per cent of the final three periods over the initial three periods.

Represented by a graph we get curves as given on Plate II.

TABLE VI.

Record of Part I.

<u>Daily Group</u>				<u>Twice Daily Group</u>			
<u>Schleef</u>	<u>Mayer</u>	<u>Berryman</u>	<u>Average</u>	<u>Carney</u>	<u>Lyon</u>	<u>Norris</u>	<u>Average</u>
96	130	101	109	182	156	121	153
110	154	113	126	152	121	105	126
153	174	172	166	162	145	164	157
206	200	201	202	226	155	160	180
254	229	205	229	253	211	211	225
304	263	235	267	290	214	226	243
329	296	281	302	311	288	260	286
360	343	294	332	352	349	279	327

Note: The above table shows the relative learning capacity of the subjects, when all work together. Daily and twice-daily means that these subjects worked daily and twice a day respectively in the Experiment proper.

TABLE VII.

Record of Part III.

	<u>Daily Group</u>				<u>Twice Daily Group</u>			
	<u>Schleef</u>	<u>Mayer</u>	<u>Berryman</u>	<u>Average</u>	<u>Carney</u>	<u>Lyon</u>	<u>Norris</u>	<u>Average</u>
P.M.					184	200	149	178
A.M.	197	214	186	199	219	263	221	234
P.M.					292	305	208	268
A.M.	205	238	197	213	303	280	214	266
P.M.					346	337	245	309
A.M.	229	280	206	238	324	347	255	309
P.M.					365	357	279	334
A.M.	298	279	250	276	374	362	297	344
P.M.					386	374	302	354
A.M.	392	375	316	361	467	451	349	422
P.M.					459	435	328	407
A.M.	405	377	300	361	467	427	346	413
P.M.					495	457	382	445
A.M.	450	428	323	400	490	464	395	450
P.M.					469	441	358	456
A.M.	427	434	311	391	485	466	394	448
P.M.					430	466	421	439
A.M.	471	442	333	415	527	530	452	503
P.M.					505	488	445	479
A.M.	534	502	380	472	576	549	498	541
P.M.					536	515	452	501
A.M.	571	540	365	492	619	587	503	570
P.M.					595	586	529	570
A.M.	536	463	363	454	563	526	482	524
P.M.					608	574	536	573
A.M.	585	529	389	501	617	592	544	584
P.M.					542	551	482	525
A.M.	582	519	405	502	589	602	561	584

TABLE VIII.

<u>Daily Group</u>				
<u>Part I.</u>	<u>Schleef</u>	<u>Mayer</u>	<u>Berryman</u>	<u>Average</u>
No. of P.	8	8	8	
Av. of E.Ex.	9.9"	8.8"	10.3"	9.7"
Av. of I.3 P.	15.6	11.9	14.7	14.1
Av. of F.3 P.	5.5	6	6.7	6.1
Gain % F/I	64.8	49.6	54.4	56.3

<u>Twice Daily Group</u>				
	<u>Carney</u>	<u>Lyon</u>	<u>Norris</u>	<u>Average</u>
No. of P.	8	8	8	
Av. of E.Ex.	8.1"	9.9"	10.5"	9.5"
Av. of I.3 P	10.9	12.9	14	12.6
Av. of F.3 P	5.7	6.6	7.1	6.5
Gain % F/I	47.7	48.8	49.3	48.6

TABLE IX.

<u>Daily Group</u>				
<u>Part III</u>	<u>Schleef</u>	<u>Mayer</u>	<u>Berryman</u>	<u>Average</u>
No. of P.	14	14	14	
Av. of E.Ex.	4.9"	4.9"	6.2"	5.3"
Av. of I.3 P.	8.6	7.5	9	8.4
Av. of F.3 P.	3.2	3.6	4.7	3.8
Gain % F/I	62.8	52	48.9	54.6

<u>Twice Daily Group</u>				
(a)	<u>Carney</u>	<u>Lyon</u>	<u>Norris</u>	<u>Average</u>
No. of P.	14	14	14	
Av. of E.Ex.	5.3"	5.3"	6.8"	5.8"
Av. of I.3 P.	8.1	7.2	9.6	8.3
Av. of F.3 P.	3.7	4.	4.8	4.2
Gain % F/I	54.3	44.4	50	49.6

(b)	<u>Carney</u>	<u>Lyon</u>	<u>Norris</u>	<u>Average</u>
No. of P.	28	28	28	
Av. of E.Ex.	4.3"	4.3"	5.3"	4.6"
Av. of I.3 P.	8.1	7.2	9.6	8.3
Av. of F.3 P.	3.1	3.1	3.4	3.2
Gain % F/I	61.7	56.9	64.6	61.1

TABLE X.
Comparison between I and III.

Part I	Daily	Twice Daily	In favor of Daily	In favor of Twice Daily
Av. of E.Ex.	9.7	9.5		2.1%
Av. of F.3 P.	6.1	6.5	6.6%	
Gain % F/I	56.3	48.6	13.7%	

Part III. (a)	Daily	Twice Daily	In favor of Daily	In favor of Twice Daily
Av. of E.Ex.	5.3	5.8	9.2%	
Av. of F.3 P.	3.8	4.2	5 %	
Gain % F/I	54.6	49.6	5.3%	

Part III. (b)	Daily	Twice Daily	In favor of Daily	In favor of Twice Daily
Av. of E.Ex.	5.3	4.6		13.2%
Av. of F.3 P.	3.8	3.2		20 %
Gain % F/I	54.6	61.1		29.7%

LEARNING CURVES FOR PARTS I AND III

SUCCESSIVE PRACTICES

PLATE II

C. Again, comparing Parts II and III and summarizing from A and B we get Tables XI and XII.

In Table XII we have in answer to the first part of our problem a gain of 16 per cent in favor of once a day for the average of the entire experiment, and a gain of 16.6 per cent for the average of the final three practices, while there is a gain of 3 per cent on the final three practices over the initial three for twice a day practices.

