

# THE INFLUENCE OF PRACTICE ON THE CORRELATION OF ABILITIES

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Correlations which have been computed between mental tests have been, for the most part, comparisons of initial trials or of records made after a few preliminary trials. Only in one case was an experiment performed in which it was possible to correlate the abilities of individuals who had in all probability reached their practice limit in the tests used. Professor Hollingworth reports an investigation in which he compares records made after one, five, twenty-five, eighty, and two hundred and five repetitions of each of seven tests.\* He finds a high correlation between some of these tests (*i.e.*, the familiar adding, tapping, opposites, color-naming tests) after the two hundred and fifth trial. He finds a progressive increase in the average of correlations of all tests from the first to the two hundred and fifth trial. This increase of co-efficients with practice and final high correlation leads the experimenter to favor some form of the doctrine of "general ability," to suppose that there may be, when a practice level is reached, a positive correlation of desirable traits.

The experiment which follows was prompted by a desire to test this hypothesis further. Five tests were used in the investigation. These were:

Color-naming: Two Woodworth-Wells blanks pasted together. Record, time required to name correctly a set of two hundred colors. Test repeated twenty-five times.

Tapping: Record, number of taps executed in two minutes with the hand stylus, right hand. Test repeated twenty-five times.

Adding: Kraepelin blank used. Record, time required to add one hundred examples of two numbers each. Test repeated thirty times.

Multiplying: Record, time required to solve mentally a set of five multiplication examples. The examples required the multiplying of one two-place by another two-place number. No number below four was used—no example was repeated. Test repeated twenty-two times.

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\*H. L. HOLLINGWORTH, *Vocational Psychology*, Ch xi; also *Correlation of Abilities as Affected by Practice*, *J. of Ed. Psych.*, Sept. 1913, pp. 405-414.

Word-building: Record, number of shorter words built from a given word (as weather, psychiatry, etc.) in a specified time. Words varied in difficulty and the amount of time was changed as the experiment proceeded. The test had twenty-two repetitions.

It is important to note the difference between these last three tests and those used in Professor Hollingworth's investigation. A repetition of the tests used in the former experiment meant a going-over of identical material. Definite bonds were formed and perfected. Responses in the opposites and adding tests became like responses in the color-naming test. The adding, multiplying, and word-building tests of the present investigation were chosen with a view to eliminating, as far as possible, the probability of a change in the nature of the tests. Responses cannot be stereotyped for they are changed at each repetition. In the adding experiment, there were six different sets of one hundred numbers each used. There was no possibility, then, of learning the order of appearance of the answers. In the multiplication test we have each time a different problem, and in the word-building a different word. Practice in these cases means not so much the strengthening of a few particular bonds, as acquiring experience in the exercise of some "mental function."

The subjects in the experiment were fifteen college students. Each subject spent two separate half-hours a week in practice. The entire experiment extended over a period of from seven to eight weeks. All records were taken, with a stop watch, by one person.

In order to find the relation of an individual's proficiency in one sort of test to her proficiency in the others at different points of the curve of practice, the practice period was divided into eight parts, at each of which parts the records were correlated. These divisions were:

*1st Division.* The initial trial.

*2nd Division.* The second, third, and fourth trial of color-naming, tapping, multiplying, word-building. The second, third, fourth and fifth trial of adding \*

*3rd Division.* Fifth, sixth, seventh of four tests. Sixth, seventh, eighth, ninth of adding.

*4th Division.* Eighth, ninth, tenth of four tests. Tenth, eleventh, twelfth, thirteenth of adding.

*5th Division.* Eleventh, twelfth, thirteenth of four tests. Fourteenth, fifteenth, sixteenth, seventeenth of adding.

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\*The adding test was the shortest and was given the largest number of trials. Therefore four adding trials were united to make one division, while only three of each of the other tests were used.

6th Division. Fourteenth, fifteenth, sixteenth of four tests. Eighteenth, nineteenth, twentieth, twenty-first of adding.

7th Division. Seventeenth, eighteenth, nineteenth of four tests. Twenty-second, twenty-third, twenty-fourth, twenty-fifth of adding.

8th Division. Twentieth, twenty-first, twenty-second of four tests. Twenty-sixth, twenty-seventh, twenty-eighth, twenty-ninth of adding.

