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CORRELATION OF SOME PSYCHO-  
LOGICAL AND EDUCATIONAL  
MEASUREMENTS

WITH SPECIAL ATTENTION TO THE  
MEASUREMENT OF MENTAL ABILITY

BY

WILLIAM ANDERSON McCALL

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS  
FOR THE DEGREE OF DOCTOR OF PHILOSOPHY, IN THE  
FACULTY OF PHILOSOPHY, COLUMBIA UNIVERSITY

PUBLISHED BY

*Teachers College, Columbia University*  
NEW YORK CITY

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*Columbia Cont. to Educ.*

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W. A. M.



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## CORRELATION OF SOME PSYCHOLOGICAL AND EDUCATIONAL MEASUREMENTS

### I

#### PROBLEMS

"The results of all good experimental work will live, but as yet most of them are like hieroglyphics awaiting their deciphering Rosetta Stone." These are the words of Spearman. Such words are true of all fields of research, but they are worse than true of the field of Correlational Psychology. The Rosetta Stone of Correlational Psychology must do more than interpret; it must reconcile. For this nothing less than a Philosopher's Stone will suffice, and Science, succeeding Black Magic, fully realizes that such a stone will not be found, but must be formed by a slow and laborious process. It is the hope that this study will contribute its small part to the making.

Correlational Psychology is in this more or less chaotic condition, not only because of poor experimental technique and diverse and inadequate statistical methods, but also because of the very great complexity, importance, and number of the problems which it has elected to attack. Such complexity, importance, and number of problems is revealed by a very brief survey of the literature on correlation. But not to go farther afield, it is excellently illustrated by the problems which it is the purpose of this research to examine. These problems follow:

1. What are the intercorrelations among our psychological and educational tests or the functions which they measure?
2. What is the relative value of each test as a measure of mental ability?
3. In the practical measurement of mental ability for educational and vocational purposes which tests are the more valuable?

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4. In the construction and in the application of psychological tests for the measurement of mental ability, do 'speed' tests or 'power' tests offer more promise, whether as to correlation, convenience, or time spent?

5. What characteristics in a test make for high correlation with mental ability?

6. What is the value of improvement as a measure of mental ability?

7. What is the significance of chronological age as an intellectual index?

8. Is there such a thing as a negative correlation between desirable traits? Is the law of human nature correlation or compensation?

9. Do our results support Spearman's "Theorem of the Universal Unity of Intellectual Function," or Burt's "Hierarchy of the Specific Intelligences"?

These problems have been attacked experimentally. The following pages describe the experiment, the use made of the data, and the results obtained. This experiment was devised originally to study problems other than those considered here. In fact, this study was not even conceived until the experiment was completed. While this means a certain roughness of technique, it has the advantage of guaranteeing the impartiality of the data.

## II

### EXPERIMENTAL MATERIAL AND METHOD

#### 1. SUBJECTS

The subjects for this experiment were eighty-eight public school children of an average age of about twelve and one-half years and about equally divided as to sex. These eighty-eight children were two typical 6B classes in a typical elementary school in New York City. The two class rooms adjoined and the teachers who had charge of the children used the departmental method of instruction. That is, the two teachers divided the subjects to be taught equally between them and each taught her allotted subjects to both classes. In this way both classes received exactly the same instruction. The classes were equal in mental ability as measured by what is later described as the six preliminary tests, though the last fact is not essential to this study. Further, it should be noted that while children were at the beginning shifted from one room to the other in order to make the classes equal in ability, in no case were children specially brought in from other classes. The eighty-eight children who made up the two classes were the children the experimenter found there when he began the experiment—they were typical classes.

#### 2. TESTS WITH THEIR ADMINISTRATION AND SCORING

The general plan of the experiment was to give six preliminary tests, to follow these with an extended practice series, and to conclude with six final tests which were to be similar to, but not identical with, the six preliminary ones. Certain special tests were given along with the practice series without interrupting it.

In the administration of the tests every effort was made to treat both classes exactly alike. This was all the easier because

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a test in one room was followed immediately by the same test in the other room. Written instructions were used at the beginning of each new test to avoid unconscious variation. During the practice series each class was tested for about half an hour. The testing began in one room half an hour after lunch and was concluded in the other room half an hour before the children were dismissed. The beginning class on one day would be the concluding class on the following day. A teacher was always present when the children were being tested, though she took no part in the administration of the tests. The entire experiment was conducted by the author with the exception of the six preliminary and six final tests. Each of these sets was given to both classes in one day. This required an assistant, but even here the writer started every test and left the assistant to collect the papers.

This experiment was throughout a group experiment, there being no individual testing. The detailed method for the practice series was as follows: The experimenter entered the class room and announced the names of the three pupils making the highest scores in each of the tests on the previous day. In addition to the regular procedure, if a new test were beginning, instructions were read and what was to be done was illustrated: Otherwise, the monitors distributed material face down. At the signal: Hands Up! all raised their hands. At the signal: Go! all began the test. At the signal: Stop! all ceased immediately, wrote their names and identification numbers on the sheets and turned them over to the monitors, who did the collecting. This was repeated for the other tests of that day, after which the experimenter went through a similar procedure with the other class.

The tests used on any one day during the practice series, the number of days they were used, the dates they were used, together with the average score made by both classes in each test are all shown in Table A. A brief description of the tests employed, the time allowed for each, and the method of scoring are given below.

##### *Preliminary and Final Tests*

*Visual Vocabulary:* The children were given the Thorndike Reading Scale A, which contains forty-three words. The first five words are easy and equally difficult. Each succeeding group



of five words grows progressively more difficult. The last group, consisting of only three words, is the most difficult of all. Thus both the lower and upper limits of the ability of the children were measured. The children were to write the letter F under every word that meant a flower, and the letter A under every word that meant an animal, and so on. In this as in all the preliminary and final tests the time allowance was thirty minutes. If a child completed a test, leaving nothing undone, before the expiration of the half-hour, he could hand his paper to the experimenter. This last rule held not only for all the preliminary and final tests but also for the special tests which were sprinkled along during the practice experiment. The Visual Vocabulary was scored in terms of penalties:

Score = Errors + Omissions.

The final Visual Vocabulary Test was similar to, though not identical with, the one just described. The two tests were administered and scored in exactly the same way.

*Reading:* Thorndike's Reading Scale Alpha was used. This scale contains four paragraphs, each one being more difficult to comprehend than the preceding. Each paragraph was followed by several questions. The child's written answers to these questions were taken as a measure of his comprehension of the paragraph. A complete sentence was not required of the child, one word sometimes being sufficient to express the idea. Time allowed: 30 minutes.

Score = 2 (correct answers) + 1 (semi-correct answers).

The final Reading Test is similar. I, J, K and L of Thorndike's longer Reading Scale were used. The scoring was identical.

*Completion:* The Trabue Completion Test, consisting of twenty-eight mutilated sentences, was used. The difficulty of completing the first sentence is small, but there is a gradual increase in difficulty with each succeeding one. The child was to write in the missing word or words. Time allowed: 30 minutes.

Score = 2 (sentences completed correctly) + 1 (sentences completed semi-correctly).

A similar set of twenty-eight sentences was employed in the same way for the final test.

*Arithmetic:* Six problems in arithmetic, which grew progressively more difficult, were selected for this test. The child

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handed in his work with his answers, but only the answers which were correct received a score.

Score = Number of problems correctly solved.

Six similar problems were used for the final test.

*Omnibus I A:* The Omnibus Test is so called because it represents a compilation by Professor Thorndike of several tests which psychology has found valuable. These are Easy and Hard Opposites, Verb-Object, Supraordinate, Mixed Relation, Easy and Hard Direction, and Addition. Time allowed: Thirty minutes. The method of scoring this as all the other Omnibus Tests varied with each special part, hence it would be tedious to give it. The method used was that devised by Professor Thorndike. Anyone who desires to use these tests is referred, for a copy of the method of scoring, to the Department of Educational Psychology, Teachers College.

The Final Test was Omnibus I B which includes the same tests as the one just described, the only difference being a slight variation of the tasks.

*Omnibus II A:* This tested reasoning ability, the ability to give the opposites to certain hard words, the ability to give a verb to a specified subject and to add the proper letters to unfinished words, and the ability to solve certain problems in arithmetic. Time allowed: Thirty minutes.

Omnibus II B or the Final Test is a slight variation of Omnibus II A.

### *Special Tests*

*Proverb:* The Proverb Test was recently devised by Professor H. A. Ruger. It consists of thirteen English proverbs followed by their corresponding African proverbs. In some the similarity is easy to perceive; in others it is more difficult. The children were to match the proverbs. Time allowed: Fifteen minutes.

Score = Number correctly matched.

Other special tests were given from time to time but since these tests were not given twice they have not been used in this study. It is necessary that there be two measures of a function if a correlation is to be corrected for attenuation. The Ruger Proverb Test has been retained just because it was recently devised.

*Age:* Because of its possible significance, the age of reaching

the grade has been used as a measure of the children. This age measure was taken from the official school record, and is expressed in months.

*School Mark:* This measure was an average of all the marks given by the two teachers to each child in each subject taught during the semester in which this experiment was being carried on. No previous marks have been used.

*Teacher Rank:* The two teachers were each asked to rank the eighty-eight children for mental ability. These ratings were made independently, although it must be remembered that the teachers had often talked together concerning the children.

### *Practice Tests*

*Cancellation of z's:* For this the Woodworth-Wells Cancellation Sheet was used. This sheet contains a series of groups of five figures arranged in random order. The children were directed to cancel the figure 2. Time allowed: One minute.

Score = 2 (number cancelled correctly) — 2 (number omitted) — 3 (number wrongly marked).

*Cancellation of z's:* Exactly the same test as the above, except that the children cancelled the figure 3.

*Cancellation of A's:* On the Cancellation A Sheet fifty capital letter A's were arranged at random among other letters of the alphabet of which there were fifty each. The children cancelled the letter A. The time allowed and the scoring were as in the Cancelling 2 Test.

*Cancellation of S's:* In every respect the same as the preceding test except that the letter S was cancelled.

*Addition:* The Addition sheet employed by Thorndike, Kirby, and others was used in this test. It is made up of columns of ten one-place numbers arranged in random order, no figure less than 2 being used. The children were to write the sum of each column of figures. Four similar sheets were rotated to prevent memorizing. Time allowed: Ten minutes.

Score = Number of columns added correctly.

*Copying Addresses:* This test was recently devised by Professor Thorndike. A sheet containing twenty-five names arranged in alphabetical order was given to each child, together with the small directory from which the names were taken. The children

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found in the directory the New York City address and wrote it beside the appropriate name. A different list of names was used each day. Time allowed: Ten minutes.

Score = Number of addresses correctly copied.

*Handwriting:* Similar paragraphs were cut from the *Youth's Companion* and pasted on cards. Each child was given a paragraph and a sheet of blank paper with directions to copy as much of the paragraph as he could while writing as well as he could. This test was given twice each day, a new paragraph being used each time. It need hardly be said that in this test as well as the others all the children did exactly the same thing in any one test. Time allowed: Four minutes for each test.

Score = 1 (number of lines or fraction of lines copied) minus 1-10 (each omission or error).

Each omission or error counted as one (1).

Any word or words omitted were of course deducted from the gross number of lines covered to get the figure which was substituted in the first parenthesis above.

*Miscellaneous Arithmetic:* The children worked for twenty minutes each day in Thorndike's booklet "Exercises in Arithmetic No. 5." Since this test has never been accurately scored it was of little value for this study, consequently no further mention will be made of it.

TABLE A

PRACTICE SERIES: Average score made by 88 individuals in the tests shown at the top on the days shown at the left.

	Add.	Can. 2	Can. 3	Can. A	Can. S	Cop. Add.	Hand-writing
2/4	32.1	70.1	88.7	26.6			
2/5	37.8	78.5	99.8	35.2			
2/8	37.8	85.2	102.7	38.8			
2/9	40.2	90.3	105.0	44.4			
2/10	41.6	92.7	105.5	47.4			
2/11	44.4	94.9	114.5	55.4	42.0		
2/15	43.0	97.3	116.0	54.4	49.0		
2/16	45.4	101.6	118.9	55.2	54.1		
2/17	47.9	108.2	123.3	59.3	58.6		
2/18	50.0	110.4	126.9	62.5	63.6		
2/19						11.0	7.38
2/23						13.4	6.82
2/24						14.8	6.52
2/25						17.8	7.20
2/26						18.5	7.06
3/1						18.0	6.96
3/2						17.0	6.61
3/3						18.4	6.62
3/4						18.6	6.41
3/5						22.2	6.84
3/6-4/14	Miscellaneous Arithmetic						
4/14	46.1			61.3	64.4	21.6	
4/15	48.8			64.0	69.9	22.9	
4/16	51.4			70.8	72.6	21.8	
4/19	48.1			70.4	73.3	21.0	
4/20	50.3	106.9	124.5			22.8	
4/21	53.1	110.8	128.3			23.4	
4/22	54.1	114.9	129.4			24.8	
4/23	56.3	122.6	136.0			25.8	
4/26	54.1	125.1	138.7			27.5	
4/27	56.4	122.3	135.0			25.4	

### III

## STATISTICAL TREATMENT OF RESULTS

### I. RAW AND CORRECTED ARRAYS

The net original scores from the tests used in this study are given in the Appendix. In order that a coefficient of correlation might be calculated from these original data, it was necessary to reduce to one figure the many measures obtained from a practice test. No such reduction was necessary for the data obtained from the preliminary, final, and special tests, because each of these was given but once. Further, in order to get a *true* coefficient of correlation two measures of every function were necessary for each individual tested. This was simple in the case of the preliminary tests. The score made by each child in the preliminary test which was given February 3 was paired with the score made by the same child in the corresponding final test given April 28. The ability rank given by one teacher was paired with the rank of that same child given by the other teacher. School marks made in arithmetic, geography, and spelling were totaled and paired with the total of marks made in grammar, composition, and reading. Omnibus I A and Omnibus I B, being so much alike, were combined and paired with the sum of Omnibus II A and Omnibus II B. Of the other special measures—Ruger Proverb and the Age of Reaching the Grade—no second measure was available. In the case of the practice tests the scores made by any one child on days 1, 3, 5, etc., were added and averaged. With this was paired the number obtained from summing and averaging the scores made by that same child on days 2, 4, 6, etc. The practice test—Cancellation of S's—was given an odd number of days, so day 1 was omitted as being the one most likely to be unreliable.

An 'array' is simply a column of figures to be correlated with some other column which permits of pairing by individuals. These arrays may be measures of the same function or of different functions. The preceding paragraph describes the method used in constructing what may be called the 'raw arrays.' Obviously, many factors may enter to make it impracticable or impossible to calculate a coefficient of correlation from such arrays. In the case of a practice test, for example, an individual might be absent on the last few odd days. This would probably make the first member of the pair smaller than the second. Or, again, one or more individuals might be absent on a day when a preliminary, final, or special test was given. Since each of these tests was given but once, obviously the absent individuals would have no score at all in that function. Since it was desired that every test be correlated with every other test, the raw arrays were examined, and whenever any individual was found who lacked a score for any preliminary, final, or special test, that individual was entirely eliminated from this study. Whenever, in the case of the practice tests, any individual had been absent more than two odd days or two even days, that individual was also eliminated. The absences just mentioned refer, of course, to those days on which the particular test under consideration was given. Any other absence standard might have been employed. The more-than-two-days-absent standard seemed to be the one which would give the maximum accuracy of the scores with the maximum number of subjects.

But the pairing in arrays was still more refined in the practice tests. We may take Addition as an example of all of these. Suppose an individual were absent two days out of the ten odd days while he was present the ten even days. An average from the remaining eight odd days would be unduly decreased or increased as compared to the corresponding average from the ten days, according to whether the two absences were near the beginning or near the end of the practice. In order to overcome this difficulty, at least in part, the two scores which that individual would probably have made were padded in. Table A offers a means for determining this probability for any day in the practice. From Table A was calculated the average per cent of each day's increase or decrease with respect to the preceding day.

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Using this per cent, the score which would probably have been made on the day when the individual was absent, was calculated from the last score made before or the first score made after the absence. Table B gives the raw arrays for all the tests used for the entire eighty-eight subjects. By eliminating the individuals who were absent on *single-test* days and also those who were absent more than two odd or two even days for any one practice test, the eighty-eight subjects were reduced to sixty-three subjects. When the two or less absent days were filled in with the probable scores, Table C resulted. Let us call Table C the 'corrected arrays.'

In closing this discussion one further remark is necessary. The original intention was to use more special tests than are shown in Table B. While these were dropped later, they figured in the elimination of pupils. Still another fact must be noticed. The teachers, who gave their opinion of the children's mental ability, ranked them in order from one to eighty-eight. When many individuals were eliminated gaps occurred in their ranks. It was decided to close up these gaps and make the range from one to sixty-three.

TABLE B

RAW ARRAYS: Scores or average scores made by 88 children in the tests shown at the top of each column. Under the practice tests: Column 1 = average from odd days; column 2 = average from even days; figure to left of a parenthesis = total score from number of tests shown in the parenthesis.

Ind.	Addition		Cancelling 2		Cancelling 3	
	10 tests	10 tests	8 tests	8 tests	8 tests	8 tests
	1	2	1	2	1	2
1	102.7	105.7	138.0	142.0	153.5	160.0
2	38.3	356.0[9]	92.3	696.0[7]	111.5	804.0[7]
3	71.1	71.9	98.8	105.5	117.5	119.5
4	36.0	38.7	87.3	91.8	103.5	106.1
5	261.0[9]	268.0[8]	720.0[7]	724.0[7]	120.8	827.0[7]
6	348.0[9]	356.0[9]				134.0[1]
7	42.1	45.9	680.0[7]	92.0	105.0	110.3
8	30.0	264.0[8]	80.3	54.2[6]	102.3	696.0[6]
9	56.5	58.5	132.0	136.5	133.3	135.8
10	9.8	12.0	70.0	74.0	92.0	104.8
11	18.4	16.5	98.5	111.8	840.0[7]	864.0[7]
12	120.0[6]	125.0[6]	662.0[6]	692.0[6]	814.0[6]	814.0[6]
13	91.3	94.9	130.3	133.9	157.5	162.5
14	71.4	76.4	113.8	119.0	121.8	120.5
15	27.8	31.8	105.3	106.0	138.0	132.0
16	47.0	49.8	732.0[7]	115.0	125.8	878.0[7]
17	28.3	266.0[9]	96.0	728.0[7]	115.5	822.0[7]
18	61.4	64.6	87.5	96.5	103.8	103.5
19	80.7	84.7	93.5	94.0	101.5	748.0[7]
20	67.6	63.3	93.5	106.3	123.5	124.9
21	23.5	26.5	111.8	114.3	120.5	125.3
22	268.0[9]	315.0[9]	682.0[7]	650.0[7]	744.0[7]	747.0[7]



Statistical Treatment of Results

Ind.	Addition		Cancelling 2		Cancelling 3	
	10 tests	10 tests	8 tests	8 tests	8 tests	8 tests
	1	2	1	2	1	2
23	54.3	54.9	100.0	107.3	114.8	124.5
24	50.8	012.0[9]	105.5	102.9	122.0	860.0[7]
25	228.0[5]	270.0[5]	524.0[5]	492.0[5]	595.0[5]	626.0[5]
26	51.1	50.4	84.0	91.8	99.8	106.3
27	57.4	58.7	100.8	113.8	113.0	113.3
28	194.0[9]	28.0	97.5	103.8	117.8	124.5
29	36.2	36.5	124.0	112.9	133.0	138.3
30	527.0[9]	50.4	530.0[7]	76.8	054.0[7]	92.5
31	14.5	14.7	82.3	83.8	101.5	105.3
32	42.5	44.1	760.0[7]	111.8	122.8	125.3
33	66.2	68.5	118.0	122.0	132.8	139.8
34	149.0[3]	160.0[3]	250.0[3]	268.0[3]	314.0[3]	238.0[2]
35	49.2	40.8	76.5	80.8	68.3	101.8
36	24.9	228.0[9]	93.3	710.0[7]	107.4	826.0[7]
37	64.6	70.4	100.8	110.4	806.0[7]	842.0[7]
38	29.6	291.0[9]	82.8	81.3	67.5	100.3
39	52.7	53.2	88.8	90.3	111.3	112.0
40	34.0[1]	78.0[2]	06.0[1]	170.0[2]	87.0[1]	294.0[2]
41	35.5	37.8	83.0	85.0	93.0	92.3
42	634.0[9]	592.0[8]	674.0[7]	618.0[6]	863.0[7]	704.0[6]
43	70.8	75.0	94.5	95.8	115.3	113.0
44	53.1	53.7	122.3	120.8	132.0	135.5
50	39.2	41.6	134.3	143.3	1024.0[7]	150.8
51	86.8	82.9	422.0[7]	56.0	62.0	79.8
52	68.9	65.5	62.0	64.3	67.0	74.3
53	230.0[6]	260.0[8]	880.0[6]	126.0[6]	102.0[6]	178.0[6]
54	50.6	53.7	139.3	145.5	145.3	1079.0[7]
55	37.1	40.0	93.8	96.5	118.0	121.3
56	207.0[8]	221.0[9]	794.0[7]	810.0[6]	832.0[6]	902.0[6]
57	21.9	211.0[9]	38.3	346.0[7]	89.3	94.8
58	64.5	70.9	164.1	160.0	110.4	121.4
59	42.9	45.2	82.0	84.0	110.2	122.5
60	23.9	25.3	87.5	90.3	99.3	650.0[7]
61	27.0	257.0[9]	94.3	106.5	103.9	101.3
62	89.2	94.8	115.0	119.5	129.3	132.9
63	31.6	38.2	98.5	108.3	125.5	129.3
64	284.0[9]	263.0[9]	89.8	610.0[7]	104.8	740.0[7]
65	226.0[8]	242.0[8]	062.0[7]	594.0[6]	704.0[6]	660.0[5]
66	57.2	59.3	87.0	88.3	108.0	108.5
67	45.0	51.9	127.5	133.8	145.3	149.3
68	501.0[9]	445.0[8]	470.0[6]	494.0[6]	564.0[6]	602.0[6]
69	06.0[2]	[0]	170.0[2]	170.0[2]	275.0[3]	264.0[2]
70	29.9	30.9	78.5	85.3	692.0[7]	106.5
71	405.0[9]	45.3	720.0[7]	102.0	822.0[7]	128.3
72	87.9	90.8	103.3	105.8	115.0	121.3
73	46.6	43.7	118.9	125.5	129.0	126.5
74	22.7	24.6	93.3	97.8	735.0[7]	107.0
75	29.3	27.3	142.8	129.5	141.8	148.5
76	50.5	55.8	112.8	126.3	128.3	136.3
77	22.4	24.3	120.3	130.0	1068.0[7]	189.1
78	40.6	42.0	82.3	91.5	102.8	111.0
79	798.0[9]	80.8	752.0[7]	114.1	900.0[7]	129.3
80	92.8	99.4	722.0[7]	736.0[7]	166.3	117.0
81	65.6	66.6	111.5	120.3	132.0	132.3
82	44.9	429.0[9]	113.1	732.0[6]	132.5	980.0[7]
83	277.0[8]	283.0[6]	508.0[6]	546.0[6]	690.0[6]	615.0[6]
84	39.7	40.8	135.0	141.0	151.5	1083.0[7]
85	161.0[5]	204.0[6]	272.0[4]	354.0[5]	378.0[4]	404.0[4]
86	19.9	19.3	102.0	101.8	118.0	118.5
87	29.4	303.0[9]	108.0	116.8	136.5	134.8
88	26.7	27.9	82.5	90.3	87.8	87.8
89	264.0[4]	197.0[3]	350.0[4]	298.0[3]	454.0[4]	332.0[3]
90	53.0	54.8	134.0	131.0	135.6	145.8
91	40.3	368.0[5]	102.3	724.0[7]	131.5	958.0[7]
92	45.4	416.0[9]	89.0	91.3	109.5	111.8
93	423.0[9]	439.0[9]	572.0[7]	484.0[6]	708.0[7]	864.0[7]