In answer to the second part there is 8 per cent in favor of twice daily when considering the average of the entire experiment, 11.1 per cent for the average of the final three periods, and 25.7 per cent for the gain of the final three periods over the initial three periods.

Represented graphically, we get from Tables VII and XIII, Plate III.

TABLE XI.

Daily Group

<u>Part II.</u>	<u>Mayer</u>	<u>Schleef</u>	<u>Berryman</u>	<u>Average</u>
No. of P.	8	8	8	
Av. of E.Ex.	8.3"	7.2"	8.6"	8"
Av. of I.3 P.	11.3	8.7	11.9	10.6
Av. of F.3 P.	5.9	5.8	7.3	6.3
Gain % F/I	47.8	33.3	33.6	39.2

Twice Daily Group

	<u>Lyon</u>	<u>Carney</u>	<u>Norris</u>	<u>Average</u>
No. of P.	8	8	8	
Av. of E.Ex.	6.5"	8.2"	8.2"	7.6"
Av. of I.3 P.	8.2	9.7	9.7	9.2
Av. of F.3 P.	5	6.3	6.8	6
Gain % F/I	39.3	35.4	30	34.9

TABLE XII

Comparison between II and III.

Part II	Daily	Twice Daily	In favor of Daily	In favor of Twice Daily
Av. of E.Ex.	8"	7.6 "		5%
Av. of F.3 P.	6.3	6		4.7 %
Gain % F/I	39.2	34.9	11%	

Part III. (a)	Daily	Twice Daily	In favor of Daily	In favor of Twice Daily
Av. of E.Ex.	5.3"	5.8"	16%	
Av. of F.3 P.	3.8	4.2	16.6%	
Gain % F/I	54.6	49.6		2%

Part III. (b)	Daily	Twice Daily	In favor of Daily	In favor of Twice Daily
Av. of E.Ex.	5.3"	4.6"		8%
Av. of F.3 P.	3.8	3.2		11.1%
Gain % F/I	54.6	61.1		25.7%

TABLE XIII.

Record of Part II.

<u>Daily Group</u>				<u>Twice Daily Group</u>			
<u>Mayer Schleef Berryman Average</u>				<u>Lyon Carney Norris Average</u>			
133	163	148	148	180	146	147	158
167	240	169	192	239	213	217	223
188	238	181	202	251	211	206	223
234	237	204	225	294	195	225	238
246	267	219	244	303	211	222	245
273	276	256	268	309	248	256	271
328	320	240	296	382	276	241	299
330	335	289	318	296	359	315	357

LEARNING CURVES FOR PARTS II AND III

PLATE III

D. By way of still further comparison, Parts I and II may be combined into a check or control experiment by combining the records of the subjects at the end of eight practices in I with the records at the end of eight practices in II. This gives us Table XIV which, when summarized and combined with Part III of Table X, gives us Table XV. From this it will be seen that for the first part of the problem it shows for the average of the entire experiment a gain of 13.7 per cent, for the average of the final three practices a gain of 10.5 per cent for once a day, and 2.8 per cent for the gain per cent of the final three practices over the initial three in favor of twice a day.

In answer to the second part, there is a gain of 9.8 per cent in favor of two periods a day, when the average of the entire experiment is considered, a gain of 15.8 per cent on the average of the last three periods, and a gain of 26.7 per cent gain per cent of the final three periods over the initial three.

Represented graphically from Tables VII and XVI we get curves as shown on Plate IV.

TABLE XIV.

Daily Group

Parts I & II	<u>Schleef</u>			<u>Mayer</u>			<u>Berryman</u>			Av. of Av.
	I	II	Av.	I	II	Av.	I	II	Av.	
Av. of E.Ex.	9.9"	7.2"	8.6"	8.9"	8.3"	8.6"	10.3"	8.6"	9.5"	8.9"
Av. of I.3 P	15.6	8.7	12.2	11.9	11.3	11.6	14.7	11	12.9	12.2
Av. of F.3 P	5.5	5.8	5.7	6	5.9	6	6.7	7.3	7	6.3
Gain % F/I	64.8	33.3	49.1	49.6	47.8	48.7	54.4	33.6	44	47.3

Twice Daily Group

Parts I & II	<u>Carney</u>			<u>Lyon</u>			<u>Norris</u>			Av. of Av.
	I	II	Av.	I	II	Av.	I	II	Av.	
Av. of E.Ex.	8.1"	8.2"	8.2"	9.9"	6.5"	8.2"	10.5"	8.2"	9.4"	8.6"
Av. of I.3 P	10.9	9.7	10.3	12.9	8.2	10.6	14	9.7	11.9	10.9
Av. of F.3 P	5.7	6.3	6	6.6	5	5.8	7.1	6.8	7	6.3
Gain % F/I	47.7	35	41.4	48.8	39.3	44.1	49.3	30	40	41.8

TABLE XV.

Comparison between I & II combined and III.

