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THE RELATION OF LENGTH OF MATERIAL TO TIME TAKEN FOR LEARNING

and

THE OPTIMUM DISTRIBUTION OF TIME.

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PART I.

The primary object of this paper is to report the results of a somewhat elaborate series of experiments undertaken to determine the relation of *length* of material to *time* taken for learning. The materials used were nonsense syllables, digits, prose and poetry. In view of the fact that these materials were memorized by two methods, viz.,— by what we shall call the "continuous" method and the "once-per-day" method, opportunity was given to compare these two methods both as to economy[1] and durability of impression,[2] and in view of the fact that other distributions[3] of time were later used in another set of experiments, it was felt that the sum total of the results obtained on *The Optimum Distribution of Time* were sufficient to warrant putting this down as part of the title.

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Were one undertaking a really thorough investigation of the problem of the relation of length of material to time taken for learning, it is obvious that for each and every "length," various distributions of the study periods should be tried— i. e., not only should each prose passage, set of digits, and what

[1] i. e., total time taken.
[2] i. e., retentiveness.
[3] e. g., twice per week, once per week, etc.

not, be memorized by the "continuous" method,[4] but it should be memorized by reading twice a day, once a day, once a week, etc. Such a procedure would, of course, give us what I have termed above as "The Optimum Distribution of Time." By also varying the methods of presentation, e. g.,—reading the material to the subject, letting him read it, etc., etc.,—we would but add another contribution to the more general problem of *The Most Economical Method of Learning.* Tho this problem will be discussed more in detail later on[5] in this paper, it will not be amiss to say a few words on it here.

Of the many factors[6] that must be considered in the problem of Economical Learning only three concern us at present—(1) the length of practice periods, i. e., how long should we study at each period? (2) Frequency of practice periods,—i. e., how often should we study? (3) Method or manner of practice,—i. e., how should we study?

Supposing now, that each of these three questions be decided for—say memorizing a passage of prose, it does not necessarily follow that the same procedure should be adopted for digits. Still less does it follow that it would necessarily be the best procedure for learning a language or learning to typewrite. *Individual experiments must be conducted for each and every material.* The results of many experiments have now proven to us that the so called "natural" or "psy-

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[4] i. e., in one sitting.

[5] Part III of this article. JOURNAL OF EDUCATIONAL PSYCHOLOGY, March, 1914.

[6] e. g., intensity of sound, when material was presented aurally; color, when presented visually, etc., etc. These and many other such factors would have to be considered in any investigation of the most economical method of learning, if the investigation were a thorough one.

Another factor that would have to be borne in mind is that after a certain time a physiological limit is reached, beyond which further practice increases neither the speed nor the accuracy.

Most important of all, however, is the fact that what is most "economical" for one individual is not necessarily the most economical for another. Again, certain factors count more with some individuals than with others, e. g., it has been shown (Cohn. Zeit. f. Psych. Vol. XV.) that in "silent" reading, the inhibition of all articulation made a much greater difference with some individuals than with others.

Aside from *attention* it should be remembered that *interest*, or *attitude of mind*, for want of a better term, plays a considerable part. It was shown by Witasek (Zeit. f. Psych. 1907, XLIV) that active recitations of the material being memorized were far superior to the more passive readings of the material. Witasek found that long before a list could be recited perfectly, it was possible to recite portions of it, and he found that when the subject *relies upon his memory* in attempting the reproduction, (only being prompted when he hesitated) the list was learned in fewer repetitions.

chological'' method[7] of learning a language is not the most economical. It has been shown that such associations do not develop in truly natural learning—and, that any attempt to force these foreign associations into the subject's mind, retards, rather than hastens, his progress. Here, as with learning to telegraph, the natural and most enocomical method is to allow the ''habits'' to grow and develop together.

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We shall now consider, but first from an historical point of view, the problem that it is the main object of this paper to present, namely, the *relation between amount to be learned and time taken for learning.* I say *''time taken''* instead of *number of repetitions* (which at first thought would seem the better comparison) for the reason that we shall later compare the *total time* taken by the ''once-per-day'' method with the total time taken by the ''continuous'' method.