14 *Correlation of Psychological and Educational Measurements*

TABLE B (continued)

Ind.	Cancelling A		Cancelling S		Copying Addresses	
	7 tests	7 tests	4 tests	4 tests	10 tests	10 tests
	1	2	1	2	1	2
1	54.6	66.7	65.5	73.5	19.6	18.3
2	42.0	298.0[6]	52.0	69.0	22.5	230.0[9]
3	47.3	50.3	43.3	46.0	16.3	18.2
4	50.9	54.1	63.0	65.6	14.7	16.6
5	200.0[6]	270.0[5]	210.0[3]	226.0[3]	22.1	188.0[3]
6	252.0[0]	276.0[6]	-5.0	86.0[3]	11.8	117.0[9]
7	43.7	56.6	40.0	35.0	13.5	15.8
8	45.1	277.0[5]	57.3	60.0	23.5	25.4
9	404.0[3]	444.0[6]	78.0	77.0	21.0	23.0
10	39.4	46.0	51.0	55.3	14.9	16.5
11	51.9	338.0[0]	49.5	148.0[3]	21.4	245.0[9]
12	203.0[5]	342.0[5]	126.0[2]	164.0[2]	58.0[5]	89.0[6]
13	69.1	70.0	61.0	66.0	25.8	28.4
14	58.0	58.9	75.3	80.5	17.1	17.6
15	88.1	87.7	85.5	83.0	17.4	19.3
16	57.1	58.1	65.3	70.8	19.0	20.1
17	29.4	35.1	34.5	44.5	16.6	157.0[9]
18	53.7	56.6	59.0	62.5	22.3	25.2
19	49.4	51.9	60.0	52.5	17.4	19.4
20	46.6	46.6	71.8	77.5	22.1	22.8
21	58.0	58.0	77.5	77.5	13.8	14.6
22	298.0[6]	46.3	64.0	79.3	18.5	160.0[9]
23	54.0	51.4	56.0	66.5	17.4	187.0[3]
24	70.8	432.0[6]	93.5	284.0[3]	26.3	246.0[9]
25	259.0[5]	304.0[3]	128.0[2]	146.0[2]	91.0[5]	96.0[5]
26	376.0[6]	65.1	75.5	75.5	20.5	22.4
27	60.6	69.3	72.0	64.5	28.9	29.3
28	250.0[6]	44.6	160.0[3]	58.0	146.0[9]	18.5
29	59.7	824.0[6]	73.5	74.5	20.6	28.9
30	258.0[6]	37.7	58.5	64.0	25.5	23.7
31	38.6	232.0[6]	60.5	62.5	158.0[9]	16.5
32	49.4	52.4	71.5	66.5	23.1	23.5
33	72.9	71.7	37.0	62.0	16.6	15.3
34	132.0[2]	154.0[3]	[0]	[0]	[0]	[0]
35	46.9	41.4	55.0	59.5	20.8	23.2
36	36.9	40.6	18.5	108.0[3]	17.0	158.0[9]
37	80.6	90.9	82.0	87.0	21.1	21.7
38	41.7	38.6	52.0	56.5	15.6	16.0
39	41.7	46.0	77.5	81.0	18.5	20.2
40	0[1]	36.0[2]	[0]	[0]	[0]	[0]
41	50.3	50.6	132.0[3]	51.5	18.9	18.8
42	318.0[0]	358.0[5]	145.0[2]	228.0[3]	29.7	26.1
43	58.3	68.3	63.5	64.5	17.5	16.8
44	75.4	73.4	68.5	67.0	148.0[8]	182.0[9]
45	55.4	65.4	76.8	86.0	25.3	249.0[9]
46	45.4	55.4	39.8	157.0[3]	21.8	23.3
47	21.1	33.1	42.0	44.0	14.7	142.0[9]
48	290.0[6]	316.0[6]	178.0[3]	209.0[3]	178.0[8]	210.0[9]
49	55.9	73.0	49.0	55.5	22.6	23.1
50	24.9	44.9	51.5	49.5	16.2	19.1
51	356.0[6]	58.3	80.5	82.0	184.0[9]	203.0[9]
52	44.6	46.3	32.5	59.5	17.4	18.0
53	65.3	70.9	68.5	69.3	21.5	23.0
54	39.7	44.9	72.0	76.0	18.1	18.8
55	42.3	43.7	48.5	53.0	19.1	19.1
56	48.9	334.0[6]	66.0	204.0[3]	14.4	130.0[9]
57	58.0	60.3	69.8	76.0	23.5	24.4
58	64.6	62.0	65.5	66.5	17.3	16.2
59	267.0[6]	49.7	170.0[3]	62.0	204.0[9]	264.0[9]
60	44.3	47.7	43.5	59.0	113.0[9]	88.0[7]
61	35.1	42.0	68.0	71.0	16.0	16.7
62	43.7	48.0	60.5	61.8	18.5	19.9
63	206.0[5]	210.0[5]	136.0[3]	174.0[3]	175.0[9]	21.8
64	100.0[3]	84.0[2]	26.0[1]	[0]	[0]	[0]
65	50.9	54.9	49.5	53.5	19.6	22.4
66	58.1	56.7	66.0	68.5	164.0[9]	19.9
67	51.7	53.7	53.0	60.0	20.5	22.6
68	53.7	58.3	73.0	212.0[3]	14.1	15.9
69	43.1	48.9	68.0	68.0	17.8	18.8
70	76.3	87.3	80.3	91.5	18.8	20.5
71	50.3	55.7	64.5	70.0	29.8	29.9
72	57.4	56.9	71.0	77.0	22.7	23.5
73	41.4	43.7	45.0	54.5	19.5	20.7

Ind	Cancelling A		Cancelling S		Copying Addresses	
	7 tests	7 tests	4 tests	4 tests	10 tests	10 tests
	1	2	1	2	1	2
79	-31.1	-28.6	26 0	27 0	178.0[9]	187.0[9]
80	52.1	54.4	62.5	61 0	21.9	23 0
81	79.1	83 1	66.5	69.5	30.5	32.5
82	68 9	432.0[6]	44 5	176.0[3]	22 0	24.7
83	226.0[5]	268 0[6]	164 0[2]	164 0[2]	202.0[9]	206 0[9]
84	56.6	66 0	62.5	78.5	19.9	22.6
85	26 0[1]	156.0[3]	32 0[1]	200.0[3]	102 0[7]	139 0[7]
86	58.6	59.4	66 0	67 5	16 1	16 3
87	45.1	339 0[6]	58.0	194 0[3]	17.5	187.0[9]
88	41 7	42 9	51.5	59.0	13 6	15 3
89	186.0[4]	168 0[3]	60 0[1]	[0]	[0]	[0]
90	72 3	83 1	86.0	94.0	21 9	24 7
91	324.0[6]	322 0[5]	252 0[3]	264.0[3]	178 0[9]	194.0[9]
92	43.1	278 0[6]	184.0[3]	182 0[3]	22 2	207.0[9]
93	65.6	69 7	61.0	184 0[3]	171.0[8]	211.0[9]

Ind.	Handwriting		Visual Vocabulary		Completion	
	10 tests	10 tests	1	2	1	2
	1	2	1	2	1	2
1	6.38	6 42	12	21	30	17
2	7.27	60 00[8]	14	13	39	37
3	7.60	6 99	21	25	29	23
4	6.04	6 15	20	28	29	24
5	7.11	53 20[8]	17	20	32	24
6	6.15	48 40[8]	33	37	8	15
7	6.66	6 79	30	27	31	26
8	4 57	4 38	11	24	38	36
9	7.58	7 17	24	31	27	24
10	5 55	5 68	18	24	38	25
11	5.87	6.62	14	15	26	32
12	65.60[8]	7 58	19	22	38	35
13	9.43	9 19	21	30	27	26
14	6 52	6 61	13	6	27	23
15	4.55	4 50	25	29	28	30
16	7.22	6 88	11	23	19	27
17	4 69	4 88	14	20	38	38
18	6 19	6 34	11	21	29	32
19	6 51	6 42	16	33	26	26
20	6 75	6 35	17	24	30	31
21	5 97	6 57	20	29	27	28
22	6 99	7 34	14	21	34	31
23	6 41	5 99	15	18	25	31
24	6 31	5 95	15	21	30	31
25	6 08	6 26	15	—	30	29
26	5 85	5 97	20	21	28	29
27	7 90	7 97	4	14	43	46
28	7 02	7 07	13	21	36	25
29	7 29	7 30	13	23	24	31
30	4 90	43 00[8]	16	17	28	33
31	47 00[8]	5 87	10	23	31	28
32	8 42	8 72	14	22	30	30
33	6 60	6 55	12	—	36	27
34	[0]	[0]	12	—	36	—
35	6 98	7 35	5	10	47	41
36	7 94	7 56	29	27	25	25
37	7 03	6 78	20	26	30	30
38	4 92	4 94	18	19	30	30
39	6 35	6 07	13	21	29	30
40	[0]	[0]	24	—	22	—
41	7 47	7 07	8	17	38	36
42	7 94	6 79	14	19	30	33
43	6 63	9 61	21	22	23	—
44	43 20[6]	42 00[6]	16	23	25	28
50	8 59	8 23	20	28	28	27
51	6 79	6 65	13	16	38	32
52	5 43	44 50[8]	18	31	27	30
53	50 00[8]	6 73	19	25	31	25
54	7 24	7 59	30	27	28	29
55	5 76	6 44	14	21	24	26
56	9 61	8 98	15	—	31	—
57	5 25	4 99	14	20	32	29
58	6 49	6 57	21	23	28	27
59	7 31	6 68	13	24	32	34
60	6 83	6 72	18	33	25	29

16 *Correlation of Psychological and Educational Measurements*

TABLE B (continued)

Ind.	Handwriting		Visual		Completion	
	10 tests		Vocabulary		Completion	
	1	2	1	2	1	2
61	5.18	5.07	15	26	29	28
62	7.33	7.62	12	15	33	37
63	5.43	5.78	18	29	30	30
64	7.03	6.92	6	—	29	—
65	7.89	63.00[8]	7	28	19	22
66	7.12	7.30	10	24	27	28
67	7.87	8.32	19	30	25	25
68	7.72	8.56	9	13	43	—
69	[0]	[0]	35	—	25	—
70	6.99	7.13	22	28	29	27
71	5.58	6.19	18	23	31	30
72	7.10	6.91	14	22	38	32
73	7.05	7.08	15	33	22	20
74	6.08	6.88	16	23	30	25
75	8.21	8.06	24	25	22	20
76	9.41	8.93	14	24	30	33
77	7.15	7.35	15	24	29	—
78	5.60	5.45	14	21	35	35
79	6.52	6.60	15	33	28	23
80	8.14	7.85	11	17	42	42
81	9.47	9.60	12	20	35	37
82	7.41	7.47	17	30	27	33
83	53.79[8]	60.80[8]	9	22	36	28
84	6.29	6.32	11	21	31	33
85	30.10[6]	37.39[6]	16	24	34	30
86	6.90	7.04	16	18	25	28
87	6.17	6.48	20	31	19	33
88	5.63	5.91	14	26	29	28
89	[0]	[0]	20	—	33	—
90	7.23	7.47	21	19	22	30
91	7.35	7.39	23	20	28	—
92	8.42	8.41	12	16	34	36
93	60.10[8]	7.32	15	23	31	23

  

Ind.	Arithmetic		Reading		Omnibus I	
	1		2		A	B
	1	2	1	2	1	2
1	1	5	21	24	41.0	41.0
2	4	5	30	36	29.0	19.0
3	4	5	23	28	42.5	39.5
4	2	2	27	27	43.0	46.0
5	4	2	24	31	30.0	30.0
6	1	1	17	12	66.0	64.0
7	2	2	19	16	43.0	43.5
8	5	4	29	28	29.5	22.5
9	5	5	23	16	32.0	39.5
10	2	2	22	31	37.5	43.0
11	4	4	31	37	32.0	47.5
12	4	6	27	43	36.0	28.0
13	4	3	18	23	32.0	41.0
14	3	4	21	23	46.0	43.0
15	1	1	26	28	32.0	31.5
16	5	3	31	32	39.0	42.0
17	0	2	29	28	44.5	44.0
18	3	2	28	32	27.5	26.0
19	3	4	26	28	35.5	38.0
20	2	4	21	33	20.5	34.5
21	1	2	26	31	54.0	44.0
22	5	3	28	31	34.0	40.0
23	4	3	24	37	25.0	32.0
24	2	4	29	34	31.5	27.0
25	2	—	29	—	31.5	—
26	2	4	24	25	30.0	39.0
27	4	5	32	43	7.5	19.5
28	1	3	25	27	39.5	24.0
29	4	4	23	35	56.0	42.0
30	3	3	26	31	25.5	25.5
31	4	3	27	28	44.0	29.5
32	1	2	25	29	17.5	29.0
33	2	—	27	28	42.5	33.0
34	2	—	28	—	25.0	—

Statistical Treatment of Results

Ind.	Arithmetic		Reading		Omnibus 1	
	1	2	1	2	A	B
35	5	3	31	46	10.5	16.0
36	5	2	25	21	61.0	44.0
37	1	3	27	26	28.5	25.5
38	5	4	25	37	42.5	30.5
39	4	4	25	33	27.0	33.5
40	0	—	20	—	36.0	—
41	5	4	25	41	15.5	4.5
42	4	3	26	40	18.0	30.0
43	4	4	28	—	32.0	—
44	4	3	24	58	33.0	30.0
50	2	1	22	22	34.0	35.0
51	3	5	28	35	28.0	13.5
52	3	4	27	32	42.0	30.0
53	4	4	23	31	38.0	34.5
54	2	3	21	19	43.0	37.0
55	4	4	28	37	28.5	36.5
56	2	—	23	—	31.0	—
57	4	3	30	41	30.0	33.0
58	3	3	24	30	51.5	27.5
59	2	3	26	33	22.5	35.0
60	5	2	30	28	40.5	35.0
61	1	4	26	28	55.5	25.0
62	3	4	25	39	28.5	19.5
63	1	3	25	25	59.5	44.0
64	3	—	30	—	8.0	8.0
65	3	2	24	20	69.0	53.0
66	1	3	25	40	26.0	34.0
67	1	3	34	26	31.5	35.5
68	5	4	28	—	18.5	17.0
69	2	—	27	—	50.0	—
70	4	3	23	23	30.0	28.5
71	2	4	26	34	28.0	30.0
72	6	6	25	34	17.0	24.5
73	2	4	25	22	39.5	44.0
74	5	5	27	31	35.0	26.5
75	4	3	23	33	43.0	43.0
76	2	4	22	26	37.0	34.0
77	2	2	21	—	36.0	26.0
78	4	5	23	35	28.5	30.5
79	4	1	25	15	59.0	64.0
80	6	5	25	40	28.5	16.0
81	5	3	28	45	23.0	13.5
82	3	3	27	28	29.5	17.0
83	0	3	21	32	28.0	41.0
84	2	4	27	32	34.5	24.5
85	5	5	29	43	27.0	27.0
86	1	3	28	33	34.5	23.0
87	1	5	25	35	38.5	30.0
88	3	5	29	37	37.5	23.0
89	5	—	24	—	34.0	—
90	1	4	9	27	38.0	39.5
91	3	2	28	—	35.5	45.0
92	4	4	23	38	25.5	31.0
93	3	5	26	27	36.5	38.5

  

Ind.	Omnibus II		Proverb	Teacher Rank	Age in months	
	A	B				
1	69.5	78.0	2	64	53	155
2	45.0	45.5	4	39	28	153
3	71.0	73.5	3	29	41	145
4	82.0	63.0	2	72	71	153
5	63.0	52.5	10	25	30	155
9	94.0	52.0	3	58	38	172
7	69.5	65.5	2	80	30	156
8	39.0	60.0	6	16	14	137
6	69.5	63.5	2	33	20	151
10	64.5	62.0	1	42	38	163
11	75.0	68.5	4	37	54	153
12	87.0	51.0	—	44	44	173
13	82.0	76.0	4	50	49	136
14	82.0	85.0	6	82	84	148
15	82.0	73.5	3	41	45	134
16	91.0	66.5	5	70	81	166
17	79.0	59.5	—	64	69	159
18	53.0	48.5	3	13	29	137
19	65.5	70.5	3	76	68	165

18 *Correlation of Psychological and Educational Measurements*

TABLE B (continued)

Ind.	Omnibus II		Proverb	Teacher Rank	Age in months	
	A	B				
	1	2		1	2	
20	80.0	58.5	3	65	63	144
21	84.5	64.5	1	61	61	139
22	81.0	53.5	—	66	67	163
23	54.0	43.0	5	26	18	145
24	78.0	47.0	4	19	11	143
25	49.5	—	—	7	8	146
26	79.0	68.0	3	78	62	182
27	24.5	22.0	11	1	4	139
28	76.0	57.5	3	84	70	155
29	81.0	83.0	7	20	26	154
30	42.0	54.0	2	31	20	150
31	78.0	65.0	3	46	45	152
32	59.0	59.5	4	55	60	162
33	82.5	61.0	2	67	79	167
34	51.0	—	—	60	62	152
35	89.0	40.0	11	4	5	194
36	76.0	74.0	—	71	57	143
37	70.5	81.5	6	29	26	161
38	75.5	60.0	5	52	34	142
39	60.5	44.5	2	18	37	150
40	101.5	—	—	63	66	166
41	59.0	29.0	11	3	1	154
42	52.0	72.0	4	22	23	147
43	73.0	—	5	36	32	146
44	64.0	51.0	7	48	31	141
45	78.5	70.0	5	29	55	146
46	47.5	44.5	3	15	9	140
47	67.0	64.0	4	35	33	150
48	88.5	55.0	—	40	48	147
49	90.5	77.0	1	86	86	163
50	60.0	63.5	5	58	40	153
51	91.5	—	4	81	78	183
52	64.5	32.0	1	38	56	147
53	80.5	65.0	4	9	13	135
54	76.0	73.0	10	45	38	160
55	81.5	75.5	3	75	65	166
56	89.5	72.0	5	43	51	137
57	50.0	43.0	5	14	6	162
58	78.0	61.5	2	69	83	156
59	34.0	34.5	13	12	32	146
60	118.0	89.0	—	87	85	196
61	63.0	66.0	5	51	52	154
62	86.0	72.0	4	74	77	155
63	36.0	39.0	13	8	12	138
64	67.0	—	—	83	73	166
65	88.5	65.0	5	24	43	133
66	82.0	61.5	2	49	59	140
67	53.0	42.5	9	19	7	151
68	79.0	67.5	5	79	58	180
69	76.0	65.5	4	11	15	142
70	83.0	55.0	3	57	50	158
71	90.5	73.5	4	47	21	151
72	72.5	67.0	8	32	35	141
73	69.5	64.5	2	21	22	149
74	80.5	86.0	—	65	87	154
75	41.5	26.0	7	6	2	142
76	47.5	46.5	2	2	3	145
77	49.5	55.5	11	5	10	132
78	80.5	62.0	2	73	70	135
79	80.5	63.5	8	56	64	143
80	79.5	33.5	4	28	42	151
81	57.5	65.0	1	68	75	145
82	84.0	61.5	5	17	24	137
83	73.0	68.0	7	34	25	144
84	65.0	—	—	62	16	138
85	94.0	83.5	4	83	47	150
86	73.5	64.5	3	77	74	182
87	62.0	58.5	9	27	17	130
88	64.0	66.5	4	23	19	154

TABLE C

CORRECTED ARRAYS: Scores or average scores made by 63 children in the tests shown at the top of the column. Under the practice tests: Column 1 = average score from odd days; column 2 = average score from even days. The number of days is shown at the top. B = boy; G = girl.