Parts I & II	Daily	Twice Daily	In favor of Daily	In favor of Twice Daily
Av. of E.Ex.	8.9"	8.6"		3.3%
Av. of F.3 P.	6.2	6.3	1.6%	
Gain % F/I	47.3	41.8	11.6 %	

Part III (a)	Daily	Twice Daily	In favor of Daily	In favor of Twice Daily
Av. of E.Ex.	5.3"	5.8"	13.7%	
Av. of F.3 P.	3.8	4.2	10.5%	
Gain % F/I	54.6	49.6		2.8 %

Part III (b)	Daily	Twice Daily	In favor of Daily	In favor of Twice Daily
Av. of E.Ex.	5.3"	4.6"		9.8%
Av. of F.3 P.	3.8	3.2		15.8%
Gain % F/I	54.6	61.1		26.7 %

TABLE XVI.

Daily Group

Parts I & II

<u>Mayer</u>			<u>Schleef</u>			<u>Berryman</u>			<u>Av. of Av.</u>
<u>I</u>	<u>II</u>	<u>Av</u>	<u>I</u>	<u>II</u>	<u>Av</u>	<u>I</u>	<u>II</u>	<u>Av</u>	
130	133	132	96	163	130	101	148	125	129
154	167	161	110	240	175	113	169	141	160
174	188	181	153	238	196	172	181	177	201
200	234	217	206	237	222	201	204	203	214
229	246	238	254	267	261	205	219	212	234
263	273	268	304	276	290	235	256	246	268
293	328	311	329	320	325	285	240	263	299
343	330	337	360	335	348	294	289	292	326

Twice Daily Group

<u>Lyon</u>			<u>Carney</u>			<u>Norris</u>			<u>Av. of Av.</u>
<u>I</u>	<u>II</u>	<u>Av.</u>	<u>I</u>	<u>II</u>	<u>Av.</u>	<u>I</u>	<u>II</u>	<u>Av.</u>	
156	180	168	182	146	164	121	147	134	155
121	239	180	152	213	183	105	217	161	175
145	251	198	162	211	186	164	206	185	190
155	294	225	226	195	211	160	225	193	210
211	303	257	253	211	232	211	222	217	235
214	309	262	290	248	269	226	256	241	257
288	382	335	311	276	294	260	241	251	293
349	396	373	352	359	356	279	315	297	309

LEARNING CURVES FOR PARTS I AND II COMBINED AND PART III

SUCCESSIVE PRACTICES

PLATE IV

TABLE XVII.

Collecting the results obtained in A,B,C and D from
Tables V, X, XII, XV we get Table XVII.

Parts Compared	On the Basis of	In favor of Daily	In favor of Twice Daily
I & II	Av.of E.Ex.	5.3 %	
I & III	Av.of E.Ex.	9.2 %	
II & III	Av.of E.Ex.	16 %	
I,II & III	Av.of E.Ex.	13.7 %	
I & II	Av.of Final 3 P.	20 %	
I & III	Av.of Final 3 P.	5 %	
II & III	Av.of Final 3 P.	16.6%	
I,II & III	Av.of Final 3 P.	10.5%	
I & II	Gain % F/I	28.9%	
I & III	Gain % F/I	5.3 %	
II & III	Gain % F/I		2 %
I,II & III	Gain % F/I		2.8%

It will thus be seen that in answer to the first part of our problem, If a person has a certain number of practices to put in, is it more profitable to put in one or two practices daily? that comparing the daily groups with the twice a day group in every possible way and from different standpoints, the results when taking the average of the entire experiment and the average of the final three practices, point without an exception to a decided, constant and reliable gain for once a day practices. Taking the gain per cent of the final three practices over the initial three practices, there is a slight gain in two cases for twice a day practice. The gain in both cases is less than the probable error and can hardly be called a gain. Further, this method of calculating the relative value of any data is open to serious objections and is, beyond a doubt, the least reliable of the three ways adopted. According to it, the subject who is slow in getting started or who starts above or below his true ability stands a much better chance to make a higher or lower gain per cent than the one who starts off easily and evenly. In this way the actual results can to a large extent be vitiated, which is not so much the case when following the other methods.

TABLE XVIII.

Parts Compared	On the Basis of	In favor of Daily	In favor of twice daily
I & II	Av. of E.Ex.		21.1%
I & III	Av. of E.Ex.		13.2%
II & III	Av. of E.Ex.		8 %
I, II & III	Av. of E.Ex.		9.8 %
I & II	Av. of Final 3 P.		30.9%
I & III	Av. of Final 3 P.		20 %
II & III	Av. of Final 3 P.		11.1 %
I, II & III	Av. of Final 3 P.		15.8 %
I & II	Gain % F/I		22.7%
I & III	Gain % F/I		29.7%
II & III	Gain % F/I		25.7%
I, II & III	Gain % F/I		26.7%

In answer to the second part of our problem we gather from Table XVIII, which is derived from Tables V,X, XII, and XV, that irrespective of the basis on which we figure, there is a gain for two periods daily.

Generally stated, the results mean that in establishing a habit, if one practices in the forenoon, a second practice in the afternoon gives returns also, but is not quite so valuable, in its effects, as one forenoon practice.

SECTION III.

(b) Second Experiment.

With the intention of checking up the results in the first experiment, a second and more extended experiment was performed.

The results of the first experiment, while fairly definite, left some doubt in our minds as to their validity and finality. There were several chances for errors to creep in. By eliminating the possible sources of error in the second experiment, we have obtained results that seem conclusive.

The errors of the first experiment were in the main:

1. Subjects wrote from different parts of the monograph, causing a varied fluctuation due to the difference in the length of the words.
2. Subjects were informed of their own as well as the records of others, thus some were encouraged while others became discouraged and indifferent.
3. The same method was not pursued in the initial practices of the different Parts; that is, in Parts I and II twenty minutes were devoted to the study of the alphabet, while in Part III the learning of the alphabet and the writing occurred simultaneously.

This may have influenced subsequent practices and progress.

