THE INFLUENCE OF IMPROVEMENT IN ONE MENTAL FUNCTION
UPON THE EFFICIENCY OF OTHER FUNCTIONS[1]
III.FUNCTIONS INVOLVING ATTENTION, OBSERVATION AND DISCRIMINATION

E. L. Thorndike & R. S. Woodworth (1901)

The functions trained in these experiments were those of observing accurately some detailed features of the words on printed pages. The subject would, for instance, practice marking every word containing the two letters *e* and *s* until he attained a considerable improvement in speed and possibly in accuracy as well. Before and after this training he would be tested in marking words containing other combinations of letters, misspelled words, a certain letter printed promiscuously amongst others, words of a certain length, different parts of speech, etc.

The quickness of the work was measured by the time taken to do a given amount, or in some cases by the amount done in a given time. The accuracy was measured in two ways, (1) by the number of omissions, and (2) by the proportion of the words [p. 554] marked to those which should have been marked. A comparison of tests before and after training can thus be made. It is wise to use two measures of accuracy, since a change from say 4 to 2 omissions does not mean so much improvement as 50 per cent. On the other hand, a change from marking 96 to marking 98 per cent. of the words that should be, means an improvement of more than 2 per cent., for the more accurate one is at the start the harder it is to gain further accuracy.

The early and late tests were rarely with perfectly equal tasks. If you use the same pages after as before training, you get a probability of practice effect from the first test itself. If you use different pages, they are of course of slightly varying difficulty. Individual records, then, must not be taken too seriously. General tendencies are all that we pretend to demonstrate.

The experiments seem to be fairly good ones, for they concern processes comparable to the

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training in school life which pretends to improve our general habits and powers of attention, discrimination and accurate work, and are still easily administered and calculated.

We may first examine a sample test in some detail and then recount briefly the results of the others.

Five subjects practiced marking the words containing *e* and *s* in a book containing matter of about uniform style and difficulty and character of topics. Before they began and after they had attained considerable improvement they were tested with marking words containing *i* and *t*, *s* and *p*, *c* and *a*, *e* and *r*, on similar pages (different pages being used before and after training), with marking words containing *a* and *n*, *l* and *o*, and *e* and *r*, on pages different from those used in the training series in length of lines, size of type and style of matter (the same pages being used before and after training), with marking the misspelled words on a page containing a hundred such, with marking the letter *A* on a sheet containing 500 capital letters in a random arrangement.

Their records are given in Tables I., II. and III. Tables I. and II. give the improvement in the training series. There was equality in the length of the first and last pages marked, but [p. 555] unluckily the first page had an unusually large number of words containing *e* and *s*, making it a harder page. The second page on the other hand had fewer than those which happened to be final pages for the different subjects. Under A we have given the records for time, percentage marked and omissions in the case of the second page, and under B in the case of the first page. Under C we have given the records for the last page in the case of each subject, and under D the records for the average of the last four pages.

The comparison from A to C seems the best to go by. This comparison makes the training seem a little more than it perhaps was, in that the errors of the last trials are more below the average of the last four trials than they should be, but this is offset by the facts that the tests under C had 12 per cent. more *s* and *e* words than did those under A and that the latter were second tests.

TABLE I.
IMPROVEMENT IN TRAINING SERIES.

	Time.				Percentage Marked.				Omissions.			
	First Training.		Last Training.		First Training.		Last Training.		First Training.		Last Training.	
	A.	B	C.	D.	A.	B.	C.	D.	A.	B.	C.	D.
Ber.	185	235	150	151	78	92	96	93	16	8	4	6
Br.	245	290	120	118	86	100	90	93	10	0	8	5
Be.	240	262	150	155	83	76	81	75	12	28	13	20
Wh.	185	225	105	101	81	90	98	90	13	12	2	7.5
E.M.T.	165	190	105	111	84	83	95	95	11	20	4	4
Totals.	1020	1202	630	636					63	68	31	42.5

TABLE II.
RATIOS OF END OF TRAINING SERIES TO BEGINNING.