This problem is one that has received but little attention from the experimental psychologist. The first in the field is Dr. Hermann Ebbinghaus. Ebbinghaus[8] found that after one reading he could repeat 7 syllables: 12 syllables took 16.6 readings; 16 syllables, 30 readings, etc. The following table expresses his results in tabulated form—with certain additions of my own made for purposes of comparison that will be discussed later.

TABLE A.

Number of syllables	Number of repetitions	Difference in repetitions[10]	Time for one reading[9]	Total time[9]
7	1	..	3.5 sec.	3.5 sec.
12	17	16	24. "	102. "
16	30	13	32. "	240. "
24	44	14	48. "	528. "
36	55	11	72. "	990. "

[7]This method is that of first thoroughly learning the various letters, then combining the letters into syllables, then combining the syllables into words, then combining the words into sentences and finally combining sentences into the desired thought.

[8]*Uber das Gedächtnis.* Translation by Ruger & Busenius, p. 47.

[9]Figured at the rate of 2 syllables per second. This was not Ebbinghaus's actual rate but it is near enough for purposes of comparison with my own rate of 2 syllables per second.

[10]i. e., the increase in repetitions over that that was needed for the preceding set of syllables.

It will be seen that the number of repetitions increases at first with great rapidity, but that later the increase becomes less and less—the increase in repetitions being relatively much greater than the increase in the number of syllables.

Binet[11] found a similar tendency. He found that 11 digits could be reproduced after 4 seconds of study; 13 took 38 seconds; while 14 took 75 seconds. Binet and Henri[12] working together obtained the following:

TABLE B.

Number of Digits	Number of Seconds
10	17
15	75
20	135
25	180
30	260
50	420
100	1500
200	4520

Offner[13] in attempting to explain such a result as the above said that it was possible that the greater the number of members in a series,—the less the attention paid to each member. This, however, would assume that each and every series demanded, and always received, a certain definite amount of attention, which would mean that the greater the number of digits, syllables or what-not in a series, the less attention each digit or syllable would receive. Offner also suggested, as a partial explanation of the relative increase in time needed for the longer series, the fact that in a *long* series the act of forgetting has been in operation longer than in a *short* series—since it takes longer to read: hence, the greater number of repetitions required. Myers sought to explain these results on the grounds that the longer series fatigued more and that the individual members received, therefore, relatively less attention. This is somewhat similar to Offner's explanation and contains undoubtedly a considerable element of truth. It is doubtful, however, if the decrease in attention is proportionate. Ebbinghaus sought to explain his results by the narrowness of the span of consciousness and in retroactive inhibition.

[11] *Psychologie des grands calculateurs*, 1894.
[12] BINET & HENRI. *La Mémoire des Mots.* L'Année Psychol. I, 1895.
[13] OFFNER. *Das Gedachtnis.* Berlin, 1909.

Although Ebbinghaus distinctly states in his preface: "The tests were all made upon myself and have primarily only individual significance"[14]—yet his "curve of forgetting" that developed from his experiments with nonsense syllables has given us what is sometimes known as *Ebbinghaus's law.* Strange to say, however, no systematic inquiry has, until recently,[15] been made to test the validity of this "law." Not only are his results quoted in nearly all the works on psychology—but conclusions, supposed to be of educational significance are drawn from them. It should also be borne in mind that on this subject Ebbinghaus's experiments were few in number. His data for 24 syllables are based on but 3 experiments; those for 36 syllables on only two.

Both Radosavljevich and Meumann noted that the change from 8 to 12, or 12 to 16 syllables, did not demand a very great increase in the number of repetitions. In fact, frequently 16 syllables were memorized with fewer repetitions than 8 or 12 syllables. The following tables (C to I inclusive) give the results obtained by various investigators of this problem of the number of repetitions required to memorize varying numbers of nonsense syllables. Excepting Table G, each table is for one, and only one, subject. As may be noted, the individual differences are marked. The "difference" column is meant to show the relative increase, or decrease in the number of repetitions. It will be noted that with Ebbinghaus the increase is always considerable, e. g., 24 syllables take 44 repetitions, whereas 36 take 55—an increase of 11. With the same series of syllables, Meumann's increase is only 3.