5. The interference caused by the signal at the end of the first and second ten minutes served as added stimulus to some, while others were not affected, or affected negatively.
6. The number of practices, eight, in the control experiment, were not sufficient to give a valid index of the speed and ability of the subjects.

The second experiment was conducted with eight University students acting as subjects and lasted for thirty days. The first fifteen days, one practice daily between eight and nine in the forenoon under identical conditions for all subjects, constituted the control experiment. During the second fifteen days, or experiment proper, the subjects were divided into two groups. These groups were of almost equal ability based on the average speed attained in the control experiment. Both groups practiced daily for fifteen days from eight to nine, Group II putting in a second practice between five and six of the same day.

The subjects in Group I were: Eulalie Church, Junior in Arts and Science; Ruth Rollins, Senior in Arts and Science; Libuse Soukup, Junior in Education; Opal M. Zimmerman, Senior in Education.

In Group II, Mrs. G.S. Gehlbach, Senior in Arts and Science; Lucile Kehr, Senior in Arts and Science; Ruth Miller, Senior in Education; "Bob" Mary Lindsey, Senior in Education.

The method of procedure was to have each subject use alphabet III in the control experiment, Alphabet IV (page 75) in the experiment proper, and copy from a psychological monograph as many words as possible in thirty minutes.

Loose leaf paper and pencils were used. Before the signal for beginning was given all subjects numbered sheets and recorded the name, date, and physical condition on the first sheet.

At the appointed signal they would turn a copy of the alphabet face up and with it before them proceed to copy the monograph, using the arbitrary alphabet. In doing this all started at the same time with the same word and continued uninterruptedly for the entire period.

No daily introspections were taken, the physical condition, general attitude, and progress in learning being obtained from what subjects recorded, by careful and constant investigation, and from an extensive introspection and questioning at the close of the experiment.

The subjects were instructed not to make any comparisons of their daily progress, nor were they to practice or study the writing outside of the time under observation. That the subjects put forth approximately the same effort

ALPHABETS.

III.

a = 0

b = +

c = 9

d =

e = /

f =

g = =

h = i = j = k =

l = 8

m = X

n = o = p = q = r =

s = 7

t =

u = 4

v = >

w = T

x = *

y = 7

z =

IV.

a = b = c = d = e = f =

g = 2

h = i =

j = 5

k =

l = 9

m = n = o =

p = X

q = r =

s = 6

t = u = v = w = x =

y = //

z =

and received the same amount of practice in both control and experiment proper may be inferred from their standing as indicated in Tables V and VI. With the exception of one change in their relative standing when ranked according to average speed for the entire experiment, the subjects all retained the ranking in the experiment proper that they had attained in the control experiment. This change can readily be explained when we know that G, who dropped from the first to second place, had a bad cold and several severe nervous shocks during the experiment proper.

The physical condition of all the subjects, aside from what has been referred to above, was of the very best; cases of indisposition were few, and of such a nature as not to materially change the results.

The general attitude of the subjects, without an exception, was one of interest and pleasure in and toward the work; one might say, very nearly the same that would have existed when working at some other task; thus results are fairly representative of the subjects' actual learning ability.

The results obtained in the control experiment are given in full in Tables I and II. Table I represents the successive daily records of the group which constituted the once a day group in the experiment proper, Table II, that of the twice a day group. Tables III and IV represent the

work of the once and the twice a day groups respectively, in the experiment proper.

These Tables show that all subjects worked fifteen days in each experiment, with the exception of the subject R., who in both instances put in thirteen days under the same conditions and with the group to which she belonged.

TABLE I.

Daily Records of Daily Group in Control Experiment.

Subjects.

<u>Practice</u>	<u>Church</u>	<u>Rollins</u>	<u>Soukup</u>	<u>Zimmerman</u>	<u>Average</u>
1	137	123	100	70	107
2	200	125	136	119	145
3	246	155	176	152	182
4	258	173	215	202	212
5	293	213	267	245	254
6	256	240	332	300	307
7	315	226	312	285	284
8	358	255	350	289	313
9	380	336	428	338	370
10	400	335	444	350	382
11	460	357	479	370	416
12	462	400	484	395	435
13	493	382	521	428	456
14	505		517	428	483
15	530		531	449	503

TABLE II.

Daily Record of Twice a Day Group in Control Experiment.

<u>Subjects.</u>					
<u>Practice</u>	<u>Gehlbach</u>	<u>Kehr</u>	<u>Miller</u>	<u>Lindsey</u>	<u>Average</u>
1	125	115	96	68	101
2	196	166	127	130	155
3	237	208	137	167	187
4	247	239	171	198	214
5	280	261	215	251	252
6	344	304	272	274	298
7	298	298	251	267	278
8	368	355	308	303	333
9	416	400	356	365	384
10	419	385	357	358	380
11	416	418	370	372	394
12	408	419	400	408	409
13	490	477	416	434	454
14	492	482	460	465	475
15	515	495	468	435	478

TABLE III.

Daily Record of Once a Day Group in Experiment Proper

Subjects.

<u>Practice</u>	<u>Church</u>	<u>Rollins</u>	<u>Soukup</u>	<u>Zimmerman</u>	<u>Average</u>
1	197	146	191	145	170
2	230	211	212	184	209
3	251	215	240	224	232
4	307	234	285	247	268
5	334	265	319	289	302
6	300	237	309	275	380
7	373	289	390	343	349
8	375	321	389	329	353
9	400	308	432	375	379
10	457	370	458	418	426
11	393	354	412	363	380
12	433	362	423	393	403
13	445	380	470	422	429
14	468		471	450	463
15	491		475	458	475

TABLE IV.