	Time.	Percentage Marked.	Omissions.
Ber.	81	123	25
Br.	49	105	80
Be.	62.5	98	108
Wh.	56	121	75
E. M. T.	64	113	36
Totals.	62	115	50

[p. 556] A-C comparison. In these and all following tables figures referring to time are given in seconds unless otherwise stated.

TABLE III.

IMPROVEMENT IN TEST SERIES IN TIME.

THE FIRST COLUMN UNDER EACH HEADING REFERS TO A TEST BEFORE TRAINING, THE SECOND COLUMN TO ONE AFTER.

	i-t		s-p		c-a		e-r		a-n		l-o		e-r		Misspelled Words		A's		All Tests Together	
Ber.	200	150	165	160	170	163	210	172	62	68	55	40	65	68	175	160	75	79	1177	1060
Br.	176	146	170	95	140	110	225	203	68	45	64	35	85	63	120	108	110	85	988¹	795
Be.	232	180	184	170	186	170	306	225	101	71	78	54	108	73	190	150	—	—	1385	1093
Wh.	190	175	170	120	120	140	175	180	80	55	65	45	70	60	135	120	78	75	1083	970
E. M. T.	170	115	146	105	165	120	183	165	85	48	65	46	68	50	140	103	97	85	1119	837
Totals.	968	766	835	650	781	703	1099	945	396	287	327	220	396	314	760	641	360	324	5752	4755

Ratio in training series.

	i-t	s-p	c-a	e-r	a-n	l-o	e-r	Misspelled Words	A's	All Tests Together
Ber. 81	75	97	96	82	110	73	105	91	105	90
Br. 49	83	56¹	78	90	66	55	74	90	77	81
Be. 62.5	78	92	91	73	71	70	68	79		79
Wh. 56	92	70	117	102	69	70	86	90	96	90
E. M. T. 64	68	72	73	90	57	71	74	70	88	75
Totals. 62	79	78	90	86	72	67	79	84	90	83

¹ Possibly 155 above and so .90 here and a higher average below.
² Br. s-p test thrown out.

[p. 557] Table III. gives the improvement in time in the various tests. Part *A* gives the absolute quantities and Part *B* the ratios of the tests after training to those before.

TABLE IV.

IMPROVEMENT IN TEST SERIES IN ERRORS.

	i-t		s-p		c-a		e-r		a-n		l-o		e-r		Misspelled Words		A's		All Tests Together	
Ber.	17	23	5	2	5	5	38	35	9	13	3	5	3	2	10	9	5	3	95	97
Br.	19	27	4	6	8	11	15	17	14	14	0	4	2	2	6	1	2	1	70	83
Be.	30	16	8	2	12	6	24	22	13	15	1	1	3	5	1	7	17	5	109	89
Wh.	10	5	5	1	10	3	34	17	8	10	2	0	0*	0	11	5	1	0	81	41
E. M. T.	38	18	6	2	8	7	49	22	6	12	2	2	3	3	7	10	0	0	119	76
Totals.	114	89	28	13	43	32	160	113	50	64	8	12	11	12	35	32	25	9	474	386

Ratio in training series.

	i-t	s-p	c-a	e-r	a-n	l-o	e-r	Misspelled Words	A's	All Tests Together
Ber. 25	135	40	100	92	144	167	67	90	60	102
Br. 80	142	150	137	113	100	∞	100	16	50	119
Be. 108	53	25	50	92	115	100	167	700	45	89
Wh. 15	50	20	30	50	125	0	100	45	0	51
E. M. T. 36	47	33	88	45	200	100	100	143	100	64
Totals. 50	78	46	74	70	128	150	109	91	36	81

[p. 558] Table IV. gives in a similar manner the improvement as measured by the number of errors.