Ind	Addition		Cancelling 2		Cancelling 3	
	10	10	8	8	8	8
	tests	tests	tests	tests	tests	tests
	1	2	1	2	1	2
1B.	102.7	105.7	138.0	142.0	153.5	160.0
2B.	38.3	38.7	92.3	98.1	111.5	118.3
3B.	71.1	71.9	98.8	105.5	117.5	119.5
4G.	36.0	38.7	87.3	91.8	103.5	106.1
7G.	42.1	45.9	79.4	92.0	105.0	110.3
9B.	55.5	58.5	132.0	136.5	133.3	135.8
10B.	9.8	12.0	70.9	74.0	92.0	104.8
11B.	18.4	16.5	98.5	111.8	121.0	124.5
13B.	91.3	94.9	130.3	138.9	157.5	162.5
14B.	71.4	76.4	113.8	119.0	121.8	120.5
15G.	27.8	31.8	105.3	106.0	138.0	132.0
16B.	47.0	49.8	108.3	115.0	135.8	125.4
18G.	61.4	64.6	87.5	96.5	103.8	105.5
19G.	80.7	84.7	93.5	94.0	101.5	104.8
20G.	57.6	63.3	95.5	106.3	123.5	124.9
21G.	23.5	26.5	111.8	114.3	129.5	125.3
23B.	54.3	54.9	100.0	107.3	114.8	124.5
24G.	50.8	57.3	105.5	102.9	122.0	124.0
26G.	51.1	50.4	84.0	91.8	99.8	106.3
27G.	57.4	58.7	100.8	113.8	113.0	116.3
28G.	21.8	23.0	97.5	103.8	117.8	124.8
29B.	35.2	36.5	124.0	112.9	133.0	138.3
30B.	53.2	50.4	73.6	76.8	90.0	92.5
31B.	14.5	14.7	82.3	83.8	101.5	105.3
32B.	42.5	44.1	108.6	111.8	122.8	125.3
35B.	40.2	40.8	76.5	86.8	98.3	101.8
37G.	64.6	70.4	100.8	110.4	117.2	120.5
38B.	20.6	22.0	82.8	81.3	97.5	100.3
39G.	32.7	33.2	98.8	90.3	113.3	112.0
41B.	35.5	37.8	83.0	85.0	93.0	92.3
42B.	79.2	74.8	97.6	96.6	113.9	113.8
50G.	39.2	41.6	134.3	143.3	144.0	150.8
51G.	86.8	82.9	64.6	56.0	82.0	79.8
52G.	66.9	65.8	62.0	64.3	67.0	74.3
54G.	50.6	53.7	150.5	145.5	115.3	159.9
55B.	37.1	40.0	93.8	96.5	118.0	121.3
57G.	21.9	23.4	58.3	74.1	89.3	94.8
58B.	64.5	70.9	104.1	109.0	116.1	121.4
59B.	42.9	45.2	82.0	84.0	116.3	122.5
60B.	25.9	25.3	87.5	90.3	99.3	93.4
61B.	27.0	28.4	94.3	105.5	103.9	109.3
62B.	80.2	94.8	115.0	119.5	129.3	132.9
63G.	31.6	28.2	98.5	108.3	125.5	129.3
66B.	57.2	59.3	87.0	88.3	105.0	105.5
67B.	48.0	51.9	127.5	133.8	145.3	149.3
70G.	29.9	30.9	78.5	85.3	98.3	106.5
71B.	45.0	45.3	106.6	102.0	120.1	128.3
72B.	87.9	90.8	103.3	105.8	115.0	121.3
73B.	40.6	43.7	118.9	125.5	129.0	130.5
74G.	22.7	24.6	93.3	97.8	106.8	107.0
75G.	29.3	27.3	142.8	139.5	141.8	148.5
76B.	50.5	55.8	112.8	126.3	128.3	136.3
78B.	40.6	42.0	82.3	91.5	102.8	111.0
80B.	93.8	99.4	97.4	104.0	106.3	117.0
82G.	44.9	47.7	113.1	119.8	132.5	138.7
83G.	33.6	34.5	94.9	95.6	113.7	108.9
84G.	30.7	40.8	135.0	141.0	151.5	153.4
86G.	19.9	19.3	102.0	101.8	118.0	118.5
87G.	29.4	33.4	108.0	110.8	130.5	138.8
88B.	26.7	27.9	82.8	90.3	87.8	97.8
90B.	53.0	54.8	134.0	131.0	138.0	145.8
92B.	45.4	47.1	89.0	91.3	109.5	111.8
93B.	48.5	49.0	82.5	82.5	104.8	115.7
Av. =	47.1	49.2	99.8	104.1	115.6	119.8

TABLE C (continued)

Ind.	Cancelling A		Cancelling S		Copying Addresses		Handwriting	
	7	7	4	4	10	10	10	10
	tests	tests	tests	tests	tests	tests	tests	tests
	1	2	1	2	1	2	1	2
1B.	54.6	65.7	65.5	73.5	19.6	18.3	6.4	6.4
2B.	42.0	47.8	52.0	60.0	22.5	24.9	7.3	7.3
3B.	47.3	50.3	43.3	46.0	16.3	18.2	7.6	7.0
4C.	50.9	54.1	63.0	65.5	14.7	16.6	6.0	6.2
7C.	43.7	56.6	40.0	35.0	13.5	15.8	6.7	6.8
9B.	71.9	77.3	78.0	77.0	21.0	23.0	7.6	7.2
10B.	39.4	46.0	51.0	55.3	14.9	16.5	5.6	5.7
11B.	51.9	50.2	49.5	50.1	21.4	28.2	5.9	5.6
13B.	69.1	70.0	61.0	66.0	25.8	28.4	9.4	9.2
14B.	58.0	53.9	75.3	80.5	17.1	17.6	6.5	6.8
15C.	88.1	87.7	85.5	83.0	17.4	19.3	4.7	4.5
16B.	57.1	58.1	65.3	70.8	19.0	20.1	7.2	6.9
18C.	53.7	56.6	59.0	62.5	22.3	25.2	6.2	6.3
19C.	49.4	51.9	60.0	52.5	17.4	19.4	6.5	6.4
20C.	46.6	46.6	71.8	77.5	22.1	22.8	6.8	6.4
21C.	56.0	58.0	77.5	77.5	13.8	14.6	6.0	6.6
23B.	54.0	51.4	56.0	66.5	17.4	19.7	6.4	6.0
24C.	70.6	74.7	93.5	97.8	26.3	30.6	6.3	6.0
29C.	59.2	65.1	75.5	75.5	20.5	22.4	6.9	6.0
27C.	60.6	68.3	72.0	64.5	28.9	29.3	7.9	8.0
28C.	43.0	44.6	53.0	58.0	10.4	18.5	7.0	7.1
29B.	59.7	58.7	73.5	74.5	26.0	28.9	7.3	7.3
30B.	59.7	37.7	58.5	64.0	25.5	25.7	4.9	5.4
31B.	38.6	40.2	60.5	62.5	17.2	16.5	5.0	5.9
32B.	49.4	52.4	71.5	66.5	23.1	23.5	8.4	8.7
35B.	40.9	41.4	55.0	59.5	20.8	23.2	7.0	7.4
37C.	80.6	90.9	82.0	87.0	21.1	21.7	7.0	6.8
38B.	41.7	38.6	52.0	56.5	15.6	16.0	4.9	4.9
39C.	41.7	46.0	77.5	81.0	18.5	20.2	6.4	6.1
41B.	50.3	50.6	43.3	51.5	18.9	18.8	7.5	7.1
42B.	55.0	60.0	51.3	61.5	29.7	28.1	7.9	6.9
50G.	55.1	65.1	76.8	86.0	25.3	27.3	8.6	8.2
51G.	45.4	55.4	39.8	32.9	21.8	23.3	6.7	6.7
52C.	21.1	33.1	42.0	44.0	14.7	14.4	5.4	5.5
54G.	35.9	73.0	49.0	35.5	22.6	23.1	7.2	7.6
55B.	34.9	44.9	51.5	49.5	16.2	19.1	5.8	6.4
57C.	41.6	16.3	52.5	59.5	17.1	18.0	5.3	5.0
58B.	65.3	70.9	68.5	69.3	21.5	25.0	6.5	6.6
59B.	39.7	44.9	72.0	76.0	18.1	18.8	7.3	6.7
60B.	42.3	43.7	48.5	53.0	19.1	19.1	6.8	6.7
61B.	48.9	55.4	66.0	69.5	14.4	15.7	5.2	5.1
62B.	56.0	60.3	69.8	76.0	23.5	24.4	7.3	7.6
63C.	61.0	62.0	65.5	66.5	17.3	16.2	5.4	5.8
66B.	35.1	42.0	68.0	71.0	15.0	16.7	7.1	7.3
67B.	43.7	48.0	60.5	61.8	18.5	19.9	7.9	8.3
70C.	50.9	54.0	49.5	53.5	10.9	22.4	7.0	7.1
71B.	58.1	56.7	66.0	65.5	21.3	19.9	5.6	6.2
72B.	51.7	53.7	53.0	60.0	20.5	22.6	7.1	6.9
73B.	63.7	58.3	73.0	73.7	14.1	15.9	7.1	7.1
74C.	13.1	48.9	68.0	68.0	12.8	18.8	6.1	6.9
75C.	70.3	87.3	89.3	91.5	18.8	20.5	8.2	8.1
76B.	50.1	35.7	64.5	70.0	20.8	20.9	9.4	8.0
78B.	41.1	43.7	15.0	34.5	19.5	20.7	5.0	5.5
80B.	52.1	51.1	62.5	61.0	21.9	25.0	8.1	7.9
82C.	68.9	73.3	41.5	36.1	22.0	24.7	7.4	7.5
83C.	36.4	52.7	71.3	77.4	21.0	21.7	6.8	7.5
81C.	60.6	66.6	62.5	78.5	19.9	25.6	6.3	6.5
86C.	36.0	59.4	66.0	67.5	16.1	16.3	6.9	7.0
87C.	15.1	54.9	58.0	67.3	15.9	18.6	6.2	6.5
88B.	31.7	12.0	51.5	59.0	15.6	15.4	5.6	5.9
90B.	72.3	88.1	86.0	94.9	21.8	21.7	7.2	7.5
92B.	11.1	36.5	58.9	61.7	21.2	23.0	8.1	8.4
94B.	65.6	69.7	61.0	63.1	21.9	23.1	7.5	7.3
A.	72.1	60.7	62.5	65.0	19.8	19.9	6.7	6.8



Ind.	Visual				Arith.		Reading	
	Vocabulary		Completion		1	2	1	2
	1	2	1	2				
1	12	21	30	17	1	5	21	24
2	14	13	39	37	4	5	30	36
3	25	21	29	25	4	2	23	28
4	20	26	29	24	2	2	27	27
7	30	27	31	28	2	2	19	16
9	24	21	27	24	5	5	29	16
10	18	24	38	25	2	2	22	16
11	14	15	26	32	4	4	31	31
13	21	30	27	25	4	3	15	26
14	13	6	27	28	3	4	21	23
15	25	29	28	30	1	1	20	28
16	11	23	19	27	5	3	31	32
18	11	21	29	32	3	2	25	32
19	16	33	26	26	3	4	20	28
20	17	24	30	31	2	2	21	33
21	30	29	27	28	1	2	25	31
23	15	18	25	31	4	4	24	37
24	15	21	30	29	2	4	29	34
26	20	21	28	29	2	2	24	25
27	4	14	43	45	4	5	32	43
28	13	21	38	25	1	5	25	27
29	13	23	24	31	4	4	23	35
30	16	17	28	33	3	3	26	31
31	10	22	21	28	4	3	27	28
32	14	22	30	30	1	2	23	39
35	5	10	47	41	5	3	31	46
37	20	26	30	30	1	3	27	26
38	18	19	30	30	5	4	25	57
39	13	21	29	30	4	4	24	33
41	8	17	38	35	5	4	23	41
42	14	19	30	33	4	3	26	40
50	20	28	28	27	2	1	22	22
51	13	16	38	32	3	5	28	35
52	18	31	27	30	3	4	27	32
54	30	27	28	26	2	3	21	19
55	14	21	24	26	4	4	28	37
57	14	20	32	29	4	3	30	41
58	21	23	28	27	3	3	24	30
59	13	24	32	34	2	3	26	33
60	18	33	25	20	5	2	30	28
61	15	26	29	28	1	4	26	28
62	12	13	33	37	3	4	25	39
63	18	29	30	30	1	3	25	25
66	16	24	27	28	1	3	25	40
67	19	30	25	25	1	3	24	26
70	22	28	20	27	4	3	23	33
71	18	23	31	30	2	4	26	34
72	14	22	38	32	6	0	25	34
73	15	33	22	20	2	4	25	22
74	16	23	30	25	5	5	27	31
75	24	25	22	20	4	3	23	33
76	14	24	30	33	2	4	22	38
78	14	21	35	35	4	5	23	35
80	11	17	42	42	5	5	25	40
82	17	30	37	33	3	3	27	28
83	9	22	36	28	0	3	21	32
84	11	21	31	33	2	4	27	32
86	16	18	25	28	1	3	25	33
87	20	31	19	33	1	5	25	35
88	14	26	29	28	3	5	29	37
90	21	19	22	30	1	4	9	27
92	12	16	34	35	4	4	23	38
93	15	23	31	23	3	5	20	27
Av.	16.1	22.6	30.	29.4	2.9	3.6	25.2	31.6

22 *Correlation of Psychological and Educational Measurements*

TABLE C (continued)

Ind.	Omnibus		Pro- verb	Age in M'nths T'ch'r		Rank	School Mark	
	1	2		1	2		1	2
1	130.5	119.0	2	155	42	41	46	48
2	65.0	64.5	4	153	30	23	55	58
3	113.5	113.0	3	145	22	32	55	51
4	125.0	109.0	2	153	53	54	43	41
7	112.5	109.0	2	156	69	58	41	45
9	101.5	103.0	2	151	25	15	61	51
10	102.0	105.0	1	163	32	27	61	49
11	107.0	116.0	4	153	28	42	49	56
13	114.0	117.0	4	136	38	37	56	56
14	128.0	128.0	6	148	61	62	38	31
15	114.0	105.0	3	134	31	36	59	61
16	130.0	108.5	5	166	52	59	28	47
18	80.5	74.5	3	137	9	24	68	71
19	101.0	105.5	3	165	57	52	46	43
20	109.5	93.0	3	144	40	49	57	66
21	138.5	108.5	1	139	48	48	39	47
23	79.0	75.0	5	145	20	13	67	63
24	109.5	74.0	4	143	7	9	76	72
26	109.0	107.0	3	182	58	60	45	41
27	42.0	41.5	11	139	1	3	74	68
28	115.5	81.5	3	155	62	56	42	52
29	131.0	105.0	7	154	15	21	59	55
30	67.5	79.5	2	150	21	30	57	54
31	122.0	91.5	3	152	35	31	50	46
32	76.5	83.5	4	162	43	47	41	55
35	49.5	56.0	11	161	3	4	68	72
37	99.0	57.0	6	161	23	22	38	58
38	115.0	90.5	5	142	49	26	69	54
39	67.5	78.0	2	150	13	28	57	61
41	74.5	53.5	11	151	2	1	76	76
42	70.0	102.0	4	147	17	18	62	67
50	110.5	105.0	5	146	47	43	55	65
51	75.5	35.0	3	149	11	7	74	69
52	109.0	91.0	4	150	27	25	65	65
54	133.5	114.0	1	163	63	63	36	41
55	88.5	100.0	5	153	56	31	47	56
57	94.5	65.0	1	147	29	41	59	66
58	152.0	92.5	4	133	6	19	72	68
59	98.5	108.0	10	160	34	29	51	59
60	123.0	110.5	3	166	50	51	37	51
61	145.0	97.0	5	157	33	39	57	53
62	78.5	62.5	5	162	19	5	67	73
63	137.5	105.5	2	135	51	61	50	51
66	89.0	91.0	5	154	39	40	62	57
67	117.5	107.5	4	155	57	57	13	50
70	116.5	91.5	5	132	19	33	68	66
71	110.0	91.5	2	149	37	40	53	54
72	70.0	67.0	9	151	11	6	69	69
73	118.5	111.5	5	150	59	45	41	39
74	111.0	89.0	4	142	8	11	65	63
75	131.0	104.0	3	138	15	38	51	50
76	117.5	107.5	4	151	36	10	58	56
78	89.0	95.0	2	140	16	17	67	70
80	70.0	52.0	7	142	5	2	73	77
82	79.0	72.5	11	133	4	8	73	76
83	108.5	142.5	2	155	51	53	39	53
84	114.0	88.0	3	143	11	50	46	66
86	115.5	88.0	1	145	10	15	59	63
87	111.5	91.5	5	137	12	19	68	70
88	102.5	91.0	7	141	20	20	63	68
90	132.0	123.0	4	159	11	35	52	49
92	87.5	89.5	9	159	21	12	61	57
93	109.5	105.0	1	134	18	11	55	58
Av.	103.8	93.1	4.4	150.3	32	32	56.1	57.1

## 4. DEVIATIONS AND THEIR COMBINATION

The next step in calculating the coefficients of correlation was to turn all the scores in any one column of Table C into plus and minus deviations from the average shown at the foot of that column. These deviations are given in Table D. At the foot of each column is the square root of the sum of the deviations squared, which we shall find to be useful later. Further it will be remembered that Visual Vocabulary and the Omnibus tests were scored in terms of penalties, and what amounts to the same thing, a small measure by Teacher Rank means large excellence. To make these tests comparable to the others all their plus deviations were changed to minus and all their minus deviations to plus.

The reader will notice that two new tests appear in this deviation table. For reasons to be considered later it was found desirable to combine Visual Vocabulary with Completion. Column 1 of this new measure is the algebraic sum by individuals of the deviations of Visual Vocabulary (1) and Completion (2); Column 2 is the sum of Visual Vocabulary (2) and Completion (1). The second of these tests or measures is a Composite. Column 1 of this Composite is an algebraic total by individuals of all the column 1's of all the tests shown in Table E. Column 2 of the Composite is the same thing for all the column 2's. But contrary to the Visual Vocabulary and Completion combination, not all the tests in Table E received equal weight. The weight actually given to each half of each test is shown under "Weight given,"<sup>1</sup> in Table E. These weights were guesses, guided by what experimental evidence was then available, as to the relative value of each test as a measure of mental ability. Now the desired weighting was obtained by multiplying or dividing the deviations in any one column by the figure under "Multiple" in Table E. These figures were those which, when divided or multiplied into the square root of the sum of the deviations squared divided by ten, changed these square roots to the relative sizes shown under "Weight given" in Table E. In psychological literature such a Composite is usually taken as a measure of general mental ability.

<sup>1</sup> This weight was given before our own coefficients were calculated.