Daily Record of Twice a Day Group in Experiment Proper.

Subjects

<u>Practice</u>	<u>Gehlbach</u>	<u>Kehr</u>	<u>Miller</u>	<u>Lindsey</u>	<u>Average</u>
1	161	169	158	125	153
2	165	185	167	167	171
3	218	232	208	206	216
4	261	234	245	252	248
5	250	235	251	231	242
6	271	258	271	263	266
7	296	293	280	280	287
8	322	287	315	328	313
9	361	333	346	344	346
10	319	318	313	340	322
11	291	310	300	294	300
12	361	371	364	372	367
13	399	397	386	364	386
14	392	380	380	378	382
15	391	426	373	365	389

The calculations applied to this data are: What is the gain per cent of one group over the other from the standpoint of:

1. Average speed of the entire experiment as expressed in seconds per words
2. Average speed for the final three practices
3. Gain per cent of the final three practices over the initial three practices.

Both groups had close to the same ability in the control experiment, as will be seen by referring to Table V and Plate I. The difference due to the alphabets and the slight difference in ability was equated in later calculations by applying the ratio found in the control experiment to the data obtained in the experiment proper.

Tables V and VI were obtained by first finding the daily speed of each subject in seconds per words, that is, dividing the total number of seconds in a practice by the number of words written. The average of these daily records for the entire number of practices gives the average of the entire experiment; in like manner the average of the three initial and the average of the three final practices was found. The gain per cent of the final three practices over the initial three was obtained by finding what per cent the actual improvement was of the initial three practices.

TABLE V.

Control Experiment.

<u>Group I.</u>	<u>Church</u>	<u>Rollins</u>	<u>Soukup</u>	<u>Zimmerman</u>	<u>Average</u>
No. of Per.	15	13	15	15	
Av. of E.Ex.	5.75"	8.23"	6.59"	7.99"	7.14"
Av. of I.3 P.	9.84	13.54	13.46	17.55	13.59
Av. of F.3 P.	3.54	4.75	3.44	4.14	3.98
Gain % F/I	64	64.9	74.4	76.4	69.9

<u>Group II.</u>	<u>Gehlbach</u>	<u>Kehr</u>	<u>Miller</u>	<u>Lindsey</u>	<u>Average</u>
No. of Per.	15	15	15	15	
Av. of E.Ex.	5.94"	6.37"	7.74"	7.8"	6.96"
Av. of I.3 P.	10.38	11.71	15.35	17.02	13.61
Av. of F.3 P.	3.61	3.72	4.03	4.05	3.85
Gain % F/I	65.2	68.2	73.7	76.2	70.8

TABLE VI.

Experiment Proper.

<u>Group I.</u>	<u>Church</u>	<u>Rollins</u>	<u>Soukup</u>	<u>Zimmerman</u>	<u>Average</u>
No. of Per.	15	13	15	15	
Av. of E.Ex.	5.31"	6.81"	5.37"	6.12"	5.90"
Av. of I.3 P.	8.04	9.74	8.47	10.08	9.08
Av. of F.3 P.	3.85	4.86	3.81	4.07	4.17
Gain % F/I	52.1	50	55.1	59.6	54.2

<u>Group II.</u>	<u>Gehlbach</u>	<u>Kehr</u>	<u>Miller</u>	<u>Lindsey</u>	<u>Average</u>
No. of Per.	15	15	15	15	
Av. of E.Ex.	6.55"	8.53"	6.69"	6.91"	6.67"
Av. of I.3 P.	10.11	9.33	10.29	11.31	10.26
Av. of F.3 P.	4.57	4.5	4.75	4.88	4.67
Gain % F/I	54.7	51.8	53.8	56.8	54.2

Summarizing Tables V and VI we obtain comparisons and results as given in Table VII.

TABLE VII.

Control Experiment				
	Daily	Group.Twice Daily	In favor of Daily	In favor of Twice Daily
Av.of E.Ex.	7.14"	6.96"		2.5 %
Av.F.3 P.	3.98	3.85		3.2 %
Gain % F/I	69.9	70.8		1 %

Experiment Proper				
	Daily	Group. Twice Daily	In favor of Daily	In favor of Twice Daily
Av. of E.Ex.	5.90"	6.67"	16 %	
Av.F. 3 P.	4.17	4.67	15.9 %	
Gain % F/I	54.2	54.2	1 %	

From Table VII it will be seen that in the control experiment the twice a day group was in every instance a trifle better than the once a day group. In the experiment proper we have results as indicated. If we now apply the ratio maintained in the control experiment to these figures we get results as follows:

1. Average of the entire experiment, 16% in favor of once a day practice.
2. Average of the final 3 periods, 15.9% in favor of once a day practice.
3. Gain per cent initial over final practices, 1 % in favor of once a day practice.

Represented by a graph we get curves as given on Plate I. In this plate the number of words written in one period are represented on the vertical axis, the successive practices on the horizontal axis. The black line represents the daily group, the green line, the twice a day.

SUCCESSIVE PRACTICES

PLATE I

Turning now to a consideration of the second part of the problem, and considering C. and Z. who worked once daily for fifteen days and G. and M. who put in two periods for the same length of time, we find results as follows:

Table VIII gives the records of C. and Z. of Group I, and of G. and M. of Group II in the control experiment. Table IX gives us their record in the experiment proper.

From these tables we obtain Table X, when we apply the same calculations to them that have been applied to other similar data.

Summing up Table X we get Table XI, from which it will be seen that no matter whether we take average of the entire experiment, average of the final three periods, or gain per cent of the final three periods over the initial three periods, there is in every instance, a gain in favor of putting in two periods a day.