Table V. gives in a similar manner the improvement as measured by the percentage of words marked.

TABLE V.

IMPROVEMENT IN TEST SERIES; PERCENTAGE OF WORDS MARKED.

	Training Series.	i-t	s-p	c-a	e-r	a-n	l-o	e-r	Misspelled Words.	A's.
Ber.	123	92	119	100	104	76	66	104	101	102
Br.	105	87	88	91	98	100	55	100	105	101
Be.	98	127	146	120	102	85	100	91	96	112
Wh.	121	107	125	122	124	88	129	100	107	101
E. M. T.	113	145	127	103	149	70	100	100	97	100
Totals.	115	108	119	107	113	82	89	99	101	103

By testing eight other individuals with three of the tests in the same manner as the five of the tables, save that the former had no training whatever between the tests, we gained an approximate measure of the improvement to be expected on the after-training tests because of their being a second trial. The ratios of their speeds were 95, 91, and 86, but the sum of the omissions of the eight rose from 14 to 20, 8 to 10, and from 36 to 48. So no improvement can be demonstrated in their records.

It is clear from the tables that the improvement in the function of observing and marking words containing *s* and *c* is not equivalent to improvement in the group function of observing the make-up of words. Neither the speed nor the accuracy acquired in the training is a general power equally applicable to other data. And although the functions operative in the tests were so similar to that trained the loss of efficiency with them is considerable.

Speed is more likely to be improved than accuracy. This may mean that certain habits of eye movements and stops are formed that are identical elements in both functions trained and tested. The most notable improvements in accuracy occur with *s-p* and *e-r* on the same style of page as the training series (ratio of percentages of words marked 119 and 113). But here again there are identical elements, observing the letter *s* in the first, [p. 559] observing the letter *e* in the second, and the width of column, similar sort of distractions, etc., in both. Of the three tests with a different sort of page from that used in the training, *e-r* shows again the most improvement (here the least deterioration) in accuracy.

We cannot ascertain just which of the functions tested improved most and so cannot discuss the way in which greater alteration of the data alters the efficiency of the group function. The reason for this is that we cannot equate time saved with accuracy lost or *vice versa*. As was stated on page 554, the variability of any single test makes any minute examination of the tables unprofitable.

We shall present the experiments of which this is a type in a still more condensed summary.

(*a*) Subject T.
Training: 90 minutes' practice marking verbs; time for first 10 pages 417, errors 10; time in last 10 pages 341, errors 1; percentages 82.8 and 10.
Tests: (1) Other parts of speech; before training 412, 15; after training 398, 4; percentages 96.6, 26.3. (2) Marking words containing *s-p*, *i-t*, etc., before training 638, 8; after training 610, 9; percentage 96, 112.

(*b*) Subject T.
Training: 123 minutes' practice marking prepositions. Time at start 907; errors, -- mistakes 16, omissions 10; time at end 756; errors, -- mistakes 2, omissions 4; percentages 83.3, 12.5 and 40.
Tests: Other parts of speech; before training 308, 4; after training 314, 3; percentages 102, 75.

(*c*) Subject T.

Training: 90 minutes' with verbs and 30 minutes with prepositions.
Tests: Marking words over 7 letters and words over 5 letters; before training 233, 2; after training 188, 2; percentages 81 and 100.

(*d*) Subject T.
Training: 72 minutes' practice marking adjectives; time at start 620, errors 19 or 30; time at end 488, errors 5; percentages 79 and 26 or 17.
[p. 560] Tests: Conjunctions and pronouns; before training 142, 6; after 127, 2; percentages 90 and 33.

(*e*) Subject T.
Training with prepositions and adjectives as described.
Tests: (1) Marking words containing *s-p, i-t,* etc.; before training 700, 9; after training 619, 6; percentages 88 and 67; (2) marking words of 5 and of 7 letters; before training 188, 2; after training 203, 0; percentages 108, 0.