It will be noted that some of these results are very different from those obtained by Ebbinghaus, for while with Ebbinghaus there is a relative increase in the number of repetitions with increase in number of syllables, with Meumann there is a relative decrease in number of repetitions with an increase

[14] *Uber das Gedächtnis*—translation by Ruger & Busenius. Ruger and Bussenius evidently feel that the point in question is of considerable importance. In their "translator's" introduction they say that in spite of "the fact that his experiments were performed only on himself and that the numercial results obtained are consequently limited in significance," Ebbinghaus . . . . . etc.

[15] The first serious inquiry into the matter was made by V. A. C. Henmon. The results of his work were read before the A. A. A. S. at the 1911 Washington meeting.

TABLES C to I.

	TABLE C. Meumann[1]			TABLE D. Ebbinghaus[2]			TABLE E. Henmon[3]			TABLE F. Henmon[4]			TABLE G. D O. Lyon[5]			TABLE H. D. O. Lyon[6]			TABLE I. D O. Lyon[7]		
	No. of Syll.	Rep.	Diff.[8]	No. of Syll.	Rep.	Diff.[8]	No. of Syll.	Rep.	Diff.[8]	No of Syll.	Rep.	Diff.[8]	No of Syll.	Rep.	Diff.[8]	No. of Syll.	Rep.	Diff.[8]	No. of Syll.	Rep.	Diff.[8]
8	8	5		7	1											8	5		8	4	
10			2			9	10	7		10	13		10	144				30			26
12	12	10	3	12	17	7	12	8	1	12	14	1				12	69	34	12	60	30
14			3			7	14	8	0	14	15	1						7			3
16	16	17	4	16	30	6	16	9	1	16	15	0				16	83	7	16	67	4
18	18	21	4			5	18	11	2	18	16	1						3			3
20			4			3	20	14	3	20	19	3	20	138				3			3
24	24	30	6	24	44	6	24	13	—1	24	16	—3				24	94	5	24	80	7
30			1			4	30	20	6	30	26	4						5			16
32			1			2										32	103	4	32	105	9
36	36	33	1	36	55	5												5			0
40													40	174				5			1
48																48	120	7	48	107	1
72																72	306	186	72	230	120

[1], [2], [3]Experimenter using himself as subject.—Average of several trials.

[4]Average of 3 experiments on one subject.

[5]Average of one experiment on 14 subjects. Approximate only, being figured (at rate of 2 syllables per second) from the total times given in Table O.

[6]Average of two experiments on one subject, not the experimenter.

[7]Approximate only—being computed (at the rate of 2 syllables per second) from the total time given under *"continuous method"* on Plate 1.

[8]i. e.—The increase in repetitions over that which was needed for the preceding set of syllables. In order to make the various "Difference" columns uniform—i. e.—comparable—the probable amounts for each number in Column 1 of Table C—have been inserted.

in the number of syllables. "Meumann holds" says Henmon[16] "that this is what might be expected. An increase in amount of work to be done, if it is not too great, makes little difference when once the initial disinclination or inertia is overcome, when adaptation of attention is secured, when the associative processes have been aroused, and a general adjustment to the work is once attained. All of these formal conditions of learning should be effective for series no matter what their length within the limits of fatigue. Hence, it is reasonable to expect a relative decrease in energy required for learning with an increase in amount to be learned."

The results of Henmon's experiments with nonsense syllables that concern us here are shown in tables E and F in conjunction with those of Ebbinghaus and Meumann. His results differ widely from those of Ebbinghaus and Binet but are in fairly close accord with those of Meumann and Radosavljevich. There is a relative decrease in the number of repetitions as the number of syllables increases. Particularly noteworthy is the fact that the number or repetitions for the series from 10 to 18 is practically constant. The results are even more striking than those of Meumann in showing the relative economy with the longer series.