By referring to Table X and the curves on Plate II we see that the groups were practically equal in the control experiment, thus the divergence of the curve of the experiment proper shows what gain may be expected from putting in a second period daily.

TABLE VIII.

Control Experiment.

<u>Church</u>	<u>Daily Group</u>		<u>Twice Daily Group</u>		
	<u>Zimmerman</u>	<u>Average</u>	<u>Gehlbach</u>	<u>Miller</u>	<u>Average</u>
137	70	104	125	96	111
200	119	160	196	127	162
246	152	199	237	137	187
258	202	230	247	171	209
293	245	269	280	215	248
356	300	328	344	272	308
315	285	300	298	251	275
358	289	323	368	308	338
380	338	359	416	356	386
400	350	375	419	357	388
460	370	415	416	370	393
462	395	429	408	400	404
493	428	466	490	416	453
505	428	467	492	460	476
505	449	477	515	468	492

TABLE IX.

Experiment Proper.

	<u>Church</u>	<u>Daily</u>		<u>Twice Daily</u>		<u>Average</u>
		<u>Zimmerman</u>	<u>Average</u>	<u>Gehlbach</u>	<u>Miller</u>	
A.M.	197	145	171	161	158	159
P.M.				165	167	166
A.M.	230	184	207	218	208	213
P.M.				261	245	253
A.M.	251	224	237	250	251	251
P.M.				271	271	271
A.M.	307	247	277	296	280	288
P.M.				322	315	318
A.M.	334	289	311	361	346	353
P.M.				319	313	316
A.M.	300	275	287	291	300	295
P.M.				361	364	363
A.M.	373	343	353	399	386	392
P.M.				392	380	386
A.M.	375	329	352	391	373	382
P.M.				448	416	432
A.M.	400	375	387	430	420	425
P.M.				434	392	414
A.M.	457	418	437	498	485	442
P.M.				451	445	448
A.M.	393	363	378	428	425	426
P.M.				495	394	444
A.M.	433	393	413	462	452	457
P.M.				456	435	445
A.M.	445	422	433	463	475	469
P.M.				447	456	451
A.M.	468	450	459	493	478	485
P.M.				480	460	470
A.M.	491	458	474	501	487	494
P.M.				452	445	495

TABLE X.

Control Experiment.

<u>Subjects</u>	<u>Church</u>	<u>Zimmerman</u>	<u>Av.D.</u>	<u>Gehlbach</u>	<u>Miller</u>	<u>Av.T.D.</u>
Av. of E.Ex.	5.75"	7.99"	6.87"	5.94"	7.74"	6.84"
Av. I.3 P.	9.84	17.55	13.69	10.38	15.35	12.86
Av. F.3 P.	3.54	4.14	3.84	3.61	4.03	3.82
Gain % F/I	64	76.4	70.2	65.2	73.7	69.4

Experiment Proper

Av. of E.Ex.	5.31"	6.12"	5.71"	5.23"	5.38"	5.31"
Av. I.3 P.	8.04	10.08	9.06	10.11	10.29	10.20
Av. F.3 P.	3.85	4.07	3.96	3.78	3.93	3.85
Gain % F/I	52.1	59.6	55.8	62.6	61.8	62.2

TABLE XI.

Control Experiment.

	<u>Daily Group</u>	<u>Twice Daily</u>	<u>In favor of Daily</u>	<u>In favor of Twice Daily</u>
Av. of E.Ex.	6.87"	6.84"		.4 %
Av. F.3 P.	3.84	3.82		.5 %
Gain % F/I	70.2	69.4	1.1%	

Experiment Proper

Av. of E.Ex.	5.71"	5.31"	6.5%
Av. F.3 P.	3.96	3.85	2.3%
Gain % F/I	55.8	62.2	13 %

Applying the ratio existing in the control experiment to the data of the experiment proper we have the following results:

Average of the entire experiment 6.5% in favor of two periods daily, i.e. the average speed of the twice a day group is 6.5% better than it would have been had they worked only once a day.

Average final 3 periods, 2.3% in favor of two periods daily. Gain per cent of final three over the initial three periods is 13% in favor of two periods daily.

Represented by a graph we have curves as indicated on Plate II. The lower black line contrasted with the green line is the standing of the two groups in the first part of our problem; the upper green line contrasted with the black line is the standing of the groups in the second part.

SUCCESSIVE PRACTICES

PLATE II

SUMMARY - CONCLUSIONS.

The experiments besides verifying many of the results of experimenters recorded in Section I, revealed

- (1) That individual differences as concerns ability to work forenoon or afternoon vary and seem to be special traits either inherent or due to habit; the general rule is, that afternoon practices are not as good as forenoon, however, in the case of a number of subjects the forenoon practices seemed more fatiguing and did not give as high a speed as the afternoon practices. The most striking case was subject S. of the first experiment. The record made by her does not show that afternoon practices at all times gave most improvement, but it does show that for all the days on which two practices were put in the average number of words written in a period in the forenoon was 345 as against 357 in the afternoon. Subject C of about the same ability wrote on the same days and under identical conditions an average of 321 words in the forenoon and 318 in the afternoon.

Further subject S.'s introspections tell us that in order to maintain previously established records a great effort had to be put forth in the forenoon practices which was not the case in the afternoon.

- (2) That bodily fatigue accompanies the mental fatigue felt at the close of a period of intensive work. This feeling

does not necessarily indicate that the record for that day is greater or less than the day before, the subject's judgment on this point is not a safe criterion, more frequently he has done just the opposite in the period to what he reports as his opinion. The explanation of this may be that a subject's judgment of his accomplishment may be based on the strain of the performance which would seem to be more when the subject is fatigued or working under unfavorable conditions.