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TABLE D

## DEVIATIONS FROM THE AVERAGE OF EACH TEST

Ind.	Addition		Cancelling 2		Cancelling 3		Cancelling A	
	1	2	1	2	1	2	1	2
1	55.6	56.5	35.2	37.9	37.9	40.2	2.2	9.0
2	-8.8	-10.5	-7.5	-6.0	-4.1	-0.5	-10.4	-8.9
3	24.0	22.7	-1.0	1.4	1.9	-0.3	-5.1	-6.4
4	-11.1	-10.5	-12.5	-12.3	-12.1	-13.7	1.5	-2.6
7	-5.0	-3.3	-20.4	-12.1	-10.6	-9.5	-8.7	-0.1
9	9.4	9.3	32.2	32.4	17.7	16.0	19.5	20.6
10	-37.3	-37.2	-29.8	-30.1	-23.6	-15.0	-13.0	-10.7
11	-23.7	-32.7	-1.3	7.7	5.4	4.7	-0.5	-0.5
13	44.2	45.7	30.5	34.8	41.9	42.7	16.7	13.3
14	24.3	27.2	14.0	14.9	6.2	0.7	5.6	2.2
15	-19.3	-17.4	5.5	1.9	22.4	12.2	25.7	31.0
16	-0.1	0.6	8.5	10.9	10.2	5.6	4.7	1.4
18	14.3	15.4	-12.3	-7.6	-11.8	-14.3	1.3	-0.1
19	33.6	35.5	-6.3	-10.1	-14.1	-15.0	-3.0	-4.6
20	10.5	14.1	-4.3	2.2	7.9	5.1	-5.8	-10.1
21	-23.6	-22.7	12.0	10.2	4.9	5.5	3.6	1.3
23	7.2	5.7	0.2	3.2	-0.8	4.7	1.6	-3.3
24	3.7	8.1	5.7	-1.2	6.4	4.2	18.2	13.6
26	4.0	1.2	-15.8	-9.7	-15.8	-13.5	6.8	8.4
27	10.3	9.5	1.0	9.2	-2.8	-3.5	8.2	11.6
28	-25.3	-26.2	-2.3	-0.3	-2.2	-5.0	-8.9	-12.1
29	-19.9	-12.7	24.2	8.8	17.4	18.5	7.3	2.0
30	6.1	7.2	-20.2	-27.3	-25.6	-27.3	-12.7	-19.0
31	-32.6	-24.5	-17.5	-20.3	-14.1	-14.5	-13.8	-16.5
32	-4.6	-5.1	8.8	7.7	7.2	5.5	3.0	-4.3
35	-6.9	-8.4	-23.3	-17.3	-17.3	-15.0	-11.5	-15.3
37	17.5	21.2	1.0	6.3	1.6	0.7	28.2	32.2
38	-26.5	-27.2	-17.0	-19.8	-18.1	-19.6	-10.7	-13.1
39	5.6	4.9	-11.0	-13.8	-2.3	-7.8	-10.7	-10.7
41	-11.6	-11.4	-16.8	-19.1	-22.6	-27.5	-2.1	-6.1
42	23.1	25.6	-2.2	-7.5	-1.7	-6.0	2.6	3.3
50	-7.9	-7.6	34.5	39.2	28.4	31.0	3.0	8.7
51	39.7	33.7	-35.2	-48.1	-53.6	-40.6	-7.0	-1.3
52	19.8	10.6	-37.8	-39.8	-48.6	-45.5	-21.3	-23.6
54	3.5	4.5	50.7	41.4	32.7	31.1	3.5	16.3
55	-10.0	-9.2	-6.0	-7.6	0.4	1.5	-17.5	-11.8
57	-25.2	-25.8	-41.5	-30.0	-28.3	-25.0	-7.8	-10.4
58	17.4	21.7	4.3	4.9	0.8	1.6	12.9	14.2
59	-4.2	-4.0	-17.8	-20.1	0.7	2.7	-12.7	-11.8
60	-23.2	-23.9	-12.3	-13.8	-16.3	-24.4	-10.1	-13.0
61	-20.1	-20.8	-5.5	1.4	-11.7	-18.5	-3.8	-1.3
62	42.1	45.0	15.2	15.4	13.7	13.1	3.6	3.6
63	-15.5	-21.0	-1.3	4.2	9.9	9.5	12.2	5.3
66	10.1	10.1	-12.8	-15.8	-7.6	-11.3	-17.3	-14.7
67	0.9	2.7	27.7	29.7	29.7	29.5	-8.7	-8.7
70	-17.2	-18.3	-21.3	-18.8	-17.3	-13.3	-1.5	1.8
71	-2.1	-8.9	6.8	-2.1	4.5	6.5	5.7	0.0
72	40.8	40.6	3.5	1.7	-0.6	1.5	-0.7	-3.0
73	6.5	-5.5	19.1	21.4	13.4	16.7	1.3	1.6
74	-24.4	24.6	-6.5	-6.3	-8.8	-12.8	-9.3	-7.8
75	-17.8	-21.9	43.0	35.4	26.2	28.7	23.9	30.6
76	3.4	6.6	13.0	22.2	12.7	16.5	-2.1	-1.0
78	-6.5	-7.2	-17.5	-12.6	-13.8	-8.8	-11.0	-13.0
80	46.7	50.2	-2.4	-0.1	-9.3	-2.8	-0.3	-2.3
82	-2.2	-1.5	13.3	15.7	16.9	18.9	16.5	16.6
83	-13.5	-14.7	-4.9	-8.5	-1.9	-10.9	-6.1	-4.0
84	-7.4	-8.4	35.3	36.9	35.0	35.6	4.2	9.3
86	-27.2	-29.0	2.2	-2.3	2.4	-1.3	6.2	2.7
87	-17.7	-15.8	8.2	6.7	14.0	10.0	-7.3	-1.8
88	-20.4	-21.3	-17.0	-13.8	-27.8	-22.0	-10.7	-13.8
90	5.9	5.6	34.2	26.9	23.0	26.0	19.9	26.4
92	-1.7	-2.1	-10.8	-12.8	-8.1	-8.0	-9.3	-10.2
93	1.4	-10.2	-17.3	-21.6	-10.8	-4.1	13.2	13.0

$$\sqrt{\sum \text{Dev.}^2 = 167.3}$$

173.8

159.0

157.0

150.0

147.2

91.7

99.6

Ind.	Cancelling S		Copying Addresses		Handwriting	
	1	2	1	2	1	2
1	3.0	8.5	-0.2	-1.6	-0.3	-0.4
2	-10.5	-5.0	2.7	5.0	0.6	0.5
3	-19.2	-19.0	-3.5	-1.7	0.9	0.2
4	0.5	0.5	-5.1	-3.3	-0.7	-0.6
7	-22.5	-30.0	-6.3	-4.1	0.0	0.0
9	15.5	12.0	1.2	3.1	0.9	0.4
10	-11.5	-9.7	-4.9	-3.4	-1.2	-1.1
11	-13.0	-14.9	1.6	6.3	-0.8	-1.2
13	-1.5	1.0	6.0	8.5	2.7	2.4
14	12.8	15.0	-2.7	-2.3	-0.2	-0.2
15	23.0	18.0	-2.4	-0.6	-2.0	-2.3
16	2.8	5.8	-0.8	0.2	0.5	0.1
18	-3.5	-3.5	2.5	5.3	-0.6	-0.5
19	-2.5	-12.5	-2.4	-0.5	-0.2	-0.4
20	9.3	12.5	2.3	2.8	0.1	0.4
21	15.0	12.5	-6.0	-5.3	-0.7	-0.2
23	-6.5	1.5	-2.4	-0.2	-0.3	-0.8
24	31.0	32.8	6.5	10.7	-0.4	-0.8
26	13.0	10.5	0.7	2.5	-0.8	-0.8
27	9.5	-0.5	9.1	0.4	1.2	1.2
28	-8.9	-7.0	-3.4	-1.4	0.3	0.3
29	11.0	9.5	6.8	9.0	0.6	0.5
30	-4.0	-1.0	5.7	5.8	-1.8	-1.4
31	-2.0	-2.5	-2.6	-3.4	-1.7	-0.9
32	9.0	1.5	3.3	3.6	1.7	1.9
35	-7.5	-5.5	1.0	3.3	0.3	0.6
37	19.5	22.0	1.3	1.8	0.3	0.0
38	-10.5	-8.5	-4.2	-3.9	-1.8	-1.9
39	15.0	16.0	1.8	0.3	-0.3	-0.7
41	-19.2	-13.5	-0.9	-1.1	0.8	0.3
42	-11.2	-3.5	9.9	8.2	1.2	0.0
50	14.3	21.0	5.5	7.4	1.9	1.4
51	-22.7	-12.1	2.0	3.4	0.9	-0.1
52	-20.5	-21.0	-5.1	-5.5	-1.3	-1.3
54	-13.5	9.5	2.8	3.2	0.5	0.8
55	-11.0	-15.5	-3.6	-0.8	-0.9	-0.4
57	-10.0	-5.5	-2.4	-1.9	-1.4	-1.8
58	6.0	4.3	1.7	3.1	-0.2	-0.2
59	9.5	11.0	-1.7	-1.1	0.6	-0.1
60	-14.0	-12.0	-0.7	-0.8	0.1	-0.1
61	3.5	4.5	-5.4	-4.2	-1.5	-1.7
62	7.3	11.0	2.7	4.5	0.6	0.8
63	3.0	1.5	-2.5	-3.7	-1.3	-1.0
66	5.5	6.0	-4.8	-3.2	0.4	0.5
67	-2.0	-3.2	-1.3	0.9	1.2	1.5
70	-13.0	-11.5	0.1	2.5	0.3	0.3
71	3.5	3.5	1.5	6.9	-1.2	-0.6
72	-9.5	-5.0	0.7	2.7	0.4	0.1
73	19.5	8.7	-5.7	-4.0	0.4	0.3
74	5.5	3.0	-2.0	-1.1	-0.6	0.1
75	26.8	26.5	-1.9	0.9	1.5	1.3
76	2.0	5.0	10.0	10.0	2.7	2.1
78	-17.5	-19.5	-6.3	0.6	-1.1	-1.3
80	0.0	-4.0	2.1	3.1	1.4	1.1
82	-18.0	-8.9	2.2	4.8	0.7	0.7
83	11.8	12.4	1.2	2.4	0.1	0.7
84	0.0	13.5	0.1	2.7	-0.4	-0.3
86	3.5	2.5	-3.7	-3.6	0.2	0.2
87	-4.5	0.2	-2.3	-1.3	-0.5	-0.3
88	-11.0	-6.0	-6.2	-4.6	-1.1	-0.9
90	23.5	29.0	2.1	4.8	0.5	0.7
92	-3.6	-3.3	2.4	3.1	1.7	1.6
93	-1.5	-1.0	2.1	3.2	0.8	0.5
$\sqrt{\sum \text{Dev.}^2} =$	99.9	97.6	31.0	33.9	8.36	7.72

TABLE D (continued)

Ind.	Visual		Completion		Arithmetic	
	Vocabulary		1	2	1	2
	1	2				
1	+ 4.1	+ 1.6	00	-12.4	- 1.9	1.4
2	+ 2.1	+ 9.6	9	7.6	1.1	1.4
3	- 8.9	+ 1.6	- 1	- 6.4	1.1	1.4
4	- 3.9	- 3.4	- 1	- 5.4	- 0.9	- 1.6
7	-13.9	- 4.4	1	- 3.4	- 0.9	- 1.6
9	- 7.9	+ 1.6	- 3	- 5.4	2.1	1.4
10	- 1.9	- 1.4	8	- 4.4	- 0.9	- 1.6
11	+ 2.1	+ 7.6	- 4	- 2.6	1.1	0.4
13	- 4.9	- 7.4	- 3	- 3.4	1.1	- 0.6
14	+ 3.1	+16.6	- 3	- 1.4	0.1	0.4
15	- 8.9	- 6.4	- 2	0.6	- 1.9	- 2.6
16	+ 5.1	- 0.4	-11	- 2.4	2.1	- 0.6
18	+ 5.1	+ 1.6	- 1	2.6	0.1	- 1.6
19	+ 0.1	-10.4	- 4	- 3.4	0.1	0.4
20	- 0.9	- 1.4	00	1.6	- 0.9	0.4
21	- 3.9	- 6.4	- 3	- 1.4	- 1.9	- 1.6
23	+ 1.1	+ 4.0	- 5	1.6	1.1	0.4
24	+ 1.1	+ 1.6	00	- 0.4	- 0.9	0.4
26	- 3.9	+ 1.6	- 2	- 0.4	- 0.9	0.4
27	+12.1	+ 8.6	13	16.6	1.1	1.4
28	+ 3.1	+ 1.6	6	- 4.4	- 1.9	- 0.6
29	+ 3.1	- 0.4	- 6	1.6	1.1	0.4
30	+ 0.1	+ 5.6	- 2	3.6	0.1	- 0.6
31	+ 6.1	+ 0.6	1	- 1.4	1.1	- 0.6
32	+ 2.1	+ 0.6	60	0.6	- 1.9	- 1.6
35	+11.1	+12.6	17	11.6	2.1	- 0.6
37	- 3.9	- 3.4	00	0.6	- 1.9	- 0.6
38	- 2.1	+ 3.6	00	0.6	2.1	0.4
39	+ 3.1	+ 1.6	- 1	0.6	1.1	0.4
41	+ 3.1	+ 5.6	8	6.6	2.1	0.4
42	+ 2.1	+ 3.6	00	3.6	1.1	- 0.6
50	- 3.9	- 5.4	- 2	- 2.4	- 0.9	- 2.6
51	+ 3.1	+ 6.6	- 8	2.6	0.1	1.4
52	- 1.9	- 8.4	- 3	0.6	0.1	0.4
54	-13.9	- 4.4	- 2	- 3.4	- 0.9	- 0.6
55	+ 3.1	+ 1.6	- 6	- 3.4	1.1	0.4
57	+ 2.1	+ 2.6	- 2	- 0.4	1.1	- 0.6
58	- 4.9	- 0.4	- 2	- 2.4	0.1	- 0.6
59	+ 3.1	- 1.4	2	4.6	- 0.9	- 0.6
60	- 1.9	-10.4	- 5	- 9.4	2.1	- 1.6
61	+ 1.1	- 3.4	- 1	- 1.4	- 1.9	0.4
62	+ 4.1	+ 7.6	3	7.6	0.1	0.4
63	- 1.9	- 6.4	00	0.6	- 1.9	- 0.6
66	+ 0.1	- 1.4	- 3	- 1.4	- 1.9	- 0.6
67	- 2.9	- 7.4	- 5	- 4.4	- 1.9	- 0.6
70	- 5.9	- 5.4	- 1	- 2.4	1.1	- 0.6
71	- 1.9	- 0.4	1	0.6	- 0.9	0.4
72	+ 2.1	+ 0.6	8	2.6	3.1	2.4
73	+ 1.1	-10.4	- 8	- 9.4	- 0.9	0.4
74	+ 0.1	- 0.4	00	- 4.4	2.1	1.4
75	- 7.9	- 2.4	- 8	- 9.4	1.1	- 0.6
76	+ 2.1	- 1.4	00	3.6	- 0.9	0.4
78	+ 2.1	+ 1.6	5	5.6	1.1	1.4
80	+ 5.1	+ 5.6	12	12.6	2.1	1.4
82	- 0.9	- 7.4	7	3.6	0.1	- 0.6
83	+ 7.1	+ 0.6	6	- 1.4	- 2.9	- 0.6
84	+ 5.1	+ 1.6	1	- 3.6	- 0.9	0.4
86	+ 0.1	+ 4.0	- 5	- 1.4	- 1.9	- 0.6
87	- 3.9	- 8.4	-11	- 3.6	- 1.9	1.4
88	+ 2.1	- 3.4	- 1	- 1.4	0.1	1.4
89	- 4.9	+ 3.6	- 8	0.6	- 1.9	0.4
90	+ 4.1	+ 6.6	4	6.6	1.1	0.4
92	+ 4.1	+ 6.6	4	6.6	0.1	1.4
93	+ 1.1	- 0.4	1	- 6.4		

$$\sqrt{\Sigma \text{Dev.}^2 = 39.8}$$

43.9

42

40.9

11.3

5.58

Ind.	Reading		Omnibus		Proverb	Age in months	Teacher Rank	
	1	2	1	2			1	2
1	-4.2	-7.6	-29.7	-25.9	-2.4	4.7	-10	-9
2	4.8	4.4	+38.8	+28.6	-0.4	2.7	+2	+9
3	-2.2	-3.6	-9.7	-19.9	-1.4	-5.3	+10	-20
4	1.8	-4.6	-21.2	-15.9	-2.4	2.7	-21	+2
7	-6.2	-15.6	-8.7	-15.9	-2.4	5.7	-28	-26
9	3.8	-15.6	+2.3	-9.9	-2.4	6.7	+7	+17
10	-3.2	-0.6	+1.8	-11.9	-3.4	12.7	+0	+5
11	5.8	5.4	-3.2	-22.9	-0.4	2.7	+4	+10
13	-7.2	-5.8	-10.2	-23.9	-0.4	-14.3	-6	-5
14	-4.2	-8.6	-24.2	-34.9	-1.6	-2.3	-29	-30
15	0.8	-3.6	-10.2	-11.9	-1.4	-16.3	+1	-4
16	5.8	6.4	-26.2	-15.4	0.6	15.7	-20	-27
18	2.8	0.4	+23.3	+18.6	-1.4	-13.3	+23	+8
19	0.8	-3.6	+2.8	-12.4	-1.4	14.7	-25	-20
20	-4.2	1.4	-6.7	+0.1	-1.4	-6.3	-17	-19
21	0.8	-0.6	-34.7	-10.4	-3.4	-11.3	-16	-17
23	-1.2	5.4	+24.8	+18.1	0.6	-5.3	+12	+19
24	3.8	2.4	-5.7	+19.1	-0.4	-7.3	+25	+23
26	-1.2	-6.6	-5.2	-13.9	-1.4	31.7	-26	-28
27	6.8	11.4	+61.8	+51.6	6.6	-11.3	+31	+29
28	-0.2	-4.4	-11.7	+11.6	-1.4	4.7	-30	-24
29	-2.2	3.4	-27.2	-11.9	2.6	3.7	+17	+11
30	0.8	-0.6	+30.3	+13.6	-2.4	-6.3	+8	+2
31	1.8	-3.6	-15.2	-1.4	-1.4	1.7	-3	-2
32	-0.2	7.4	+27.3	+4.6	-0.4	11.7	-11	-16
35	5.8	14.4	+54.8	+27.1	6.6	13.7	+29	+28
37	1.8	-5.6	+4.8	+20.1	3.6	10.7	+9	+6
38	-0.2	5.1	-11.2	+2.6	0.6	-8.3	-8	+4
39	-0.2	1.1	+16.3	+15.1	-2.4	-0.3	+19	+4
41	-0.2	9.4	+29.3	+49.6	6.6	3.7	+30	+31
42	0.8	8.4	+33.6	-8.9	-0.4	3.3	+15	+14
50	-3.2	-9.6	-6.7	-11.9	0.6	-4.3	-15	-11
51	2.8	3.4	+29.3	+35.1	-1.4	-10.3	+21	+25
52	1.8	0.4	-5.2	-6.9	-0.4	-0.3	+6	+7
54	-4.2	-12.6	-29.7	-29.9	-3.4	12.7	-31	-31
55	2.8	5.4	+15.3	-6.9	0.6	2.7	-14	+1
57	4.8	9.4	+9.3	+28.1	-3.4	-3.3	+3	-12
58	-1.2	-1.6	-28.2	+6.6	-0.4	-15.3	+20	+22
59	0.8	1.4	+3.3	-14.9	5.6	9.7	-2	+3
60	4.8	-3.6	-18.2	-17.4	-1.4	15.7	-24	-13
61	0.8	-3.6	-41.2	-3.9	0.6	-13.3	-1	-7
62	-0.2	7.4	+25.3	+30.6	0.6	11.7	+22	+27
63	-0.2	-6.6	-33.7	-12.4	-2.4	5.7	-19	-29
66	-0.2	8.4	+14.8	-0.9	0.6	3.7	-7	-8
67	-1.2	-5.6	-13.7	-14.4	-0.4	4.7	-23	-25
70	-2.2	1.4	-12.7	+1.6	0.6	-17.3	+13	-1
71	0.8	2.4	-6.2	+1.6	-2.4	-19.3	-5	-15
72	-0.2	2.4	+33.8	+20.1	4.6	0.3	+18	+26
73	-0.2	-9.6	-14.7	-18.4	0.6	29.7	-27	-14
74	1.8	-0.6	-7.2	+4.1	-0.4	-8.3	+24	+21
75	-2.2	1.4	-27.2	-19.9	-1.4	7.7	-13	-6
76	-3.2	4.4	-13.7	-14.4	-0.4	0.7	-4	+16
78	-2.2	3.4	+14.8	-1.9	-2.4	-10.3	+16	+15
80	-0.2	8.4	+33.8	+41.1	2.6	-8.3	+27	+30
82	1.8	-3.6	+24.8	+20.6	0.6	-18.3	+28	+24
83	-4.2	0.4	-4.7	-49.4	-2.4	4.7	-22	-21
84	1.8	0.4	-10.2	+5.1	3.6	-7.3	-12	-18
86	2.8	1.4	-14.7	+5.1	-3.4	-2.3	-18	-23
87	-0.2	3.4	-7.7	+1.6	0.6	-13.3	+20	+13
88	3.8	5.4	+1.3	+2.1	2.6	-6.3	+6	+12
90	-16.2	-4.6	-28.2	-29.9	-0.4	-0.3	-9	-3
92	-2.2	6.4	+16.3	+3.6	4.6	-0.3	+11	+20
93	0.8	-4.6	+3.3	-11.9	-0.4	3.7	+14	+18

$$\sqrt{\sum \text{Dev}^2 = 28.7} \quad 49.5 \quad 180.0 \quad 164.0 \quad 20.7 \quad 82.6 \quad 144.3 \quad 144.3$$

TABLE D (continued)

Ind.	School Mark		Composite		Visual Vocabulary + Completion	
	1	2	1	2	1	2
	1	-10.0	-0.4	-31.3	-46.8	-8.3
2	-1.1	0.0	80.2	83.2	9.5	18.6
3	-1.1	-6.4	-15.4	-40.8	-15.3	0.6
4	-13.1	-16.4	-68.3	-96.4	-9.3	-4.4
7	-15.1	-12.4	-68.3	-115.1	-17.3	-3.4
9	4.9	-6.4	28.7	-20.8	-13.3	-1.4
10	4.9	-8.4	-14.6	-72.1	-6.3	6.6
11	-7.1	-1.4	5.3	1.8	4.7	3.6
13	-0.1	-1.4	-5.3	-2.5	-8.3	-10.4
14	-18.1	-26.4	-59.2	-23.1	1.7	13.5
15	2.0	3.0	-25.2	-65.9	-8.3	-8.4
16	-18.1	-19.4	-49.4	-35.3	2.7	-11.4
18	11.9	13.6	56.0	37.7	7.7	0.6
19	-10.1	-14.4	-28.5	-61.5	-3.3	-14.4
20	0.9	8.6	-23.5	16.8	0.7	-1.4
21	-17.1	-10.1	-91.1	-84.0	-5.3	9.4
23	10.9	6.6	32.4	59.5	2.7	-0.4
24	19.9	14.6	47.8	77.1	0.7	1.8
26	-8.1	-16.4	-46.8	-52.5	-4.3	-0.4
27	17.9	10.6	153.6	184.3	28.7	21.6
28	-14.1	-5.4	-48.7	-41.9	-1.3	7.6
29	2.9	-5.4	-10.2	16.2	4.7	-0.4
30	0.9	-3.4	31.3	14.2	3.7	3.6
31	-6.1	-11.4	-24.6	-52.2	4.7	1.6
32	-15.1	-2.4	-0.3	2.9	2.7	0.6
35	11.9	14.6	158.5	127.0	22.7	29.6
37	1.9	0.6	11.4	43.6	-3.3	-3.4
38	3.9	-3.4	-22.0	2.3	-1.5	3.5
39	0.9	3.0	33.5	28.1	3.7	0.6
41	19.9	16.6	96.8	113.9	14.7	13.6
42	5.9	-0.1	73.0	26.0	5.7	3.6
50	-1.1	7.6	-19.2	-37.0	-6.3	-7.4
51	17.9	11.6	78.5	83.1	5.7	14.6
52	-8.9	-7.6	-26.1	-19.7	-1.3	-11.4
54	-20.1	-13.4	-21.5	-74.2	-27.3	-6.4
55	-0.1	-11.4	-15.2	-22.2	-1.3	-4.4
57	2.9	8.6	14.3	23.5	1.7	4.6
58	25.9	10.6	9.2	20.1	-7.3	-2.4
59	-2.1	1.6	-1.2	-7.2	7.7	0.6
60	-19.1	-6.4	-56.9	-164.4	-11.3	-15.4
61	-1.1	0.6	-72.1	-30.6	-0.8	-4.4
62	12.9	15.6	54.8	132.6	11.7	10.6
63	-6.1	-6.4	-68.5	-60.8	-1.3	-6.4
66	5.9	-0.4	15.8	-6.8	-1.3	-4.4
67	-13.1	-7.4	-65.6	-60.7	-7.3	-12.4
70	1.9	8.6	-23.7	-18.2	-8.3	-6.4
71	1.9	-1.4	-6.2	2.7	-1.3	0.6
72	12.9	11.6	115.7	95.0	4.7	8.6
73	-15.1	-18.4	-72.2	-94.2	-8.3	-18.4
74	9.9	-4.4	9.7	-5.8	-4.3	-0.4
75	-5.1	-7.4	-47.8	-24.6	-17.3	-10.4
76	1.9	-1.4	-9.3	33.8	5.7	-1.4
78	10.9	12.6	41.3	44.5	7.7	6.6
80	16.9	19.6	132.0	160.9	17.7	17.6
82	16.9	18.6	87.6	55.4	2.7	-0.4
83	-17.1	-4.4	-41.7	-75.4	5.7	6.6
84	-10.1	8.6	-8.6	40.8	8.7	2.6
86	-6.1	8.6	-62.0	-13.3	-1.3	-0.4
87	11.9	12.6	-42.8	40.5	-0.3	-19.4
88	6.9	10.6	-5.9	12.0	0.7	-4.4
90	-4.1	-8.4	-89.6	-12.5	-4.8	-4.4
92	7.9	-0.4	46.2	51.3	10.7	10.6
93	-1.1	-1.4	14.8	-21.6	-5.3	6.6

$$\sqrt{\sum \text{Dev.}^2 = 87.2}$$

80.3

452.0

508.0

73.5

74.0



TABLE E

## WEIGHTS GIVEN TO EACH TEST IN EVOLVING A COMPOSITE MEASURE

Multiple = the number by which the deviations of the tests to the left were multiplied or divided to secure the desired weighting.