At each of these points the average record made by each individual in each test was correlated with her average record in other tests. The correlation formula

$$R = 1 - \frac{6\sum D^2}{n(n^2 - 1)} \text{ was used.}$$

The details of the correlation are omitted in this article. Table I gives the average correlation of each test with all other tests, at eight points in the practice period. The coefficients in the original table for each test at each point, have been averaged to make Table I.

TABLE I  
Average Correlation of Each Test With All Other Tests, including Multiplying.  
Average Used as Measure

Divisions	1	2	3	4	5	6	7	8
Color-naming . .	14	15	26	28	33	32	24	31
Tapping . . .	22	22	28	19	29	38	12	16
Adding . . . .	23	19	43	36	45	48	.42	35
Multiplying . .	17	06	19	18	20	.25	12	— 10
Word-building .	24	52	27	34	42	45	.39	26
Average . . . .	20	23	29	27	34	38	26	19
Average of each two	215		28		36		225	

Here a gradual increase in coefficients is noticeable which reaches its maximum at the sixth division, where the average correlation of all tests with all other tests is +.38. After this point there is a decrease which is slight in all tests, but multiplying.

Further inspection of the table shows that the multiplying test is characterized by low and irregular correlation with all other tests but adding. The multiplying test, the most complex of all, was the one in which there was the least approximation to a practice limit. The fact that in this test there was not enough practice to eliminate variability or to equalize the effects of previous practice might account for this lack of definite correlation. It is noticeable that the correlation did increase up to the sixth division, where it became +.25, but after that, through accidental variation or other causes, it became low again.

TABLE II

*Average Correlation of Each Test with all other Tests, excluding Multiplying.  
Average Used as Measure*

Divisions	1	2	3	4	5	6	7	8
Color-naming . . . .	16	32	36	41	.46	.45	.34	.44
Tapping . . . . .	28	25	.28	.22	.39	.49	.26	.30
Adding . . . . .	20	17	40	30	.36	50	45	45
Word-building . . . .	.26	66	33	41	.50	42	38	.38
Average . . . . .	.23	35	34	34	.43	49	38	39
Average of two . . . .	29		34		46		385	

TABLE III

*Average Correlation of Each Test with all other Tests, excluding Multiplying. Median  
used as Measure*

Divisions	1	2	3	4	5	6	7	8
Color-naming	16	32	38	42	.46	47	35	.31
Tapping . . . . .	28	+ 06	26	19	43	43	18	17
Adding . . . . .	20	- 04	45	24	.49	49	.33	33
Word-building . . . .	.29	.27	32	41	.47	45	32	26
Average . . . . .	23	.15	35	32	.36	36	.30	27
Average of two . . . .	19		335		36		295	

In order to eliminate the tendency of multiplying to lower all coefficients, other tables were prepared from which correlations with multiplying were omitted. Table II shows the average correlation of each test with all other tests excluding multiplying. There the coefficients are higher and their upward trend even more obvious. They increase steadily up to the sixth division where they fall off a bit, never becoming, however, as low as they were in the first, second, third and fourth divisions. Table III shows a like result. The difference between this table and the two preceding ones is that here the median record of each division was used as the unit of measurement, whereas in Table I and II the records in each division were averaged.

TABLE IV

*Average Correlation of each Test with all other Tests, excluding Multiplication. Best  
Record Used as Measure*

Divisions	1	2	3	4	5	6	7	8
Color-naming. . . . .	.16	.29	55	45	51	54	.50	.44
Tapping . . . . .	28	.28	25	19	42	.51	.26	.34
Adding . . . . .	20	22	.46	24	.47	57	.45	.41
Word-building . . . .	29	33	.40	32	54	61	34	.53
Average . . . . .	23	28	42	30	49	56	39	43
Average of two . . . .	.26		.385		52	5		.41

In Table IV only the individuals' best trials in each division were considered. Accidental causes, of poor records were eliminated here. One would expect, if correlations do increase with approach to a practice level, that where highest ability only was measured, coefficients would be higher than they are in the tables computed from average and median measurements. This is the case. All average coefficients are higher. The best coefficient ever reached (56 per cent. in the sixth division) is found here.