- (3) Warming up is an important factor in any practice. During the first experiment three successive ten minute records were obtained and for every subject the greatest speed was attained in the last ten minutes. Several subjects made slower records the second ten minutes than the first, probably due to fatigue which was offset by additional or special effort during the last ten minutes. An interesting point in connection with the practices was that when subjects felt fatigued at the start, the fatigue disappeared after a short practice, no sign of it reappearing later. From this, one might infer that when there is apparent fatigue neither rest nor physical exercise is necessary, but an intensive mental application will do just as well.

Restating and summarizing the results of the two experiments when considering the most economical way in

which a person can apply a certain number of practices, we may say that to crowd them in at the rate of two per day falls short of yielding the same results obtained when extending the practices over twice as long a time by from 8% to 15% depending upon whether we use average speed, final speed or gain per cent of final speed over initial speed.

Whether we consider the average speed of the entire experiment or merely the final speed attained we find in both the first and second experiment that we fall short of attaining the same efficiency by 15% when considering the same number of periods, if we put in two practices a day as against one practice daily.

On the other hand, if we have a number of days to devote to new subject matter or learning a new process and we wish to accomplish the most possible, the gain derived from applying ourselves twice daily is less than 10%.

Now as to whether it is more satisfactory to put in two practices daily than to extend the time over twice as many days and in the former case be 15% less efficient is another matter. Doubling up on the practices may at times and under certain conditions seem desirable, but the fact that a person practicing twice daily is 15% less efficient than one practicing once daily for the same number of practices when learning an entirely new set of associations as

was done in connection with this study, seems to indicate that for such material at least, two practices daily, should not be undertaken, unless, of course, one is willing to sacrifice economy in order to reduce the number of days' practice.

The plan of attempting a certain amount of work within a certain limit of time by making the recitation periods longer and in grades more frequent as well as longer is unquestionably not the most economical procedure.

With all that can be said in favor of our graded system it is nevertheless true that the multiplying and lengthening of periods in order to cover the work outlined for that grade does not contribute toward making the work thorough and beneficial. Perhaps the value of shorter periods extended over a longer time explains in part why the rural eighth grade graduate is so often superior to the boy or girl of the same grade in the city.

It seems to us that it would be immeasurably better to adopt a system of shorter periods extended over a longer term in order to cover the work now attempted in a school year. The best length of period for adults is thirty minutes, for children less and hence the best plan would be daily application, - perhaps even less, - with periods not to exceed thirty minutes and these repeated for a longer time than present day arrangements permit.

The matter of two practices daily when devoting a number of days to a task reveals a gain of less than 10%, barely sufficient to justify a person in putting in twice as much time.

Restating the whole problem and applying it in a concrete illustration let us suppose that we were learning to write, to play the piano or attempting the mastery of a language, and had a given number of hours to devote to the task. We could spend two hours daily on the matter in hand and get through in half the time it would take when applying ourselves once daily, but we would find ourselves 15% less efficient than if we had worked only once a day for twice the number of days.

Again students in various schools and subjects, - particularly in summer schools find themselves obliged to complete a course in half the time usually given to it. This necessitates a double application with the results that instead of getting as much of the subject and as thoroughly as they ought to, they get 10% more than half the results they would have obtained in regular session.

In conclusion we may say in answer to the problem of this treatise that having a certain number of applications to put in on a task, on a subject or on the acquiring of a habit it is better by 15% to practice once a day and, having a number of days to give to the same problems we can improve

10% more by practicing twice daily than by making one application. Our inferences are valid, however, only in so far as the processes of habit-formation are the same in the subjects mentioned as they were in our experiments. A comparison of habit formation in different subjects, we leave for future experimenters.

SUPPLEMENTARY SECTION.

A. One versus two practices daily for later reproduction and use.

The value of once a day and twice a day practices has been recorded in Sections II and III, and show an advantage for one practice daily; the value of two periods a day indicate insufficient returns when we consider that twice the time was given to the matter in hand.

What is the permanent effect of two periods daily as compared with one, for later reproduction and use? Was a question arising in connection with our main problem.

Attempting to get an answer to this question we had subjects C and S of the daily group in the second experiment and G and M of the twice a day group of the same experiment, return after an interval of fifteen days and put in one period daily for five days, on the same material and under the same conditions previously maintained.

By referring to the records of the subjects of both groups as given in Table I of this section we see that taking the average of the entire experiment, average of the final three periods and the final practice, the twice a day group is on the average not quite as good as the once a day in the control experiment, but practically of the same ability in the experiment proper.

Table II gives us the record of the number of words written and seconds required to write a word in each of the five periods, after the intermission.

Considering now the records as given in Table II we see that the once a day subjects started with greater speed than the twice a day subjects and for each succeeding day maintained a greater average speed.

TABLE I.

Control Experiment.

	<u>Daily Group</u>			<u>Twice Daily Group</u>		
	<u>Church</u>	<u>Soukup</u>	<u>Ave.</u>	<u>Gehlbach</u>	<u>Miller</u>	<u>Ave.</u>
Av. of E.Ex.	5.75"	6.59"	6.17"	5.94"	7.74"	6.84"
Final 3 P.	3.54	3.44	3.49	3.61	4.03	3.82
Final P.	3.39	3.39	3.39	3.49	3.85	3.67

Experiment Proper.

	<u>Church</u>	<u>Soukup</u>	<u>Ave.</u>	<u>Gehlbach</u>	<u>Miller</u>	<u>Ave.</u>
Av. of E.Ex.	5.31"	5.37"	5.34"	5.23"	5.38"	5.31"
Final 3 P.	3.85	3.81	3.83	3.78	3.93	3.86
Final P.	3.66	3.80	3.73	4.00	4.04	4.02

TABLE II.