(*f*) Subject T.
Training with words containing *e* for 80 minutes. Time at start 543, errors 5; at end 468 and 5; percentages 86 and 100. Also some 20 minutes training in marking words containing *a* and *n*.
Tests: Words containing *s-p, i-t,* etc. Before training 441, 4; after 367, 9; percentages 83 and 225.

(*g*) Subject T.
Training with words containing *e* as above and with words containing *a* and *n* for 188 minutes. Time at start 583, errors 43; at end 436 and 13; percentages 75 and 30.
Tests: (1) Conjunctions and pronouns; before training 136, 3; after 149, 4; percentages 110 and 133. (2) Words of 7 and 5 letters; before training 203, 0; after 185, 6; percentages 91 and -- . (3) Words containing *s-p, i-t,* etc.; before training 441, 4; after 376, 7; percentages 85 and 175.

(*h*) Subject T.
Training: All the training so far described plus a vast amount of work in correcting all the work recorded so far.
Tests: Marking Latin verbs, prepositions, adverbs, and conjunctions, and French and German verbs; before training 840, 18; after training 764, 11; percentages 91 and 61.

(*i*) Subject W.
Training: About 250 minutes' practice in marking English verbs. Time at start 617, errors 22; time at end 431, errors 11; percentages 70, 50.
Tests: (1) Marking various other parts of speech; before training 42 minutes 36 seconds, errors 15; after training 40 min- [p. 561] utes 55 seconds, errors 50; percentages 97, 333; (2) marking parts of speech in French texts: before training, verbs 272, 3, adjectives 407, 3, adverbs 440, 10; after training 336, 5; 402, 4; and 394, 8, respectively. Totals before, 1, 219, 16; 1, 132, 17; percentages 93, 107.

(*j*) Subject W.
Training: That described, plus training in marking words containing *e* and *t*. In the latter the records at start and finish were 981, 20; 569, 23; percentages 58 and 115.
Tests: (1) Words containing certain other combinations of letters. The results were:

	Before Training.		After Training.		Percentages.		Percentages of totals.	
s-p	439	9	503	7	90	82	88.5	105
i-t	827	13	643	11	78	85		
r-e	432	10	271	6	63	60		
l-o	271	2	230	3	85	133		
a-n	412	11	438	20	106	182		

(2) Words of over 6 and of over 7 letters.

$$\text{Over 7 letters } 386 \quad 7; \quad 364 \quad 2 \;\Big\} \quad 94 \quad 40$$
$$\text{`` } 6 \text{ `` } \quad 392 \quad 8; \quad 364 \quad 4 \;\Big\}$$

(3) Marking logarithms containing certain pairs of numbers. The results were:

In Marking.	Before Training. Time.	Errors.	In Marking.	After Training. Time.	Errors.	Percentages.
4 and 8	118	–	3 and 7	125	–	
0 and 5	130	–	4 and 1	133	–	
	248	2		258	6	104 300

(4) Before training, marking words containing *oa*, *on*, *ti*, *es*, the two letters being in each case together in the order given; after training words containing *ea*, *io*, *ei*, and *ed*, also in each case together and in order. The results were:

	Before. Time.	Errors		After. Time.	Errors.	Percentage of Totals.
oa	387	0	*ea*	434	8	89 69
on	343	23	*io*	338	1	
ti	580	10	*ei*	358	5	
es	565	2	*ed*	535	10	
	1875	35		1665	24	

[p. 562] 231 cases of such combinations should have been marked in the early tests, 167 in the late. Thus, the percentage marked of those that should have been marked was 85 in the early tests, 86 in the late.

(*k*) Subject W.
Training for 27 minutes (all at one sitting) in marking words containing *c* and *t*. Time at start 261, errors 1; at end 134, 11; percentages 51, 1100.

The functions tested before and after this training were the marking of words containing certain other combinations of letters. The total time before training was 655 seconds, and errors 12; after training 482 and 28; percentages 74 and 233.