TABLE V

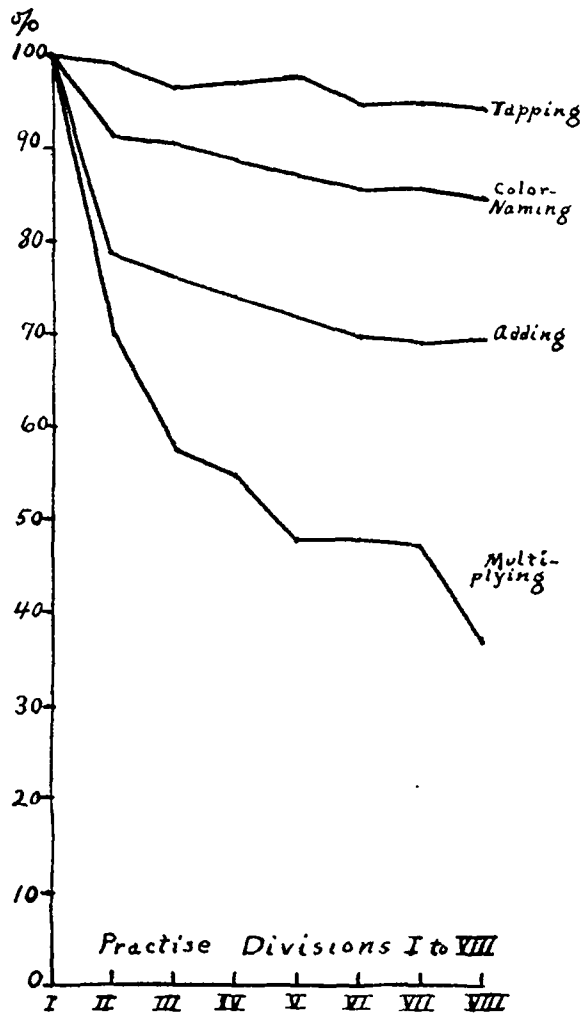
*Correlation of each Test with every other excluding Multiplication at Highest Point Reached by Each Subject*

	Color-naming	Tapping	Adding	Word-building
Color-naming . . . . .		49	.53	36
Tapping . . . . .	49		21	37
Adding . . . . .	53	21		52
Word-building . . . . .	36	37	.52	
Average . . . . .	.46	36	42	42
Average of Average . . . . .			.42	

This is brought out even more clearly by Table V. The eight divisions are done away with, and each subject's highest point only is considered. This is the point which might have become the average if sufficient practice had been given. The correlation is relatively high—the average is 42 per cent.

Tables II, III, IV and V all show an increase in correlation up to the sixth point, followed by a slight decrease which makes the last two coefficients, though greater than those of the first to the fourth periods, a little less than the coefficients of the fifth and sixth divisions.

Individual practice curves, and averages of these curves show this same phenomenon. Inspection of the individual curves (not shown in the article) reveals great improvement up to the sixth division, followed by relatively little or entire lack of improvement. In the figure the records of the fifteen individuals have been averaged. The amount of time required for the initial trial of each test has been taken as the standard and averages of subsequent practice divisions are represented in terms of per cent. of this record. No word-building curve is shown, for the varying difficulty of the words and the different amounts of time allowed make such a curve worthless. The curves of the other four tests show gradual, steady decrease until the sixth division, after which there is an average



improvement of only seven tenths of one per cent., in color-naming, five-tenths of one per cent., in adding, and three-tenths of one per cent. in tapping. Multiplying shows a greater improvement (10 per cent.) but even this is small when we compare it with the 52 per cent. improvement gained before this. It seems as though at the sixth division some sort of a practice level is normally reached. This point corresponds exactly with the place where increase of correlation coefficients has ceased.

This correspondence might imply a casual relation of some sort. The lack of improvement in ability might be suggested as the cause of lack of improvement in inter-correlations. *Where practice improves performance, correlations increase.* Where there is a fall in effort, ability, or what-not, or where accidental causes lower proficiency, the coefficients stand still or show a slight decrease.

The results of this experiment seem to show a positive correlation increasing with practice between the abilities measured by these tests. This is brought out by a correlation of median points and average points of all tests but multiplying, confirmed by a comparison of best records, that is, of records representing more closely the approach to the practice limit. The fact that multiplying, a more complex, less easily mastered test, correlates poorly need not weigh against our hypothesis, but may even be urged in support of the assumption that higher proficiency is needed for greater positive correlation. A comparison of practice curves with correlation coefficients brings further evidence for the theory that improvement in ability is a factor in the increase of correlations.

The great similarity of the subjects used and the dissimilarity of the tests makes these results fairly convincing. But the small number of subjects available gives opportunity for many accidental errors, which further experimentation, now being carried on along this same line, may eliminate. The point here considered relates to one only of a number of problems which have practical and theoretical importance and which justify a detailed inquiry into the psychology of practice limits.