		Sq. root of Sum Dev. <sup>2</sup> Divided by 10*		Multiple		Weight Given
Addition	1	16.73	÷	4	=	4.2
"	2	17.38	÷	4	=	4.3
Cancelling 2	1	15.90	÷	5	=	3.2
"	2	15.70	÷	5	=	3.1
Cancelling 3	1	15.00	÷	5	=	3.0
"	2	14.72	÷	5	=	2.9
Cancelling A	1	9.17	÷	5	=	1.8
"	2	9.96	÷	5	=	2.0
Cancelling S	1	9.99	÷	5	=	2.0
"	2	9.76	÷	5	=	2.0
Copying Addresses	1	3.10	×	1	=	3.1
"	2	3.39	×	1	=	3.4
Visual Vocabulary	1	3.98	×	1	=	4.0
"	2	4.39	×	1	=	4.4
Completion	1	4.29	×	3	=	12.9
"	2	4.09	×	3	=	12.3
Arithmetic	1	1.13	×	8	=	9.0
"	2	0.86	×	8	=	6.9
Reading	1	2.87	×	2	=	5.7
"	2	4.95	×	2	=	9.9
Omnibus	1	18.00	×	1	=	18.0
"	2	16.45	×	1	=	16.5
Teacher Rank	1	14.43	÷	2	=	7.2
"	2	14.43	÷	2	=	7.2
School Mark	1	8.72	×	1	=	8.7
"	2	8.03	×	1	=	8.0

\* This figure has no special significance.

## 3. CALCULATION OF RAW COEFFICIENTS OF CORRELATION

A coefficient of correlation is a numerical statement of the proportionality between two series of measures. If the excellence of the scores made by a number of individuals in one test is exactly proportional to the excellence attained by the same individuals in another test, the correlation is positive and perfect. Using  $r$  as an abbreviation for correlation:  $r = +1$ . If the proportionality is exactly inverse,  $r = -1$ . If there is no tendency to proportionality at all,  $r = 0$ . If there is a tendency to proportionality  $r$  is either a positive or negative decimal according to the direction of the tendency.

The standard method<sup>1</sup> has been used in calculating all the coefficients of correlation. This method is expressed by the Pearson formula:

$$r = \frac{\sum xy}{\sqrt{\sum x^2} \sqrt{\sum y^2}}$$

<sup>1</sup> The Bravais-Galton-Pearson method.

Referring to Table D the method of calculating the  $r$  for, say, Addition (1) and Cancellation 2 (1) was, *viz.*: The deviations in the Addition (1) column were considered  $x$ 's while the deviations in the other column were  $y$ 's. The numerator of the formula was obtained by getting an algebraic sum of the products of every  $x$  multiplied by its corresponding  $y$ . The figures at the foot of the two columns being correlated were the denominators of the formula. Given these,  $r$  was easily calculated. By employing this method the first measure of every test was correlated with its second measure; some measure of every test was correlated with some measure of every other test; in certain instances, every column of a few tests was correlated with every other column of certain other tests. These first coefficients are called *raw coefficients*.

#### 4. CALCULATION OF CORRECTED COEFFICIENTS OF CORRELATION

Thanks to the excellent work of Spearman, we now know that these raw coefficients are not true representations of the proportionality between measures or functions. He discovered that chance inaccuracies in the original scores did not balance themselves out but that they always tended to reduce the correlation toward zero.<sup>1</sup> The correlation was said to be "attenuated." The next step in this study was to correct the raw coefficients for attenuation. There was used for this purpose Spearman's formula:

$$r_{pq} = \frac{\sqrt{(r_{p_1q_1}) (r_{p_1q_2}) (r_{p_2q_1}) (r_{p_2q_2})}}{\sqrt{(r_{p_1p_2}) (r_{q_1q_2})}}$$

where, if A and B are the facts to be related,  $p$  is a series of exact measures of A,  $q$  is a related series of exact measures of B.  $r_{pq}$  is the coefficient of correlation of A and B, obtainable from the two series  $p$  and  $q$ , thus being the true coefficient.  $p_1$  and  $p_2$  are two independent series of measures of A.  $q_1$  and  $q_2$  are two independent series of measures of B.  $r_{p_1q_1}$  is the correlation when the first measure of A and the first measure of B are used.  $r_{p_1q_2}$  is the correlation when the first measure of A and the second measure of B are used and so on for the remaining

<sup>1</sup> For a criticism of Spearman's assumption see Brown, *The Essentials of Mental Measurement*.

symbols. It is now clear why two measures for each individual in every test were necessary. Without two measures the raw coefficient is the best measure obtainable.

The raw intercorrelations among all the tests (except the practice tests) for which there were double measures, were calculated for every column with every other column in that group. This group also included the Composite. These raw coefficients supplied all the necessary data for calculating the true coefficients from the Spearman formula. Now the practice tests gave much more reliable measures for each individual; hence, whenever a practice test was being correlated with any other test just enough coefficients were calculated to satisfy the shorter correction formula:

$$r_{pq} = \frac{\sqrt{(r_{p_1q_1}) (r_{p_2q_2})}}{\sqrt{(r_{p_1p_2}) (r_{q_1q_2})}}$$

By the use of either of these two formulas the *corrected* coefficient or the true correlation was found for every test or function which was measured twice. The Age of Reaching the Grade, while really one measure, was treated as though split exactly in two,  $r_{q_1q_2}$  in the shorter formula thus being considered as  $\frac{1}{2}$ . This left only one test uncorrected. Table F gives the corrected coefficients or the true correlations between the tests and the functions which they measured. A gap in the table means that the true coefficient is substantially zero. The correction at that place was impossible either because one of the raw coefficients turned out zero or because one was a small positive and the other a small negative. In either of these cases the correction formula fails to work.

The shorter correction formula above is the same as the longer formula except that two symbols have been omitted from the numerator. Theoretically, it would have been better to have retained the omitted and omitted the retained symbols, but, practically, the difference in correction is insignificant. The longer formula is to be preferred but the time required often makes its use prohibitive.

TABLE F  
CORRECTED PEARSON COEFFICIENTS OF CORRELATION

	Addition	Cancelling 2	Cancelling 3	Cancelling A	Cancelling S	Copying Addresses	Handwriting	Visual Vocabulary	Completion	Arithmetic	Reading	Omnibus	Age	Teacher Rank	School Mark	Composite
Addition	.....															
Cancelling 2	.21	.....														
Cancelling 3	.19	.94	.....													
Cancelling A	.19	.61	.69	.....												
Cancelling S	.04	.61	.40	.61	.....											
Copying Addresses	.37	.31	.30	.36	.25	.....										
Handwriting	.31	.49	.46	.57	.12	.52	.....									
Visual Vocabulary	.10	.28	.20	.27	.12	.03	.03	.....								
Completion	.17	.36	.35	.19	.19	.40	.12	.93	.....							
Arithmetic	.32	.13	.19	.21	.21	.18	.12	.53	.45	.....						
Reading	.17	.63	.60	.36	.21	.18	.45	.82	.72	.52	.....					
Omnibus	.25	.41	.42	.19	.22	.32	.12	.73	.98	.86	.97	.....				
Age	.04	.05	.10	.05	.05	.13	.03	.04	.23	.04	.08	.08	.....			
Teacher Rank	.24	.27	.29	.11	.11	.40	.03	.40	.75	.72	.78	.42	.42	.....		
School Mark	.21	.28	.27	.11	.09	.27	.38	.38	.73	.49	.64	.72	.63	.91	.....	
Composite	.37	.18	.18	.18	.09	.27	.23	.80	.96	.72	.81	1.00	.26	.80	.91	.....

## 5. RELIABILITY COEFFICIENTS

The significance of the corrected  $r$ 's shown in Table F is dependent on their reliability. This reliability is in turn dependent on the number of subjects used and the amount of correction that has been applied. The "reliability coefficient" or the raw  $r$  for two separate measures of any one test indicates the amount of this correction. The corrected  $r$  for two tests whose reliability coefficients are exceedingly small is of doubtful value. Some of the factors<sup>1</sup> which make for high reliability coefficients are: that the function tested be narrow; that the time spent in testing be long; that the test material and experimental technique for the two tests be identical; and that there be no large variation in the condition of the subjects. The reliability coefficient for every test having a double measure is shown in the table of raw coefficients further on in this book, but for convenience they are summarized below.

TABLE G

RELIABILITY COEFFICIENTS, TOGETHER WITH THE TOTAL TIME SPENT ON THE TEST OR TESTS COMPOSING EITHER ONE OF THE TWO CORRELATED MEASURES

Addition, 100 minutes (10 tests).....	.99
Cancelling 2, 8 minutes (8 tests).....	.97
Cancelling 3, 8 minutes (8 tests).....	.96
Cancelling A, 7 minutes (7 tests).....	.95
Cancelling S, 4 minutes (4 tests).....	.93
Copying Addresses, 100 minutes (10 tests).....	.92
Handwriting, 40 minutes (10 tests).....	.94
Visual Vocabulary, 30 or less minutes (1 test).....	.53
Completion, 30 or less minutes (1 test).....	.59
Arithmetic, 30 or less minutes (1 test).....	.41
Reading, 30 or less minutes (1 test).....	.37
Omnibus, 60 or less minutes (2 tests).....	.71
School Mark, 1 semester.....	.83
Teacher Rank.....	.92
Composite.....	.89

The very, very high reliability of the tests from Addition through Handwriting is due chiefly to the narrowness of the functions tested, the similarity of the test material and also, in the case of Copying Addresses and Addition, to the relatively large amount of time spent on the tests. Intercorrelation among these tests scarcely needed correction. The reliability of Arith-

<sup>1</sup> These factors do not grow out of our data.

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metic and Reading is unsatisfactory; that of Visual Vocabulary and Completion leaves something to be desired; all the rest are satisfactory. The coefficient for Teacher Rank is surprisingly large, due probably to the close coöperation of the two teachers in teaching the same children. So, with regard to reliability, the only corrected coefficients which need to be closely scrutinized are those with Arithmetic and Reading.

We have spoken of the reliability of the tests as dependent on the amount of the correction. It is important to know the reliability of any particular coefficient derived from these tests. This is dependent on the number of cases or the number of individuals. P. E. is the measure of this reliability according to the formula:

$$P. E. = \frac{.6745 (1 - r^2)}{\sqrt{n}}$$

where  $r$  = actual coefficient of correlation and

$n$  = number of cases included. If the number of cases were infinite the reliability would be absolute. We have always used sixty-three cases, hence

$$P. E. = \frac{.67 (1 - r^2)}{\sqrt{63}}$$

Using this formula we get:

PROBABLE ERROR OF THE COEFFICIENTS OF CORRELATION

$r$	P. E.
.1	.08
.2	.08
.3	.08
.4	.07
.5	.06
.6	.05
.7	.04
.8	.03
.9	.02

## IV

### CONSIDERATION OF PROBLEMS AND COMPARISON OF RESULTS WITH THOSE OF OTHER EX- PERIMENTERS

#### 1. WHAT ARE THE INTERCORRELATIONS AMONG SOME RECENT EDUCATIONAL AND VOCATIONAL MEASUREMENTS AND CER- TAIN TRADITIONAL TESTS?

The first problem which this study set out to attack has now been solved. The corrected coefficients given in Table F are the answer. Since these correlations will be considered in connection with other problems, a detailed discussion at this place would be tedious. In interpreting the corrected  $r$ 's the reader should remember one fact in addition to the cautions given in the preceding chapter. Handwriting was scored by amount copied and no attention was given to the quality of the penmanship. A large score in this test might mean that the quality of the writing had been sacrificed. On the other hand, it might be contended, from a study of the penmanship of men of great ability, that increased speed and decreased quality both correlate very highly with mental power. With no evidence to offer, the author prefers to leave the matter to the opinion of the reader.

#### 2. WHAT IS THE ORDER OF EACH TEST'S CORRELATION WITH MENTAL ABILITY?

Before this problem can be solved we must have some measure of mental ability. This study proposes three different standards by which to measure each test.

The first standard includes all the available measures which are outside our psychological tests. The ideal standard would be one which properly weighted all the activities in the life of an individual. A complete standard would take into account not

only how well one does in a psychological test but also what kind of grade is made in school, what kind of opinion the teachers have, how well the games of ball are played, the papers sold, the errands run, etc. Of all these things there are, outside the psychological tests, just two measures available: Teacher Rank and School Mark. The value of these two measures as one of our standards consists in the fact that they represent an attempted weighting of numerous activities, and that they are measures free from any preconceived opinions of this study. The corrected  $r$ 's in Table F for Teacher Rank and School Mark have been averaged for each test, and the positive size of this average has been taken as that test's correlation with mental ability.

The second standard used is the correlation of each test with the Composite. The Composite combines the standard just described with the psychological tests. Possibly the Composite gives too much weight to the Cancellation tests but, in view of the later discussions of this book, it is perhaps wiser to err in this direction. All considered, the writer believes this to be the best measure of mental ability available for this study.

The third standard by which to determine the value of a test as a measure of mental ability is the average of that test's correlations with all the other tests. But immediately we get into a difficulty, a difficulty which was minimized in connection with the use of the Composite as a standard. A glance at Table F will show that there are at least two distinct groups of tests which oppose each other: the Cancellation group and the group represented by the Complex tests. In evolving the Composite measure, this difficulty was surmounted by arbitrarily giving a relatively small weight to the Cancellation tests. But with the third standard where equal weight is given to each correlation the Cancellation group will exert an important influence. Obviously, it would not be fair to give as much weight to five Cancellation tests as to five other separate tests, especially when the Cancellation group measures such a narrow function. If there were just one such test the matter would not be so serious. If the Cancellation tests are good measures of mental ability then the Complex tests are not. In this dilemma our first standard proves its worth. Teacher Rank and School Mark, admitted by all experimenters to have considerable value as measures of men-



tal ability, vote against the Cancellation group. Further, common sense shows that the other group measures a wider range of abilities. Moreover, any one test in the Complex group shows a wider range of positive correlation. Consequently, no test will be used for the third standard that does not show a distinct positive correlation with the first standard. This eliminates Age, Handwriting, and the Cancellation tests.

Using these three standards the order of each test's correlation with mental ability is shown in Table H.

TABLE H

ORDER OF CORRELATION OF EACH TEST WITH MENTAL ABILITY BY STANDARDS 1, 2 AND 3 AND BY AN AVERAGE OF THE THREE. (Data from Table F)

	Teacher Rank and School Mark	Composite	All other tests	Average
Omnibus	.75	1.00	.66	.80
Completion	.73	.96	.64	.78
Teacher Rank		.86	.63	.75
School Mark		.91	.54	.73
Reading	.68	.81	.53	.67
Arithmetic	.62	.72	.49	.61
Visual Vocabulary	.44	.80	.56	.60
Copying Addresses	.34	.54	.39	.39
Addition	.23	.37	.20	.27
Handwriting	.02	.22	.13	.12
Cancelling A	.00	.00	-.08	-.03
Cancelling S	-.10	.00	-.09	-.06
Cancelling 2	-.28	-.18	-.23	-.23
Cancelling 3	-.28	-.18	-.24	-.23
Age	-.50	-.26	-.19	-.25

In studying Table H it is important that the reader remember that a coefficient of correlation from arrays of averages is not necessarily the same thing as an average of several coefficients of correlation. An example of the former are the coefficients in the column under Composite, while an example of the latter are the coefficients in the other three columns. But our problem is not now to discover the absolute coefficient of correlation between any one test and mental ability; it is to rank the tests relatively, i.e., which test correlates most closely, which second, which third, etc. Each of the three standards should give substantially the same ranking to each test. In fact, the agreement

is remarkable. The average of the ranking by the three standards is practically the same as the ranking by any one of the standards. This average can be taken as the answer to our problem.

### 3. HOW CLOSE IS THE CORRELATION OF EACH TEST WITH MENTAL ABILITY?

The answer to the above problem depends upon which standard is accepted as the best measure of mental ability. Omnibus correlates .75 with Standard 1, 1.00 with Standard 2, and .66 with Standard 3. Which is the truest coefficient? To trust to an average of the three, as was done in section 2, would merely serve to conceal glaring differences. The Composite is better than Standard 1 because it includes Standard 1 along with many other valuable measures. Standard 3 or the correlation of each test with all others gives an equal weight to all the measures composing it, but all three standards agree that all the tests do not equally measure mental ability. The Composite gives a weighting which is, at least, roughly correct. Strictly speaking, the correlation of a test with all other tests taken separately is a measure of a test's correlational spread rather than an absolute measure of its closeness of correlation with all these separate abilities considered together. So far as the question under consideration goes, Standard 3 assumes that, disregarding chance errors in measurement, any one test is as good a measure of mental ability as any other and that any one test is as good as all averaged together. The Composite, on the other hand, considers a sum of properly weighted abilities a better measure of mental ability than any one of them taken separately. For these reasons this study considers the Composite the best available measure for determining the absolute correlation between any one test and mental ability.

Since we are hopelessly immersed in theory, we may as well consider the most important objection likely to be offered to the Composite. It might be said that the Composite causes a test to show a spuriously high correlation with mental ability because it is composed of the tests which are to be correlated with it. On the contrary it might be argued that to eliminate Completion, say, from the Composite before correlating it with the Composite would unfairly reduce the correlation, for mental ability means

the ability to do Completion as well as the ability to do the thousand and one other things which enter into complete living. To strike a true balance between these two contentions would be difficult<sup>1</sup> if not impossible, consequently the Composite has been retained in its original form.

Using, then, the Composite as a standard, the closeness of the correlation of each test with mental ability is shown in column 2 of Table H. This column reveals five interesting facts:

a. Omnibus and Completion correlate perfectly with mental ability. To be exact, Completion correlates  $+.96$ .

b. Seven of the tests correlate closely with mental ability.

c. The Cancellation tests give a *negative* correlation with mental ability.

d. The Age of Reaching the Grade also correlates negatively with mental ability.

e. The coefficients for the tests which measure power are in every case larger than the coefficients for the tests which measure *speed*.

#### 4. WHAT IS THE PRACTICAL SIGNIFICANCE OF THESE FACTS FOR EDUCATIONAL AND VOCATIONAL DIAGNOSIS AND GUIDANCE?

Before considering each of the above facts in the light of the problem just stated it is interesting to consider another question: just what is the need for measuring mental ability? The pseudo-philosopher derives his greatest pleasure from discoursing upon the negative correlation which exists between the academic and the real world. In one respect at least this antagonism no longer exists. The most persistent demand that has come to the psychologist in the last few years has been, that he develop a means for measuring that most elusive yet pre-eminently valuable thing which we call mental ability. And this call comes from school and factory alike.

The school wants to adjust its training to the individual differences of the pupils. How can it measure these differences, is the question asked of the psychologist. The principal wishes to classify a group of children by ability. How measure the ability? The junior high school wishes to put in one group the supernormal

<sup>1</sup> There is a statistical method by which the amount of spurious correlation can be determined.

pupils, in another group the normal, and in another the subnormal. How be certain the pupil is not wrongly placed? Educators realize that some pupils simply haven't the ability to deal with mental elements, abstract symbols and the like. Which pupils? A class for mentally defective children is being formed. Who should be in the class? A college in the West is planning to select its Freshman class on the basis of mental tests. Are the tests valid measures of mental ability? Experimenters everywhere wish to form groups of equal ability. By what standard shall they be called equal? Sociologists wish to discover if unemployment is the result of mental defectiveness. How gauge the mentality? Makers of mental tests desire a standard by which to measure their own product. What standard is reliable? The youthful yet virile science of vocational guidance wants to prevent or diminish the present fearful misdirection of energy. Business is little less clamorous, but no more need be said to show the very great importance of discovering excellent measures of general ability as well as tests for special powers. Now let us return to the significance of the facts reported in the last section. The first of these was:

(a) *The Omnibus and Completion Tests Correlate Perfectly with Mental Ability*

The problem of measuring every single activity of an individual in order to determine his general mental ability, is, of course, impossible of solution. So psychology has been trying to find a few measures which epitomize all possible measures. So far as the writer is informed, the test which has received the most favorable mention in this connection has been the Ebbinghaus Mutilated Text. The Completion Test, mentioned above, is a development by Dr. Trabue of Ebbinghaus' idea. This study finds ample justification for the high favor accredited the Ebbinghaus Test and it congratulates Dr. Trabue upon a modification of it which is likely to prove still more valuable. If we remember that mental ability means mental ability as measured by our Composite, the Completion Test correlates with it  $+ .96$ . The correlation is not exactly perfect but it is very nearly so.