(*l*) Subject E. T.
Training: About 90 minutes' practice in marking French verbs. Time at start 390, errors 16; at end 353 and 5; percentages 90.5 and 31.
Tests: (1) Words containing *s-p*, etc.; before training 740, 18; after training 666, 14; percentages 90, 80. (2) English verbs, adjectives and conjunctions; before training 557, 23.5; after training 525, 19; percentages 94, 80.

(*m*) Subject E. T.
Training: About 110 minutes' practice in marking words containing *a* and *t*. Time at start 720, errors 15; at end 586 and 8: percentages 81 and 60.
Tests: Words containing *s-p*, etc. Before training 664, 14; after training 577, 21; percentages 87, 150.

(*n*) Subject E. T.
Training: That of both (*l*) and (*m*).
Tests: (1) Words containing *i-t*, etc. Before training 778, 7; after training 516, 33; percentages 68, 471. (2) Words of over 6 and of over 8 letters; before training 282, 4; after training 249, 7; percentages 87, 175.

(*o*) Subject M. T.

Training: About 75 minutes' practice marking words containing *a* and *t*. Time at start 610, errors 127; at end 575, 95; percentages 94, 75. In the early pages there were 218 words [p. 563] containing *a* and *t*, in the last pages there were 199. The proportions of words marked were thus 42 and 57, the final record being 136 per cent. of the record at the start.

Tests: Marking words containing *i-t*, *r-e*, *l-o*, *a-n*, *g-m*, *a*, *d*, *c*, *h*, six or more letters, eight or more. Before training 1290, 435; after training 1365 or 1305, 456; percentages 106 or 101, 105.

That the tests used in all these experiments were not unfair by reason of being tests of functions that could not be easily improved in any way is shown by the fact that in training series verbs, adjectives, prepositions, words containing *e*, *e* and *s*, *a* and *n*, *a* and *t*, *e* and *t*, all showed ready improvement when special practice was made a factor. W. added to this evidence by taking short training series with words containing *a* and *d*, *n* and *t*.

In about 22 minutes' practice with the former the time remained constant but the errors decreased from 17, 9, 10 and 15 in the first four pages to 4, 2, 6 and 1 in the last. Percentage 25.

In about 17 minutes' practice with *n* and *t* the times decreased from 66, 53, 46 and 64, to 39, 39, 48 and 34; the errors from 4, 4, 2 and 3, to 1, 2, 1 and 3 (*i.e.*, from 13 to 7). Percentages 70 and 54.

In the three articles of which this is the last we have endeavoured to present as succinctly as possible the results of our experiments. It has not seemed worth while to subject them to a minute analysis, for the reliability of any individual determination is not sufficient to warrant special conclusions from it. The general attitude which comes from the examination of all the facts we have demonstrated, not a set of precisely formulated judgments, is what we have aimed to produce.

The next steps in the study of the interdependence of mental functions would seem to be the exact analysis of the influence of one on the other where such is present and the discovery of its amount and nature in cases of practical importance, for instance, in the case of the training given in school subjects, in occupations, in games, etc. Under the first head we should [p. 564] hope to see experiments carefully devised, as these rough ones of ours were not, to detect the exact elements of any function that were changed by training, to measure such changes and to find which of such changes brought about increased efficiency in other functions and how. Under the second head we should put determinations of the exact improvement in the efficiency of various functions by commonly practiced educational disciplines and measures of the influence of the training of certain mental functions by school subjects on the efficiency of other functions.

Footnote

[1] *Corrigenda*. -- In Table IV. of the previous article of this series (page 385 of the July number of the REVIEW) there are three errors in computation for which I am responsible. In the 5th column 82.3 should be 92.3; in the 6th, 123.3 should be 123.2; and in the 8th, 40.3 should be 41.3. In the next to the last line of the table 60 becomes 67, and 63, 62.

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