In investigating the relation of *amount to be learned* to *repetition,* Henmon also made a departure from his predecessors by using meaningful material. His results on three subjects in memorizing 1, 2, 3, 4, and 5 stanzas of *In Memoriam* by the "whole" method is given below:

TABLE J.

		Number of Repetitions for:—		
Stanzas	Words	H (10)	D (10)	P (5)[17]
1	28	3	3	4
2	56	5	6	7
3	84	6	9	10
4	112	7	11	12
5	140	9	14	14

The results of my own experiments with poetry are given in Table K. Only two subjects were used. The stanzas aver-

[16]Op. cit.

[17]The figures in parentheses indicate the number of experiments from which the averages were made.

aged 25 words each and were of the same type as *The Ancient Mariner*. Table L gives my own individual results (as taken from Plate 3) and is placed here merely for purposes of comparison.

TABLE K.

Stanzas	Words	Number of Repetitions for:— G (6)	M (6)
2	60	7	5
5	150	17	14
10	300	19	16
25	750	22	16
50	1500	30	23

TABLE L.

Stanzas	Words	Number of Repetitions[13]
2	50	6
5	125	16
10	250	22
25	625	19
50	1250	25

Henmon found that the increase in the *number* of repetitions with the increase in *amount* is relatively less than the increase in the number of lines or stanzas. If the increase was proportional to the *amount* the number of repetitions would be 3.5, 7.0, 10.5, 14.0 and 17.5 instead of which the series is 3.5, 6.3, 8.6, 10.0 and 12.2, which are the averages of the three subjects of Table J. There is, therefore, according to Henmon, a relevant economy with the larger amounts. The economy in relearning after 24 hours is greater with the larger amounts and, according to Henmon, is relatively greater with poetry than with nonsense-syllables.

Henmon also made experiments using prose as the material. This consisted of 100-word, 200-word and 300-word passages selected from the essays of Huxley and Matthew Arnold. Sixty selections from Huxley were made, and 60 from Arnold,—20 passages of each length. One practiced subject learned 54 of these selections, (18 from each group), and recorded the number of repetitions required for learning. The results are indicated below in Table M. Table N, giving the results of some of my own experiments, which will be taken up in detail further on, is appended for purposes of compari-

[13]Approximate only,—being computed (at the rate of 2 stanzas in 0.23 minute) from the *total time* as given under "*continuous method*" on Plate 3.

son. In the paper read at Washington, Henmon stated only the number of repetitions. Assuming that the reading was performed at the ordinary rate (about 200 words per minute), I have taken the liberty to figure the approximate time taken for these repetitions, and have included it in Table M. It will be noted that with none of the passages do any of my subjects get so low a time as that obtained by Henmon. If his rate of reading was faster than I have assumed, the difference would be even more marked.

TABLE M.

Number of Words	Repetitions	Approximate Time
100	6.4	3.2 min.
200	7.3	7.3 min.
300	7.0	10.5 min.

TABLE N.[19]

Number of Words	Subject, with Number of Minutes Taken														
	B. B.	Ed. W.	El. W.	E F	E B.	H B.	A. K	A H	E E.	F. Wi.	R. W.	A. Q.	E A.	F Wo	D. L
100	8	10	12	14	13	16	19	15	21	17	18	17	35	31	10
300.....	25	24	19	47	40	26	29	32	37	36	51	48	78	41	28
500[19].	42	59	67	98	103	57	88	75	..	45	133	81	*	*	54

As will be noted from Table M, Henmon finds an approximate constancy in the number of repetitions for the passages, irrespective of their length. Tho with the nonsense syllables some of my subjects gave results that approximate those obtained by Henmon, with prose I get no such results as those that he obtained, as may be seen from Table N.

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[19]It should be noted that Henmon used 100, 200, and 300 word passages, whereas I used 100, 300, and 500.

(Continued in the February number.)