This study is equally pleased to congratulate Dr. Thorndike upon having compiled and in part devised the Omnibus Test

which correlates  $+ 1.00$  with our Composite. The Completion Test was given for thirty minutes, the Omnibus for sixty minutes. Does this correlation of  $+ 1.00$  mean that a test has at last been devised which gives a perfect measure of an intellect by one hour of testing? It must not be forgotten that the  $+ 1.00$  is a corrected coefficient. Were the  $1.00$  a raw coefficient and were the Composite adequate the above question could be given an affirmative answer. The corrected coefficient  $+ 1.00$  means that were an individual measured enough times with the Omnibus Test to be certain of an accurate score, then that individual would have as perfect a measure as if he had been given all the tests composing the Composite. How many times and how long each time a person would have to be tested in order to give a perfect<sup>1</sup> measure of him in any one function is for a future research to determine. But granting the Composite is not an adequate measure of mental ability and granting the correction is a little too large, the fact remains that the Completion Test and Omnibus Test are very excellent ones. But because of the multiplicity of mental functions and the variability of their performances it is wise to give several types of tests and possibly to secure several measures for each type. This brings us to the second significant fact mentioned a few pages back:

(b) *Seven of the Tests Correlate Closely with Mental Ability*

Since it is wiser to trust to several tests than to one or two, those interested in educational and vocational diagnosis, guidance, and classification as well as vocational selection will want advice as to what tests this study would recommend. Of the fourteen measures used, we consider the following to be the best and most reliable indices of intellect: Omnibus, Completion, Visual Vocabulary, Teacher Rank, School Mark, Reading and Arithmetic. The first five tests are the best. An average from them will give a good measure of an individual's ability, and that with the expenditure of just two hours in actual testing. The difficulty of the purely psychological tests could be varied to suit the ability of the group being tested. It ought not be long until other tests are devised which can be added to this small group. It is not too much to hope that the near future will

<sup>1</sup> This term is used loosely, for psychology is far from agreement as to what constitutes a perfect measure.

find psychologists able to measure general mental ability very accurately for a group of any size after one day of testing. Until that time comes we now have tests which will measure intellect roughly at least. And for many purposes such a rough measure will suffice.

To the five measures recommended in the preceding paragraph three criticisms suggest themselves. In the first place, Teacher Rank and School Mark are not always available. Or in cases where they are available, it is often impossible to use them because Teacher Rank is not an absolute measurement and because School Mark varies in meaning even within one school. In the second place, the psychological tests recommended, measure, primarily, abstract ability—the ability to handle ideas and symbols rather than to deal with “things and their mechanisms.” All that we know<sup>1</sup> about the relation between Idea Thinkers and Thing Thinkers indicates that the man who is good at manipulating ideas is potentially good in manipulating things. If the mechanical skill desired requires special training this criticism is more serious. The third criticism is that such tests as these can only be given to literate people. This is true but it is a fault which our schools are repairing every day. These three criticisms merely *limit* the usefulness of these measures and they emphasize the fact that even psychological testing requires the exercise of common sense.

Another result of this study which may prove of practical value is:

(c) *The Age of Reaching the Grade Correlates Negatively with Mental Ability*

Probably every text-book on the psychology of individual differences mentions *maturity* as an important factor in producing differences in mental ability. But no educational administrator now believes that mental age always coincides with chronological age. If he does so believe, he does not dare use it as the sole basis for the classification of the school children. A very common complaint among young teachers is that their chronological age weighs heavier than their mental age with school superintendents. Besides these immediately practical significances, the

<sup>1</sup>We greatly need tests of mechanical ability to experimentally test this statement.

influence of age is of keen concern to almost everyone who is engaged in educational or psychological research. Correlational psychology, for example, is in constant fear lest its insidious influence operate to produce spurious correlation. To be brief, no one would object to this statement: below the age where senility begins, the tendency is for the older individuals to be the more able. In so far as the two sixth grades studied here are typical of all grades, we find an exactly opposite tendency, which may be summarized, *viz* : in any one class the tendency is for the more mature to be the less able. This is no rank heresy nor is it an unpredictable mystery. If a pupil is overage for his group it probably means that he has been retarded, and this in turn probably means that he started life with an intellectual capacity which could be expressed as a minus deviation from the average. So the influence of maturity is not a simple one, or to speak more exactly, age is no sure criterion of mental ability. The meaning of age is dependent upon the group in question. The scope of the negative correlation found in this study needs to be tested by experiments upon other grades and other groups.

Even more important is the next fact growing out of this research:

(d) *The Cancellation Tests Show a Negative Correlation with Mental Ability*

We say above that Cancellation correlates negatively with the Composite. The zeros after Cancelling A and Cancelling S (Table H) mean that in those two cases the correction formulas could not be applied. In addition to the evidence of Table H the trustworthiness of the negative correlation is further certified to by the fact that the Cancellation tests correlated negatively with each of the seven tests which have shown themselves to be good measures of mental ability. The coefficients are small but distinct.

It is beyond the scope and data of this research to consider why, so far as psychology is concerned, there has been such a chasm between laboratory and life. We suggest that possibly we have here, in the negative correlation of Cancellation with the Composite, one element of a complete explanation. The Cancellation Test is a not unfair sample of what traditional psychology

has been employing in its laboratories. In order that positively interpreted results from such a psychological test correspond to results from practical experience, what is would have to coincide with what tends not to be. But a problem of such magnitude cannot be settled by the relatively meagre data of this study.

The point of main interest for us is that the Cancellation tests are now in very common use. A Cancellation sheet is about the first one that enters a newly established laboratory. One college is trying them out, along with others, as a partial entrance test. If other researches substantiate this one and experimenters continue to use it, the test must be interpreted negatively. But even here the correlation is so low the test is just about valueless for any positive purposes.

- (e) *The Correlations with Mental Ability of the Tests which Measure Accuracy and Speed Are Smaller than the Similar Correlations of the Tests which Measure Accuracy, Speed, and Power*

Psychological and educational tests are readily divisible into two main groups: tests which measure accuracy and speed and those which measure accuracy, speed, and power. The factors, accuracy, speed, power, are really elements of every psychological test, hence our division may seem to the reader somewhat arbitrary. The division into two groups is due not so much to differences of elements as to differences of emphasis. The emphasis in the first group is upon accuracy and speed so let us call the tests classified there, 'speed tests.' In the second group the emphasis is upon accuracy and power, so let us call these tests, 'power tests.'

As stated before, speed tests measure accuracy and speed primarily. They are usually simple in form and easily within the ability of the group being tested. Further, all parts of the test are about equally difficult. The chief characteristic of this type of test is that its units seldom approach in difficulty to the maximal ability of the group being tested. The instructions accompanying these tests, are to work as rapidly as possible without making errors. Our own Addition is an excellent example of a speed test. Curtis's Arithmetic as usually given is another example, though with sufficient time his tests could be used in



such a way as to make them power tests. Practically all the tests employed by the older, traditional psychology, such tests for example as 'Reaction Time,' 'Cancellation,' etc., belong in this group.

The power tests involve speed, to be sure, but the chief factors are accuracy and power. By 'power test' we mean one that contains units sufficiently difficult to discover the maximal ability of the person or persons being measured. A power test is usually of a more complex nature than a speed test. The first part is so easy as to be within the ability of the stupidest member of the group being measured, while the remaining parts of the test grow progressively more difficult until the maximal ability of the brightest individual is measured. Our *Trabue Completion* is an excellent example of this type. The *Binet Test* belongs in this group also. Mr. Clifford Woody is engaged in making arithmetic tests<sup>1</sup> of the same nature. In fact most of the recent educational and psychological tests could be classified here.

Of the tests used in this study, *Cancellation*, *Handwriting*, *Addition*, and *Copying Addresses* are speed tests, while *Visual Vocabulary*, *Completion*, *Reading*, *Arithmetic*, and *Omnibus* are power tests. We have called the *Omnibus* a power test not because it is of the same nature as *Completion* but because it is complex, because some of its units grow progressively more difficult, and especially because all the units of the test hover close to the maximal ability of the group tested.

For the practical purpose of measuring mental ability which tests offer more promise, those of the speed type or the power type? The first evidence we have to offer is shown in column 2 of Table I. The coefficients in that column do not recommend the speed tests. Of the five different kinds of tests used, *Copying Addresses* proves itself the best as a measure of mental ability. But even it is always surpassed in correlation by what we have termed the 'power tests.' Of course, this comparison, which has resulted unfavorably for the speed tests, refers only to the tests used in this research. *Copying Addresses*, however, probably ranks considerably above the average speed test in its correlation with mental ability. At least it probably occupies as

<sup>1</sup> "Measurements of Some Achievements in Arithmetic," Clifford Woody, Teachers College, Columbia University, *Contributions to Education*, No. 80.

favorable a position with respect to the speed tests as does, say, Visual Vocabulary with respect to the power tests. In so far as this is the case, the scope of our comparison extends to tests not employed in this study.

It is interesting to enquire into the causes for this difference in correlation between the speed and power tests. We believe that the emphasis upon *power*, not as opposed to but as superior to speed, is one significant element. Much more experimentation would be required to establish this view, but so far as they go our results harmonize with such an assumption. Another significant element seems to be the *complexity of the function tested*. On the whole the power tests do measure more complex functions. The Omnibus is preëminent in complexity and in correlation with mental ability. The Cancellation tests are preëminent as to the narrowness of function they measure and they are last in their correlation with mental ability. The tests in Table I are arranged in the order of their correlation with mental ability. An order for complexity, so far as we can judge complexity by external appearance, would seem to correspond very closely to this arrangement by correlation. It is a matter for congratulation that the more recent mental and educational tests are embodying these elements of complexity and power. It is a pity the simple speed tests are not as valuable as the complex power tests, for they are easier to score. Furthermore, the complex power tests are not readily usable in long time practice experiments. By increasing the complexity of the speed tests we may yet make them valuable measures of mental ability.

In our comparison thus far we have considered only corrected coefficients. The practical measurer of mental ability must base his conclusions upon raw scores and not upon scores derived from many more measurements. Hence a practical comparison of speed and power tests must be made with raw as well as corrected coefficients. Table I gives the raw coefficients not only of each test with every other test, but, what concerns us most, the raw coefficients of each test with the Composite. Since each test has two or more coefficients with every other test, Table I is rather confusing, so for convenience, the reader is referred to Table J which is an average of the coefficients of each test with every other.



TABLE I (continued)

Addition 1	12	.34	-.22	.29	.14	.12	.03	.21	.25	.26	.14	.36	.33	.11	.15
Addition 2	12	.34	-.22	.29	.14	.12	.03	.21	.25	.26	.14	.36	.33	.11	.15
Cancelling 1	21	.03	-.37	-.39	.39	.03	.00	.29	.25	.28	.22	.24	.11	.33	.29
Cancelling 2	21	.03	-.37	-.39	.39	.03	.00	.29	.25	.28	.22	.24	.11	.33	.29
Cancelling 3	21	.03	-.37	-.39	.39	.03	.00	.29	.25	.28	.22	.24	.11	.33	.29
Cancelling A <sub>1</sub>	16	.05	-.36	-.36	.36	.01	.06	.32	.24	.31	.19	.24	.11	.22	.29
Cancelling A <sub>2</sub>	16	.05	-.36	-.36	.36	.01	.06	.32	.24	.31	.19	.24	.11	.22	.29
Cancelling S <sub>1</sub>	16	.11	-.31	-.23	.23	.01	.12	.06	.01	.69	.03	.04	.04	.06	.16
Cancelling S <sub>2</sub>	16	.11	-.31	-.23	.23	.01	.12	.06	.01	.69	.03	.04	.04	.06	.16
Copying Addresses 1	16	.10	-.09	-.26	.26	.11	.02	.03	.08	.11	.06	.14	.03	.06	.08
Copying Addresses 2	16	.10	-.09	-.26	.26	.11	.02	.03	.08	.11	.06	.14	.03	.06	.08
Handwriting 1	12	.08	-.25	.20	.19	.10	.21	.12	.37	.32	.17	.50	.48	.35	.26
Handwriting 2	12	.08	-.25	.20	.19	.10	.21	.12	.37	.32	.17	.50	.48	.35	.26
Visual Vocabulary 1	24	.28	.40	.64	.51	.45	.49	.04	.37	.35	.35	.68	.55	.27	.35
Visual Vocabulary 2	24	.28	.40	.64	.51	.45	.49	.04	.37	.35	.35	.68	.55	.27	.35
Completion 1	23	.17	.21	.30	.64	.58	.40	.12	.44	.62	.40	.47	.71	.54	.54
Completion 2	23	.17	.21	.30	.64	.58	.40	.12	.44	.62	.40	.47	.71	.54	.54
Arithmetic 1	41	.34	.33	.40	.36	.35	.06	.47	.51	.37	.22	.56	.39	.39	.39
Arithmetic 2	41	.34	.33	.40	.36	.35	.06	.47	.51	.37	.22	.56	.39	.39	.39
Reading 1	34	.07	.37	.37	.60	.57	.48	.19	.00	.29	.38	.19	.27	.38	.30
Reading 2	34	.07	.37	.37	.60	.57	.48	.19	.00	.29	.38	.19	.27	.38	.30
Omnibus 1	40	.23	.37	.60	.57	.71	.45	.02	.59	.62	.35	.53	.88	.74	.67
Omnibus 2	40	.23	.37	.60	.57	.71	.45	.02	.59	.62	.35	.53	.88	.74	.67
Age	35	.23	.19	.22	.45	.46	.11	.44	.50	.42	.42	.42	.57	.63	.62
Proverb	06	.01	.00	.19	.02	.21	.07	.47	.34	.56	.50	.18	.32	.54	.40
Teacher Rank 1	47	.42	.29	.67	.59	.67	.44	.47	.92	.02	.69	.79	.48	.48	.40
Teacher Rank 2	47	.42	.29	.67	.59	.67	.44	.47	.92	.02	.69	.79	.48	.48	.40
School Mark 1	37	.38	.19	.52	.35	.70	.42	.59	.92	.83	.80	.89	.73	.83	.33
School Mark 2	37	.38	.19	.52	.35	.70	.42	.59	.92	.83	.80	.89	.73	.83	.33
Composite 1	56	.37	.38	.59	.88	.76	.67	.18	.76	.79	.80	.89	.73	.89	.64
Composite 2	56	.37	.38	.59	.88	.76	.67	.18	.76	.79	.80	.89	.73	.89	.64
Visual Vocabulary + Completion 1	39	.45	.30	.71	.74	.83	.63	.32	.54	.40	.33	.73	.64	.69	.69
Visual Vocabulary + Completion 2	39	.45	.30	.71	.74	.83	.63	.32	.54	.40	.33	.73	.64	.69	.69

TABLE J  
AVERAGE RAW PEARSON COEFFICIENTS OF CORRELATION. (Data from Table I)

Addition	.12	Canceling 2	.18	Copyng Addresses	.30	Handwriting	.14	Visual Vocabulary	.13	Completion	.23	Arithmetic	.14	Reading	.23	Omnibus	.12	Proverb	.14	Age	.23	Teacher Rank	.20	School Mark	.25	Composite	.13	Visual Vocabulary + Completion
Canceling 2	.18	Canceling 3	.19	Canceling 5	.50	Copyng Addresses	.30	Handwriting	.14	Visual Vocabulary	.13	Arithmetic	.14	Reading	.23	Omnibus	.12	Proverb	.14	Age	.23	Teacher Rank	.20	School Mark	.25	Composite	.13	Visual Vocabulary + Completion
Canceling 3	.19	Canceling 5	.57	Canceling A	.48	Copyng Addresses	.44	Handwriting	.22	Visual Vocabulary	.28	Arithmetic	.17	Reading	.38	Omnibus	.24	Proverb	.02	Age	.25	Teacher Rank	.25	School Mark	.18	Composite	.27	Visual Vocabulary + Completion
Canceling 5	.50	Canceling A	.57	Canceling S	.57	Copyng Addresses	.34	Handwriting	.12	Visual Vocabulary	.14	Arithmetic	.14	Reading	.23	Omnibus	.17	Proverb	.01	Age	.06	Teacher Rank	.03	School Mark	.02	Composite	.19	Visual Vocabulary + Completion
Canceling A	.57	Canceling S	.57	Canceling S	.24	Copyng Addresses	.11	Handwriting	.01	Visual Vocabulary	.18	Arithmetic	.23	Reading	.13	Omnibus	.20	Proverb	.05	Age	.06	Teacher Rank	.10	School Mark	.06	Composite	.07	Visual Vocabulary + Completion
Canceling S	.24	Canceling S	.24	Copyng Addresses	.11	Copyng Addresses	.49	Handwriting	.03	Visual Vocabulary	.21	Arithmetic	.12	Reading	.08	Omnibus	.28	Proverb	.22	Age	.13	Teacher Rank	.37	School Mark	.25	Composite	.31	Visual Vocabulary + Completion
Copyng Addresses	.30	Copyng Addresses	.12	Copyng Addresses	.11	Copyng Addresses	.49	Handwriting	.03	Visual Vocabulary	.21	Arithmetic	.12	Reading	.08	Omnibus	.28	Proverb	.22	Age	.13	Teacher Rank	.37	School Mark	.25	Composite	.31	Visual Vocabulary + Completion
Handwriting	.30	Handwriting	.12	Handwriting	.11	Handwriting	.49	Handwriting	.03	Visual Vocabulary	.21	Arithmetic	.12	Reading	.08	Omnibus	.28	Proverb	.22	Age	.13	Teacher Rank	.37	School Mark	.25	Composite	.31	Visual Vocabulary + Completion
Visual Vocabulary	.13	Visual Vocabulary	.12	Visual Vocabulary	.11	Visual Vocabulary	.49	Visual Vocabulary	.03	Visual Vocabulary	.21	Arithmetic	.12	Reading	.08	Omnibus	.28	Proverb	.22	Age	.13	Teacher Rank	.37	School Mark	.25	Composite	.31	Visual Vocabulary + Completion
Completion	.23	Completion	.22	Completion	.21	Completion	.53	Completion	.29	Completion	.12	Arithmetic	.12	Reading	.08	Omnibus	.28	Proverb	.22	Age	.13	Teacher Rank	.37	School Mark	.25	Composite	.31	Visual Vocabulary + Completion
Arithmetic	.14	Arithmetic	.13	Arithmetic	.12	Arithmetic	.12	Arithmetic	.29	Arithmetic	.12	Arithmetic	.12	Reading	.08	Omnibus	.28	Proverb	.22	Age	.13	Teacher Rank	.37	School Mark	.25	Composite	.31	Visual Vocabulary + Completion
Reading	.23	Reading	.22	Reading	.21	Reading	.53	Reading	.29	Reading	.12	Arithmetic	.12	Reading	.08	Omnibus	.28	Proverb	.22	Age	.13	Teacher Rank	.37	School Mark	.25	Composite	.31	Visual Vocabulary + Completion
Omnibus	.12	Omnibus	.11	Omnibus	.10	Omnibus	.12	Omnibus	.29	Omnibus	.12	Arithmetic	.12	Reading	.08	Omnibus	.28	Proverb	.22	Age	.13	Teacher Rank	.37	School Mark	.25	Composite	.31	Visual Vocabulary + Completion
Proverb	.14	Proverb	.13	Proverb	.12	Proverb	.12	Proverb	.29	Proverb	.12	Arithmetic	.12	Reading	.08	Omnibus	.28	Proverb	.22	Age	.13	Teacher Rank	.37	School Mark	.25	Composite	.31	Visual Vocabulary + Completion
Age	.23	Age	.22	Age	.21	Age	.21	Age	.29	Age	.12	Arithmetic	.12	Reading	.08	Omnibus	.28	Proverb	.22	Age	.13	Teacher Rank	.37	School Mark	.25	Composite	.31	Visual Vocabulary + Completion
Teacher Rank	.20	Teacher Rank	.19	Teacher Rank	.18	Teacher Rank	.18	Teacher Rank	.29	Teacher Rank	.12	Arithmetic	.12	Reading	.08	Omnibus	.28	Proverb	.22	Age	.13	Teacher Rank	.37	School Mark	.25	Composite	.31	Visual Vocabulary + Completion
School Mark	.25	School Mark	.24	School Mark	.23	School Mark	.23	School Mark	.29	School Mark	.12	Arithmetic	.12	Reading	.08	Omnibus	.28	Proverb	.22	Age	.13	Teacher Rank	.37	School Mark	.25	Composite	.31	Visual Vocabulary + Completion
Composite	.13	Composite	.12	Composite	.11	Composite	.11	Composite	.29	Composite	.12	Arithmetic	.12	Reading	.08	Omnibus	.28	Proverb	.22	Age	.13	Teacher Rank	.37	School Mark	.25	Composite	.31	Visual Vocabulary + Completion
Visual Vocabulary + Completion	.13	Visual Vocabulary + Completion	.12	Visual Vocabulary + Completion	.11	Visual Vocabulary + Completion	.11	Visual Vocabulary + Completion	.29	Visual Vocabulary + Completion	.12	Arithmetic	.12	Reading	.08	Omnibus	.28	Proverb	.22	Age	.13	Teacher Rank	.37	School Mark	.25	Composite	.31	Visual Vocabulary + Completion

Table J permits a comparison of the closeness of raw correlation between each power test and the Composite with that between each speed test and the Composite. Consulting this table we discover that Copying Addresses, which is the best of the speed tests, shows a correlation of  $+ .49$  with the Composite, while Omnibus shows a correlation of  $+ .80$ . In every instance, except in the case of Arithmetic, Copying Addresses gives a lower correlation with mental ability than do the power tests. So the raw coefficients say as emphatically as the corrected coefficients that a better idea of mental ability can be gotten by measuring with Omnibus, Completion, Visual Vocabulary and the like than could be gotten by running a practice experiment with Copying Addresses, Handwriting, Addition, or Cancellation.