Records after the intermission.

Daily Group

<u>Days</u>	<u>Church</u>	<u>Soukup</u>	<u>Average</u>	<u>Church</u>	<u>Soukup</u>	<u>Average</u>
1	461 W.	464 W.	463 W.	3.90"	3.88"	3.89"
2	468	472	470	3.85	3.82	3.84
3	487	513	500	3.70	3.51	3.61
4	558	561	560	3.23	3.22	3.23
5	535	540	538	3.37	3.34	3.36

Twice Daily Group

<u>Days</u>	<u>Gehlbach</u>	<u>Miller</u>	<u>Average</u>	<u>Gehlbach</u>	<u>Miller</u>	<u>Average</u>
1	421 W.	425 W.	423 W.	4.28"	4.24"	4.26"
2	457	443	450	3.93	4.06	4.00
3	500	465	483	3.60	3.72	3.66
4	503	518	511	3.58	3.47	3.53
5	500	515	508	3.60	3.49	3.50

Note:

In this Table the average of the number of words stands for the number of words written in a period; the average of the number of seconds, for the average number of seconds required to write one word.

It would seem, according to these figures, that those subjects practicing once a day were not only the equal of those who had put in twice as many periods, but that they started at a higher rate and were able to keep up a rate such as would indicate that the twice a day subjects had not been greatly benefited.

It is true that the twice a day subjects made a greater gain than the once a day subjects when we consider the first and fifth days record, yet there is no indication that they would have overtaken and surpassed the once a day subjects by virtue of the fact that they have previously put in twice as many periods.

B. Concentrated Practices

Two experiments were performed to determine what efficiency and progress one could attain in one day by putting in a great number of half hour practices with half hour intervals.

The first experiment was learning an alphabet and writing as had been done in previous experiments; the second was learning to typewrite.

(1) In the first experiment one subject worked four periods, the rest 10, 12, and 13 periods.

A check experiment previously given showed that the subjects were of about the same ability.

By way of testing the effect of this day's practice for later reproduction and use, all subjects worked thirty minutes on the second and third day following the all-day test.

Table III gives the record in numbers of words written during successive periods, (a) for the all-day test, (b) for the two practices on the second and third day following.

From this table for the concentrated practices for the different subjects we get curves as given on Plate I. Representing the standing of the subjects at their highest in the all-day practice in (a) of Table III and the record as attained in (b) of Table III we get Plate II.

A far more striking comparison of the value of concentrated and distributed practices is shown in Plate III. In this figure the lower curve represents fourteen practices put in, in one day by Dr. Pyle, the upper fourteen practices in as many days by subject S who was of about the same learning capacity.

In the light of these data it seems we are warranted in saying that after the third or fourth practice, further practice on that day is not profitable. It does not seem that much greater speed can be attained nor do the added practices make a person more proficient in practices after an intermission.

TABLE III.

(a)	<u>Subjects</u>			
Practices	Carney	Schleef	Pyle	Roth
1	111	75	67	82
2	187	187	144	137
3	224	204	200	171
4	229	241	206	188
5		219	197	188
6		257	216	228
7		234	224	230
8		202	219	201
9		209	232	223
10		214	243	234
11			240	240
12			149	244
13				166
14				
(b)	285	325	297	301
	336	348	332	308

CONCENTRATED PRACTICES

SUCCESSIVE PRACTICES

PLATE I

PLATE II

2. In the second experiment six subjects started to learn typewriting. Four subjects put in ten practices each in one day, practicing one half hour then resting a half hour, two put in one practice daily for ten days.

After fifteen days, dating from the day on which the ten practices were taken in the first case and from the last of the ten practices in the second case, the subjects came back and took one more practice.

The records of the groups doing the concentrated practices and those distributing them are given in Table IV. Part (a) gives the successive practices of each subject and the average of the group, part (b) is the record made upon returning after an interval of fifteen days. Considering the first two practices as index of the learning ability of the subjects and comparing the last two practices of the concentrated practice group with that of the distributed practice group there is a gain of 26.4% in favor of distributed practices, but if we compare successive practices or highest speed attained in any practice there seems to be little difference, with the exception that the concentrated group falls off in the last practices while the distributed group continues to gain. This is probably due to the fact that in typewriting where the subject comes in contact with a great number of habits of manipulation, concentrated practices are just as good as distributed ones when only

a small number of practices are considered. The subject reaches a level or plateau in from five to seven practices from which he can rise only after a great number of applications.

TABLE IV.

<u>Concentrated Practices</u>					<u>Distributed Practices</u>			
(a)	<u>Subjects</u>							
No. of	P. Gehlbach	Miller	Norris	Lyon	Ave	Tucker	Ross	Ave
1	124	112	124	82	111	104	97	101
2	216	227	230	203	219	157	157	157
3	230	259	257	244	247	215	177	196
4	250	257	235	268	252	220	218	219
5	266	266	270	273	269	227	198	213
6	230	267	239	255	248	236	236	236
7	279	276	289	296	285	278	240	259
8	298	284	271	282	284	266	263	265
9	252	272	280	290	273	261	265	263
10	284	282	270	278	278	298	270	284
(b)	252	295	255	270	268	260	250	255

Referring to Table IV, part (b) it will be seen that the value of concentrated practices as compared with distributed practices when considering learning to type-write is about equal in a small number of practices.

The subjects, after the intermission, do not show that distributed practices were more beneficial, which leads us to restate that both the concentrated and the distributed group reach a level from which neither can advance until more practices have been taken.

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