The comparison of the speed and power tests is not yet complete. The speed tests as used in this study make available two important measures: an average of all the daily scores and the amount of improvement shown by subtracting the first measure of a test from the last measure. In general, a power test provides just one measure or else so few measures that improvability is too small to be of much use. Hence the power test has but one measure to balance the two obtainable from a practice test. It is conceivable that improvability with a speed test is a better intellectual index than a score from a power test. To discover if this be the case, the improvements made in the practice tests were correlated with the Composite. The improvement arrays were calculated in the following manner: the scores made on the first day by any one individual in Cancelling 2 and Cancelling 3 were combined and subtracted from the sum of the scores made on next to the last day. In order to get a reliability measure and to correct for attenuation, a second measure was calculated for each individual by subtracting the combined scores made on the second day from the combined scores of the last day. By a similar procedure a double measure was calculated for Cancelling A, for Addition, and for Copying Addresses. The absence of any individual on any one of the four critical days was corrected for as in Chapter III, Sec. 1. The improvement thus calculated was correlated with the Composite by the method described in the early part of this book, the only difference being that in correcting for attenuation the other half of Spearman's formula was

used. The raw and corrected Pearson coefficients are given in Table K.

TABLE K

## CORRELATION OF IMPROVEMENT WITH MENTAL ABILITY (COMPOSITE)

<i>Raw Coefficients</i>	
Cancellation 2 + 3 (1) with (2) (Reliability).....	.83
Cancellation 2 + 3 (1) with Composite (2).....	.26
Cancellation 2 + 3 (2) with Composite (1).....	.13
Cancellation A (1) with (2) (Reliability).....	.41
Cancellation A (1) with Composite (2).....	-.09
Cancellation A (2) with Composite (1).....	.07
Addition (1) with (2) (Reliability).....	.80
Addition (1) with Composite (2).....	.38
Addition (2) with Composite (1).....	.13
Copying Addresses (1) with (2) (Reliability).....	.52
Copying Addresses (1) with Composite (2).....	.10
Copying Addresses (2) with Composite (1).....	.00
<i>Average Raw Coefficients</i>	
Cancellation 2 + 3 with Composite.....	.20
Cancellation A with Composite.....	-.01
Addition with Composite.....	.26
Copying Addresses with Composite.....	.05
<i>Corrected Coefficients</i>	
Cancellation 2 + 3 with Composite.....	.21
Cancellation A with Composite.....	..
Addition with Composite.....	.26
Copying Addresses with Composite.....	..

If we compare the average raw coefficients of correlation in Table K with the column under Composite in Table J we see that improvement in the practice tests was, if anything, an even poorer measure of mental ability than was an average of all the scores. By the use of averages Copying Addresses did show a substantial correlation with the Composite, whereas by the use of an improvement measure, its correlation dropped almost to zero.

In considering the practical value of tests, other factors than those discussed should receive at least a passing mention. These are ease of administration and scoring and the amount of time required. Further it is just as important to ask what is the distribution of the time given to the test as it is to ask how much time is actually spent in testing. Thirty minutes of testing concentrated in one period, for example, is usually more convenient than fifteen minutes distributed over three days.

Of all psychological tests the Binet is the best known and the most perfectly standardized; yet for general use it will probably be supplanted by tests which require less skill and less time to apply. The problem of extending the sphere of psychological and educational measurement is very largely that of substituting group for individual testing. The speed tests and power tests used in this study are all well adapted for group measurement. They do not materially differ in ease of administration, nor is there a very great difference in ease of scoring. There is a difference, however, and this difference favors the speed tests. The speed and power tests can be compared for time and convenience by consulting Table G. This table considered in conjunction with Table J shows that one hundred minutes of Copying Addresses when distributed over ten days gives a correlation of  $+ .49$  with the Composite. Omnibus with only sixty minutes of continuous testing gives a correlation of  $+ .80$  with the Composite. In every instance the time spent upon the power tests was considerably less than that spent upon Copying Addresses. To sum up the entire discussion, the power tests give a much higher correlation with mental ability than do the speed tests; and this is true whether average score or improvement is used as the measure of the speed tests. Further, the power tests equal the speed tests in ease of administration, and they surpass them in time convenience. Ease of scoring, only, favors the speed tests, but this superiority is so slight as to be of small consequence.

The issue thus far has been drawn, on the one hand, between those of our tests which are simple in nature, which measure a relatively narrow function, which are considerably below the upper limits of ability, which have units roughly equal and which were designed and are adapted to measure speed and accuracy; and, on the other hand, those tests which are relatively complex, which measure a wider range of functions, which hover close to the upper limits of ability or else begin easy and grow progressively more difficult. Thus far we have considered the comparative excellence of these two main groups of tests as measures of mental ability. We can further draw the issue not between the two types of tests but between the two methods of administering any of them. It has been claimed that the amount of improvement shown by a practice test is a better intellectual index



than are "snap-shots" with those tests. The snap-shot test measures improvement from birth or conception, not to go back further, to the time in the life of the individual when the test is given. The practice test, on the other hand, measures improvement from the first to the last trial at that particular test. This issue could be settled fairly only by comparing the coefficients gotten by correlating the score from the first trial with mental ability and by correlating improvement, found by practice at that *same* test, with mental ability. But here our troubles begin. Those complex, snap-shot tests which show a high correlation with mental ability cannot conveniently be used in a practice experiment. And since only those which we have called the speed tests can be readily used for practice purposes the issue is really the same as that between the speed tests and the power tests, the speed tests representing the improvement measure and the power tests representing the snap-shot score. The decision reached in the preceding discussion favored the power tests.

It is possible, however, to view the speed tests, such as Addition, Copying Addresses, etc., as snap-shot as well as practice tests, and thus secure a comparison of the two methods. The first trial of these tests has not been correlated with mental ability but improvement has, and the results are shown in Table K. If the average from all the trials may be considered as at least a partial representative of the first trial then the coefficients for the speed tests in Table J under the Composite reveal some interesting inconsistencies. Measured by an average, Copying Addresses shows the closest correlation with mental ability of all the practice tests; measured by improvement it shows about the least correlation. The average correlates a little closer than the improvement in the cases of Addition and Cancellation of A's, while improvement has a slight advantage in the case of Cancellation of 2 and 3. However we may explain these apparent inconsistencies by differences of physiological limit, the fact remains that improvement in these tests is a very poor measure of mental ability, even poorer than an average, and probably no better than a first trial. In no case does it even approach a snap-shot score for a power test.

## 5. WHAT ARE SOME THEORETICAL CONSIDERATIONS GROWING OUT OF THIS STUDY?

(a) Is there such a thing as a negative correlation between desirable functions? Is the law of human nature correlation or compensation?

Rightly or wrongly Emerson is usually held responsible for a philosophic statement of the law of compensation. The law has been given a more scientific terminology by certain German psychologists, especially in connection with their attempt to classify individuals into types. Stated in whatever form, the implication is that there exists a negative correlation between desirable traits. From such a doctrine springs the idea that the higher the ability in dealing with abstract things, the lower it is in dealing with concrete things; that slow learners are long rememberers; that the person endowed with beauty is by the justice of Nature left devoid of brains; in short that Nature always balances a superiority with an inferiority. In the third volume of his "Educational Psychology," Professor Thorndike vigorously assails this doctrine. "It should also be noted that in original nature the rule is correlation, not compensation." Or again, "It is very, very hard to find any case of a negative correlation between desirable mental functions. Divergencies toward what we vaguely call better adaptation to the world in any respect seems to be positively related to better adaptation in all or nearly all respects. And this seems especially true of the relations between original capacities." In the stand taken by Dr. Thorndike, the author heartily concurs. Hence it is with no small surprise that he finds himself compelled to appear as a defender of inverse correlation between desirable mental functions. The only way to avoid the necessity of advocating a theory so unpopular with recent psychology is to call the ability to cancel the figures 2 and 3 or the letters A and S, an undesirable mental trait. The ability to perceive a thing, pick it out from other things, and do something with it seems so fundamental to all our mental life that we are scarcely justified in calling such an ability undesirable. Nor can we, without outraging the best of our common sense, call undesirable the abilities to do the Visual Vocabulary, Completion, Reading, Arithmetic, and Omnibus tests, or to make good marks in school and secure the teachers' esteem. And yet between the

Cancellation tests and this more complex group we find a negative correlation.

If the reader will turn back to Table I and count the number of coefficients of correlation which have been calculated between the Cancellation group and the complex tests mentioned above, he will discover that there are 56 such coefficients. Of these 53 are negative and only 3 are positive. Further, of these 3 not one coefficient is as large a positive as  $+.10$  while there are negative coefficients of  $-.35$ ,  $-.36$ ,  $-.37$  and  $-.39$ . The average of the 3 positive  $r$ 's is  $+.07$ . The average of the 53 negative  $r$ 's is  $-.21$  (P.E.  $.08$ ). Some of the negative coefficients are small enough to be due to chance, but it is much easier to believe that the 3 positive ones are due to chance. In view of the size of the negative coefficients and the unanimity of results from all the tests we are forced to conclude that the inverse correlation is genuine. Nor is this genuineness unsupported by previous experimenters. Dr. Chapman ('14), "Individual Differences in Ability and Improvement and Their Correlation," using the same Cancellation 2 and 3 tests upon twenty-two college students, found correlations between Cancellation and Mental Multiplication of a three-place by a three-place number as follows:  $.00$ ,  $.03$ ,  $.16$ ,  $-.05$ ,  $-.13$ ,  $-.14$ . These coefficients will average a small negative.

If future results substantiate our findings, what does it mean? It means that a negative correlation *can* exist and that many more may exist than we at present suppose. There are those who believe that training in one mental function is transferred to another in proportion to the size of the positive correlation between the two. If there be anything in such a belief, positive transfer accompanying a positive correlation may imply<sup>1</sup> a negative transfer accompanying a negative correlation. Such a state of affairs existing would mean that to educate a person in one trait would be to uneducate him in all the traits correlating negatively with it. It is not impossible to conceive that some of the more or less trivial traits intensively developed by the schools correlate negatively with a hundred valuable abilities. The mere possibility argues for the future development of experimental education. Our knowledge is very meagre. The wells which man has dugged in the earth are far more numerous than the borings which psychology has made into the mental life.

<sup>1</sup> Such an implication is not necessarily true.

Though all these things be possible, we nevertheless believe with Dr. Thorndike that the law of human nature is correlation and not compensation. Although correlational psychology is a new science, it has several thousand coefficients to show for its labors. Never before, so far as the writer is informed, has a negative coefficient been so persistently in evidence. If inverse correlations were numerous, more should have made their appearance by this time. Further, the negative correlations found in this research may not mean that the functions are intrinsically inverse. Had a sufficient reward been offered, it may be that the brighter pupils in the complex tests would have forged ahead in the Cancellation tests. In a simple test like Cancellation possibly the brighter children lost interest first. Quite conceivably, different abilities have different interest and attention levels. Simple, routine, relatively easy tasks might be just right to interest the stupid, while they bored the abler individuals unutterably. Tasks difficult and complex enough to interest the abler individuals might be beyond the interest and attention of the stupid. A complete explanation of the cause would have to explain at the same time why the average from cancelling figures gave a negative correlation with the Composite while improvement at cancelling figures shows a slightly positive correlation with the Composite.

(b) What bearing do our results have upon Spearman's Common Factor?

The reader will remember that just a few pages back we were so unwary as to become involved in a discussion of the cause for a negative correlation. Why mental functions correlate in any way, whether negatively or positively, is one of the most vital, most difficult, and most disputed problems with which correlational psychology has dealt. One step toward an explanation has been an attempt to determine the correlational grouping of mental traits. Here the question asked is: With respect to their intercorrelations just how do the multitude of mental traits group themselves, into one system, two systems or many systems? Concerning this there are three different theories, the "multifocal," the "intermediate," and the "unifocal."

Spearman in an article entitled, "General Ability, Its Existence and Nature," published in Volume V of the *British Journal of*

*Psychology*, summarizes the "multifocal" theory, *vis.*: "According to this view, ability in any performance depends upon a complex of elementary factors; the correlation between two performances simply measures the degree in which the elementary factors demanded by the one happen to coincide with, or to be bound to, those demanded by the other. The elementary factors include both 'form' and 'content'; by form is meant the kind of mental operation, as discrimination, observation, inference, etc.; while the 'content' denotes the different sorts of data, as color, shape, number, etc., submitted to such operations."

Between the "multifocal" and "unifocal" theories there are various intermediate ones which organize mental traits into a variety of "faculties," "centers," or "levels." Psychologists who classify the mental life into "types" or "faculties" imply that the multitude of functions composing any one "faculty" or "type" show a close correlation with one another while they show a loose correlation with traits which belong in a different "faculty," "type," or "center." Dr. Thorndike seems to believe in correlational "levels" when he writes: "Correlations seem to be closer within the analytical or abstracting functions than between these and others. So also within the purely mental associative functions like adding, completing words, giving opposites or naming objects, than between one of them and one of the sensori-motor functions. The sensitivities seem to interrelate only loosely; and any one of them would relate very loosely to the associative or analytical functions, even when the latter was busied with data from that sense."<sup>1</sup>

The "unifocal" theory is represented by Dr. Spearman's famous "Common Factor." To quote from Spearman himself: "Here, the view supported is that all performances depend to a certain degree upon one and the same general common factor, provisionally termed 'General Ability.' Correlations are thus produced between all sorts of performances, the amount of correlation being simply proportional to the extent that the performances concerned involve the use of this general common factor, or 'General Ability.'"<sup>2</sup> This criterion proposes not as many centers as there are "elementary factors," not as many centers as there are "faculties" or "types," nor even as many centers as there are

<sup>1</sup> *Educational Psychology*, Vol. III, p. 370.

<sup>2</sup> *British Journal of Psychology*, Vol. V, p. 52.

"levels"; rather it proposes just one center. In the same article Spearman summarizes the importance of this question by saying: "This sharp divergence between the three current views appears to be of grave importance. It bars the way to all interpretation of our laboriously accumulated correlational data. It confuses all theory as to the intellectual 'make-up' of individuals. And it paralyzes our practical power of gauging the intelligence of persons, both normal and insane." Following this statement Spearman proceeds to give his proof of the existence of the "Common Factor" and of the inadequacy of all previous conceptions. After many psychological considerations he decides that the "Common Factor" is "*some common fund of energy.*" Finally he concludes with:

"(1) At present, there exists such a great divergence of opinion about the correlation between different intellectual performances, as to impede gravely the progress of psychology.

"(2) But closer consideration of all the actual data of the different authors shows that this divergence is merely due to gross misinterpretation. In reality, all the facts indicate unambiguously, that the correlation arises through all the performances, however different, depending partly on a General Common Factor."

Do our results support Spearman's contention and justify his conclusions? The first evidence we have to offer is the negative correlation between the Cancellation group and the Complex tests. Correlation, according to Spearman, is produced by the General Common Factor and modified by the "specific abilities" of the traits correlated. To quote again: ". . . every intellectual performance may be regarded as proceeding from two distinct factors; on the one hand, the specific ability or disposition for that particular performance; and on the other general ability, due to the common fund of intellectual energy." What Spearman meant by "specific ability" may be gathered from these quotations: "An 'ear' for melody is known to be particularly specific, that is, independent of other elementary capacities." And again, ". . . their correlations (specific) do not occur in a pure state, but only superposed upon correlation of a more general character." The theory of the Common Factor seems to require that all coefficients of correlation be positive. How two functions can

share in a Common Factor and yet show a negative correlation we are unable to see. Perhaps the Cancellation traits are ostracized from the exclusive society of the Common Factor. Perhaps in the tug of war the "specific abilities," heading in a negative direction, outpulled the Common Factor. The proved skill of Dr. Spearman could doubtless defend his theory from such a trivial attack.

In the article already referred to, Dr. Spearman proposes a remarkably ingenious and important method of treating correlational results. By this method he proved to his satisfaction the existence of a Common Factor, hence the fate of his theory depends upon the proper working of this method. We purpose to treat our results by exactly the same method to see whether they justify a belief in a General Common Factor. In his article Spearman gave a correlational table which had the general form of the one given below. (The coefficients are not the same.)

TABLE L  
AVERAGE RAW PEARSON COEFFICIENTS. (Data from Table J)

	Cancelling 2	Cancelling 3	Cancelling A	Cancelling S	Handwriting	Addition	Copying Addresses	Visual Vocabulary + Completion	Teacher Rank	School Mark	Omnibus	Composite
Cancelling .....	.91	.61	.59	.48	.47	.21	.29	.20	.20	.25	.34	.18
Cancelling A .....	.59	.57	.57	.48	.44	.18	.20	.27	.28	.25	.35	.18
Cancelling S .....	.48	.48	.47	.57	.44	.19	.24	.19	.03	.03	.17	.02
Handwriting .....	.47	.44	.45	.48	.41	.05	.24	.10	.09	.09	.20	.06
Addition .....	.21	.18	.19	.11	.30	.30	.40	.08	.06	.00	.09	.20
Copying Addresses .....	.29	.18	.29	.05	.30	.30	.55	.13	.23	.20	.27	.25
Visual Vocabulary + Completion .....	.27	.27	.19	.07	.40	.35	.31	.37	.37	.25	.28	.40
Teacher Rank .....	.28	.28	.28	.10	.08	.18	.31	.47	.41	.41	.60	.69
School Mark .....	.25	.25	.03	.09	.06	.23	.25	.47	.51	.51	.63	.78
Omnibus .....	.34	.35	.17	.20	.09	.22	.28	.40	.63	.58	.58	.78
Composite .....	.18	.18	.02	.06	.20	.35	.40	.69	.78	.78	.80	.80



Concerning the table of coefficients which Spearman gave, he wrote: "The most obvious method would be to devise as criterion some direct function of all the coefficients in the table. We have, however, chosen a somewhat different course. It seemed desirable to retain the power of noting whether the whole table obeyed the same law or different parts of it behaved differently. Also we were anxious to simplify the calculations as far as possible, in order to appeal to a wider circle of readers. For these reasons, our criterion was based upon singling out from the table *any pair of columns of coefficients*. . . . Our criterion consists simply in the correlation between one column of figures and the other; it is the correlational coefficient between the two series of correlational coefficients; clearly this is just as easy to work out as between any other two series of values. It should be noted that this correlation between columns is quite independent of the arrangement in which the table happens to have been drawn up."

Also Spearman tells us that he threw away the two coefficients which had no corresponding coefficients in the other column. And then, a few pages further on, he says: "Such, then, is the statistical method which we have devised for deciding between the three rival theories. If the older view of Thorndike, *vis.*, a general independence of all correlations, holds good, our correlation between columns of correlational coefficients should average *about 0*. If his newer view of "levels" or the almost universal belief in "types" is correct, then the mean correlation between columns should be a *low minus value*. If, finally, the true theory is that of a General Common Factor, the correlation between columns should be *positive and very high*."

Since Spearman's method has been applied to average raw coefficients it is highly desirable that the halves of a test from which the coefficients were derived measure substantially the same thing. Otherwise an average of the raw coefficients would be somewhat misleading. To this end, no test has been used which did not show a reliability coefficient of  $+ .70$ . According to Table G this criterion eliminates Arithmetic and Reading. Visual Vocabulary and Completion were combined, thus raising their reliability coefficient to  $+ .69$ , which was accepted as satisfactory. The intercorrelations of the accepted tests are given in Table L. It is upon this table that we purpose to test the

Spearman theorem. The reliability criterion was set up and the correlation table was constructed before it ever occurred to the writer to enquire whether it would operate favorably or unfavorably to the "Common Factor."

Now, if Spearman's "unifocal" or "Common Factor" theory is to be corroborated, the correlation between any two columns of Table L should be, to use his own words, "*positive and very high.*" To be exact, Spearman says the *average* of all the correlations should be positive and very high. But Spearman himself would be the first to say that unless all parts of the table substantially agree, the use of an average would conceal rather than reveal the truth. He perceived this when he wrote: "It seemed desirable to retain the power of noting whether the whole table obeyed the same law or different parts of it behaved differently." It cannot be emphasized too strongly that, according to Spearman's statistical method, the crucial thing, in the last analysis, is not the size of the average; it is the size of the correlation between any two columns taken from the correlational table. Bearing this in mind, is the correlation between any two columns of Table L "positive and very high," or does it tend even to be "positive and very high"? Taking various pairs of perpendicular columns from Table L and correlating them we get such results as the following:

Cancelling 2 with Visual Vocabulary + Completion.....	-.95
Cancelling 3 with Omnibus.....	-.95
Cancelling A with Teacher Rank. . . . .	-.83
Cancelling S with Composite.....	-.91

Any one of the tests shown to the left paired with any one of the tests at the right would give similar coefficients to the above. The results are just exactly opposite to what is required to satisfy Spearman's theory. Instead of the coefficients being "positive and very high" they are *negative and very high*. What then led Spearman to believe in a Common Factor? The answer is given in the following:

Cancelling 2 with Cancelling 3.....	+1.00
Omnibus with Visual Vocabulary + Completion.....	+.99

Many more such high positives could be given. Mere inspection of Table L will show that the correlation between any two columns from Cancelling 2 through Cancelling S would give a high

positive. A high positive coefficient would also be gotten from any pair from Visual Vocabulary + Completion through Composite. On the other hand, the correlation of any column in the first group with any column in the second would be a high negative. What would the *average* be? A mistake!

Lest anyone should think that the coefficients from correlated columns always approximate unity, note the following smaller coefficients:

Handwriting with School Mark.....	-.56
Cancelling 2 with Copying Addresses .....	.00
Addition with Visual Vocabulary + Completion.....	+.51

Between  $+.51$  and  $-.56$  other intermediate coefficients could be given. By the proper selection of columns to be correlated, data could be found to support all of the three main theories, the "multifocal," the "faculty" or "type" or "level," and the "unifocal."

Objections will be urged against our correlational table (Table L). It could easily be said that Teacher Rank does not measure a mental trait at all, unless perhaps it be a mental trait of the teacher, and therefore such a measure should not be included in the table of correlations. It was retained because Dr. Spearman speaks of using "Imputed Intelligence" in his tables. But the omission of Teacher Rank would not change the general conclusion.

The only really important criticism would concern itself with the number of the Cancellation tests. Spearman would probably say that because of them our table is overloaded with "specific abilities." He himself combined two Cancellation tests which occurred in one of his tables, though he offered no justification for such a procedure, except that the tests were similar. If the tests were practically identical there could be no objection to his combining them. Likewise it would be difficult to protest had he elected to treat them separately, for they were not exactly the same test. If correlation be due to "specific ability" plus "Common Factor," we should not forget the work of Thorndike and Woodworth. They have shown experimentally that traits which seem almost identical may really not be so at all. If external similarity be our measure of "specific ability," the correlation between Cancelling A and Cancelling S would be higher

than between Visual Vocabulary + Completion and Omnibus. As a matter of fact, the correlation is +.57 in the first case and +.60 in the second. There is no more reason for combining these two Cancellation tests than for combining the Visual Vocabulary + Completion and Omnibus. But supposing we yield the point and retain only Cancellation 2 and Cancellation A, then the remaining columns can be correlated to give a result like this:

Cancellation 2 with Omnibus..... —.94

But to be still more generous, we have thrown out every Cancellation test except Cancelling 2; yet we can get a result like this:

Cancelling 2 with Omnibus..... —.92

In view of the foregoing we are forced to conclude that Spearman's theory does not have universal validity. And we have proved this by the application of his own statistical method. Dr. Spearman certainly bases his theory upon numerous data collected from many sources. His averages certainly were positive and high, and he explicitly states that no individual correlation of column with column fell appreciably below positive unity. Had we correlated every column in Table L with every other column and had we taken an average of all these correlations, the mean result would have been a substantial positive. But in view of the differential action of different parts of the table, such a summation would be not only misleading but wrong.

Dr. Spearman after advancing and defending his theory of the Common Factor proceeds to state the nature of it. Concerning the former, Burt writes: "The first of Dr. Spearman's propositions, the 'Theorem of the Universal Unity of the Intellective Function' is tested by a corollary logically issuing from it, called that of the 'Hierarchy of the Specific Intelligences.' Its principle may be most briefly expressed as follows:

$$\frac{r(A, P)}{r(B, P)} = \frac{r(A, Q)}{r(B, Q)}$$

where A, B, P, Q, represent any four capacities not obviously akin.<sup>1</sup> When this formula is satisfied a correlational table can be so drawn up that the coefficients in horizontal columns grow

<sup>1</sup> *British Journal of Psychology*, Vol. III, p. 159.

smaller to the right and those in perpendicular columns grow smaller downward. Burt's coefficients did substantially satisfy the above formula, and when thrown into the usual table they formed a beautiful 'hierarchy.' Consequently, Burt agreed with Spearman's first theorem. The 'Common Factor' and the 'Hierarchy of the Specific Intelligences' must stand or fall together. Just as our results do not corroborate Spearman's contention, neither can our coefficients be so arranged as to show a hierarchy. Burt, like Spearman, claims that the above formula only holds when the capacities are "not obviously akin." This is the crucial point. We are insisting that external similarity is not a satisfactory measure of kinship. But even when we yielded to external similarity so far as to eliminate every Cancellation test except one, our results failed to substantiate Spearman's 'Common Factor' or Burt's 'Hierarchy of the Specific Intelligences.'

Complete fairness to Dr. Spearman makes another remark necessary. Spearman points out that what he calls "sampling errors" introduce a definite bias into the results obtained by correlating columns of coefficients, and that to determine the exact size of the coefficient this bias must be corrected for by a formula which he gives. In order that the correction may not be so great as to swamp the real difference, he sets up an arbitrary correctional standard by which he excludes those columns which have large sampling errors. Unfortunately, we have been unable to make clear to ourselves just how he applies this standard, hence our correlational table has been left unmodified. For this reason we do not correct our results by his formula but present them in their raw form. Anyway, the exact size of the coefficient is not necessary to test Spearman's theory. And even though Spearman finds that some column used by us did not quite satisfy his correctional standard, it is hardly conceivable that the sampling error could be so large as to completely reverse the direction of the coefficients upon which our conclusion is based.

In correlating two columns from a correlational table, two coefficients must be thrown away, one from each column. This is necessary because there will always be one coefficient in each column which lacks a corresponding coefficient in the other. But what is worse still is that every time a new pairing of columns is made different coefficients are eliminated. This increases enormously the labor of calculating the intercorrelation among the

columns, for with each new pairing a new average, a new set of deviations, and a new sum of deviations squared must be calculated. In calculating the Pearson coefficients for ordinary arrays these things are done but once. To minimize labor, therefore, we suggest that the coefficient  $+1.00$  be inserted at every place in the correlation table where there is a gap. An array will, of course, always correlate  $+1.00$  with itself. This coefficient is usually omitted in drawing up a correlational table because to insert it would not be particularly illuminating. Where, however, we wish to apply Spearman's statistical method such an insertion would prove exceedingly serviceable. We did not use the  $+1.00$  in calculating any of the coefficients used in our attempt to refute the two theories of Burt and Spearman. We believe that to fill up the gaps in a correlational table in this way is theoretically correct. In every case where we have tried correlating columns with and without the  $+1.00$  the coefficient has been very nearly the same. But even though the coefficients were not the same, the insertion of the  $+1.00$  might still be justifiable. We merely mention it here in the hope that some one with sufficient training in the theory of correlation will test our suggestion.

## CONCLUSION

The mere wording of a question may stimulate thinking which will result in experimental research. It is our only excuse for asking so many questions and giving a final answer to so few. Certain conclusions grow out of this study, but the amount of data in any one research is necessarily so meagre that universal validity can scarcely be claimed for any of them. But in view of the limitations of the study, the following seem to us worth a place in a summary:

1. The corrected correlations among the educational and psychological tests and the functions which they measure continuously vary in size from  $-.63$  to  $+.98$ .
2. Meaning by mental ability a Composite of all the measurements, the Omnibus and Completion tests correlate with it  $+1.00$  and  $+.96$ , respectively. That is to say, a perfect measure of an individual by Omnibus or Completion would be a substantially true index of his mental ability.
3. The seven best measures of mental ability together with their correlations with the Composite are: Omnibus  $1.00$ , Completion  $.96$ , School Mark  $.91$ , Teacher Rank  $.86$ , Reading  $.81$ , Visual Vocabulary  $.80$ , and Arithmetic  $.72$ .
4. Ranked in the order of their correlation with mental ability the complex educational and vocational tests come first, the relatively complex practice tests second, and the simple practice tests last.
5. The power tests, or those which measured the upper threshold of ability, showed a higher correlation with mental ability than the speed tests or those which measured how rapidly a relatively easy task could be accurately performed. The power tests were superior not only as to correlation but also as to time required and the distribution of that time.

6. The indications are that for a test to show a close correlation with mental ability it should emphasize power rather than speed and test a relatively complex function rather than a narrow mental trait.

7. Improvement at a speed, practice test was on the whole not so good an intellectual index as an average of the practice scores and not nearly so good an index as a single score from a complex, power test.

8. In this particular 6 B school grade chronological age correlated negatively with mental ability.

9. The Cancellation tests correlated negatively not only with the Composite but also with all those tests which proved to be good measures of mental ability. This demonstrates that a negative correlation between apparently desirable traits *can* exist. Heretofore, the weight of scientific evidence has been against such a possibility.

10. The correlation between columns of correlational coefficients does not corroborate Spearman's important "Theorem of the Universal Unity of Intellective Function."

11. In no way can a correlation table be so constructed from our coefficients as to satisfy Burt's "Hierarchy of the Specific Intelligences."

12. A suggestion was made whereby gaps in a table of coefficients can be filled. This suggestion, if justifiable, will greatly economize labor in applying to a table of coefficients Spearman's statistical method of correlating columns of correlational coefficients.



## VI

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## VII

### APPENDIX

#### GENERAL INSTRUCTIONS FOR THE SIX PRELIMINARY AND SIX FINAL TESTS:

I am going to give you several tests to find out how good a score you can make. Do your best in each test. To-morrow I shall read the names of the two making the highest total scores. Notice carefully all instructions so you will not need to ask questions and thus disturb others.  
(Read before each series.)

#### INSTRUCTIONS FOR VISUAL VOCABULARY, READING, COMPLETION, ARITHMETIC, OMNIBUS AND PROVERB:

There will be placed before you, face down, a sheet of paper. This paper tells you what to do and how to do it. You will have 30 minutes in which to complete the test. When you have finished everything on the paper, bring it to me and return quietly to your seat. Don't look at your paper until I say "Go," and stop instantly when I say "Stop." Do what it says to do.

(Read before each test) (Proverb: 15 min.)

#### INSTRUCTIONS FOR CANCELLATION:

You will be given a cancellation sheet. In this sheet a certain specified number or letter must be cancelled. Omit as few cases and cancel as many as you can in one minute. The sheet will be placed before you bottom-side up. When I say "Go," turn the sheet over and commence to cancel. When I say "Stop," cease immediately. Your score will be as follows: 2 (number cancelled correctly) minus 2 (number omitted) minus 3 (number wrongly marked). Watch while I show how it should be done and then you can practice at it yourself for one minute.

#### INSTRUCTIONS FOR ADDITION:

You will be given a sheet containing columns of one-place numbers. Place it before you bottom-side up. When I say "Go," turn the sheet over and begin adding. Write the sum of each column of ten figures under the line at the bottom of that column. Add as many columns as you can in ten minutes without making errors. If an answer is wrong you will receive no credit for that column. When you finish the examples on one sheet take another. Watch while I show you how it is done and then you can practice it yourself for five minutes.

#### INSTRUCTIONS FOR COPYING ADDRESSES:

You will be given a sheet containing 25 names and the directory from which these names were taken. Look in the directory for the first name

on your sheet, find the New York City address and write it after that name on your sheet. See how many of these addresses you can correctly copy on your sheet in ten minutes. Do not begin until I say "Go," and cease immediately when I say "Stop." Watch while I show you how it should be done.

**INSTRUCTIONS FOR HANDWRITING:**

There will be placed before you face downward a printed paragraph which you are to copy as much of as you can in four minutes. You will be scored for both quality and speed, so write as fast as you can while writing the best that you can. Be sure to punctuate and capitalize just as it is in the paragraph before you. Begin when I say "Go," and cease immediately when I say "Stop." Watch while I show you how to do it.

Teachers College, Columbia University, publishes the Visual Vocabulary, Reading, and Completion tests. Further information concerning the other tests may be had by communicating with the author.

TABLE M

CANCELLING A: Original scores made in 1 minute by 88 children

Ind.	2/4	2/5	2/8	2/9	2/10	2/11	2/15	2/16	2/17	2/18	4/14	4/15	4/16	4/19
1	18	44	38	48	49	72	56	62	64	69	80	90	78	84
2	32	38	32	—	32	48	38	40	56	48	44	48	60	70
3	16	24	30	40	44	54	45	50	68	62	54	48	74	74
4	20	24	40	48	52	54	54	58	60	63	58	58	74	74
5	20	36	—	—	40	48	46	50	60	70	64	66	70	—
6	—	—	4	4	18	80	45	—	45	52	60	72	80	76
7	-28	32	36	52	44	56	60	70	65	76	60	48	68	62
8	34	—	36	38	40	—	42	48	50	54	50	68	74	69
9	—	56	—	58	74	74	74	76	88	88	70	92	98	—
10	26	30	30	36	56	48	48	63	44	54	40	44	52	64
11	28	32	40	38	46	51	52	63	53	—	60	69	84	85
12	28	58	58	74	78	78	48	44	90	88	—	—	—	—
13	74	44	48	64	66	74	68	68	68	74	74	74	86	92
14	20	36	48	54	64	68	64	62	68	76	62	70	80	46
15	60	54	78	74	96	100	100	92	97	94	92	100	98	100
16	24	24	48	46	42	62	58	58	44	34	46	38	26	40
17	—	4	22	24	34	30	38	44	34	46	38	26	40	40
18	38	38	26	48	50	56	52	64	68	66	60	72	72	62
19	22	36	32	36	42	52	60	52	64	66	64	60	62	54
20	24	28	35	30	34	36	46	54	60	58	52	52	74	68
21	32	34	42	48	50	58	66	48	66	74	60	76	76	68
22	52	38	32	44	—	42	48	38	58	62	66	50	64	60
23	26	44	50	50	54	62	54	46	62	60	62	44	70	54
24	44	40	52	58	64	68	70	74	84	98	88	96	92	—
25	40	34	50	58	52	74	58	72	61	66	—	—	—	—
26	24	38	—	—	58	52	72	74	70	76	74	74	76	74
27	28	40	28	50	56	60	72	72	76	72	76	88	88	96
28	24	24	26	34	26	30	46	42	62	56	—	40	66	80
29	32	36	36	40	52	62	68	70	78	48	64	68	88	—
30	22	20	—	28	32	36	40	34	46	44	62	50	54	52
31	26	20	30	32	38	38	38	40	44	44	44	48	50	—
32	28	22	36	40	48	62	52	48	54	64	48	89	80	72
33	32	50	44	52	72	76	72	84	90	80	100	80	100	80
34	36	40	42	48	54	66	—	—	—	—	—	—	—	—
35	16	28	26	34	38	34	38	48	52	44	52	54	64	48
36	16	30	28	30	40	44	38	10	20	52	46	54	70	64
37	40	58	74	76	76	96	84	90	96	100	92	100	102	116
38	22	28	32	44	40	18	38	40	52	44	48	44	60	52
39	22	24	26	24	32	42	38	42	50	52	52	68	72	70
40	0	16	—	—	—	20	—	—	—	—	—	—	—	—
41	38	38	44	40	48	50	56	50	52	54	48	54	68	68
42	10	—	48	34	50	68	62	—	52	64	66	94	92	98
43	38	38	44	44	54	60	76	54	66	70	68	66	76	76
44	36	72	68	60	74	74	—	76	86	70	94	80	94	82
50	14	40	42	50	56	58	62	62	58	66	70	78	88	104
51	34	32	28	40	44	56	52	68	56	24	38	64	68	56
52	10	22	34	30	34	26	24	24	36	38	36	38	44	44
53	28	34	46	40	40	48	50	64	—	—	54	66	62	84
54	0	54	64	72	60	100	84	72	59	70	60	68	64	70
55	2	30	34	38	44	50	38	42	50	50	42	44	34	50
56	—	32	44	46	58	62	52	56	72	74	68	74	62	64
57	28	34	40	44	44	50	46	46	48	52	58	46	50	52
58	38	38	52	56	53	68	66	68	80	84	74	85	94	96
59	12	24	28	24	34	38	38	52	54	62	50	56	62	58
60	16	32	24	36	44	48	50	42	68	56	46	46	48	46
61	28	20	40	50	48	52	68	56	64	88	52	—	42	68
62	24	44	42	42	48	60	60	50	72	80	66	66	80	80
63	28	46	52	48	52	62	74	74	74	66	78	70	94	68
64	34	40	44	40	48	50	40	56	47	54	—	50	54	58
65	38	42	14	40	32	12	30	48	58	66	68	66	74	60
66	18	26	18	24	20	48	44	46	50	48	44	46	52	56
67	24	26	36	34	26	42	48	44	48	62	52	62	72	66
68	—	22	32	30	30	—	—	—	44	52	48	50	52	56
69	20	36	—	48	46	—	34	—	—	—	—	—	—	—
70	36	24	36	48	48	54	54	62	54	64	53	60	70	72
71	22	30	48	44	56	55	61	66	66	74	70	48	84	80
72	26	26	34	40	48	48	54	58	64	62	61	66	72	76
73	32	44	38	54	52	54	56	50	68	68	52	68	78	70
74	28	34	38	40	42	54	42	50	54	64	48	46	50	54

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CANCELLING A (continued)

Ind.	2/4	2/5	2/8	2/9	2/10	2/11	2/15	2/16	2/17	2/18	4/14	4/15	4/16	4/19
75	32	89	48	72	74	90	94	92	94	96	90	100	102	102
76	24	28	34	40	52	64	55	60	64	68	54	62	68	68
77	34	40	48	42	52	58	54	46	68	68	72	68	74	76
78	34	30	36	32	40	48	42	46	46	48	46	46	46	46
79	-39	-58	-40	-42	-50	-45	-54	-68	-93	-67	34	34	36	48
80	28	20	44	44	41	55	62	62	60	70	62	64	62	66
81	52	52	68	70	66	92	94	92	98	98	88	78	88	100
82	52	52	68	70	66	92	94	92	76	66	60	96	92	74
83	40	50	40	40	34	48	—	—	—	—	46	54	66	76
84	26	48	42	50	42	66	50	56	68	68	70	86	82	82
85	26	58	—	—	—	—	—	—	—	—	—	—	—	56
86	48	42	56	50	56	62	58	60	54	64	74	66	64	72
87	22	44	40	52	50	60	54	56	52	71	62	56	46	—
88	24	28	28	30	40	50	48	38	48	50	50	45	54	58
89	36	54	30	46	52	68	50	—	—	—	—	—	—	—
90	40	62	64	70	68	78	68	84	74	84	92	100	100	104
91	34	—	36	52	50	58	68	60	62	76	64	—	—	—
92	28	34	36	44	44	38	48	46	46	64	52	52	48	—
93	40	64	56	64	67	64	64	74	74	—	74	78	84	82

CANCELLING S: Original scores made in 1 minute by 88 children.

Ind.	2/11	2/15	2/16	2/17	2/18	4/14	4/15	4/16	4/19
1	50	58	52	40	70	72	80	92	92
2	48	48	52	56	58	46	64	58	66
3	24	30	34	27	36	52	48	64	66
4	52	54	50	64	70	64	70	70	72
5	36	62	66	—	76	68	84	80	—
6	-28	-44	—	-22	20	20	38	26	28
7	12	30	24	32	36	34	40	64	40
8	—	34	36	32	32	62	72	80	70
9	50	56	54	64	78	96	96	96	80
10	38	32	44	46	54	52	61	54	62
11	18	32	28	48	—	46	56	72	64
12	68	44	70	82	94	—	—	—	—
13	42	56	52	46	70	66	66	76	76
14	60	69	76	68	88	86	72	78	86
15	70	74	72	92	80	80	84	96	96
16	48	52	48	55	74	62	76	92	85
17	28	22	48	26	40	42	48	48	42
18	44	44	52	60	64	60	60	72	74
19	34	48	40	62	58	66	58	64	64
20	46	54	58	71	80	78	84	84	88
21	48	64	74	80	76	88	76	78	84
22	58	66	70	80	86	96	83	92	74
23	46	38	62	69	62	70	72	56	70
24	80	84	88	84	100	100	96	106	—
25	62	64	68	64	78	—	—	—	—
26	60	72	74	74	72	76	76	80	80
27	34	58	44	60	68	88	72	82	74
28	30	38	42	58	54	—	70	66	66
29	54	64	68	66	68	72	68	92	94
30	34	48	52	52	50	70	76	64	78
31	44	44	62	62	62	70	66	66	70
32	48	52	48	56	64	84	70	94	84
33	46	44	44	40	56	64	72	80	76
34	40	—	—	—	—	—	—	—	—
35	48	42	50	52	56	52	70	74	62
36	-22	-6	—	14	32	28	22	38	54
37	50	68	68	82	90	86	94	92	96
38	36	44	48	48	46	44	66	72	66
39	52	60	68	72	72	84	88	94	—
40	-12	—	—	—	—	—	—	—	—
41	36	42	38	—	48	38	58	52	62
42	14	—	—	—	48	80	88	85	92
43	39	46	52	66	66	66	70	76	70
44	44	60	54	60	66	50	72	74	76
48	48	62	76	72	78	96	100	77	90
50	34	32	48	50	—	32	65	45	44
51	46	32	40	40	40	44	46	52	50
52	46	32	40	—	—	62	72	68	72
53	44	45	55	58	38	37	68	68	60
54	33	35	38	52	52	48	44	58	64
55	28	48	38	78	94	100	84	84	74
56	66	62	76	48	58	56	64	62	74
57	26	44	44	48	58	56	64	62	72

Ind.	2/11	2/15	2/16	2/17	2/18	4/14	4/15	4/16	4/19
58	40	52	48	70	67	68	74	84	88
59	54	60	54	84	70	72	86	72	94
60	36	44	50	44	32	32	32	54	58
61	24	54	62	68	70	68	—	74	72
62	58	57	66	72	66	78	88	72	84
63	48	44	36	64	62	64	64	90	84
64	42	44	56	60	56	—	70	66	66
65	48	28	42	44	66	44	66	58	62
66	48	62	60	64	68	62	72	84	84
67	44	48	40	62	68	64	76	68	63
68	—	—	—	34	44	52	64	70	66
69	—	26	—	—	—	—	—	—	—
70	36	44	44	52	52	48	60	54	58
71	44	60	50	66	66	66	72	72	86
72	38	48	50	56	56	56	62	52	72
73	62	68	62	76	—	72	62	76	88
74	52	60	66	70	66	70	72	72	68
75	68	78	74	86	88	90	96	108	108
76	48	54	64	64	72	66	68	74	76
77	46	52	70	66	76	76	70	90	92
78	—	26	30	42	62	50	58	62	68
79	—80	—50	—60	46	50	46	58	62	60
80	60	56	56	66	68	56	57	72	63
81	42	62	60	56	68	72	74	76	76
82	42	44	—	48	58	34	62	52	56
83	52	—	—	—	—	76	78	88	86
84	52	40	62	56	74	76	88	78	90
85	—	—	—	—	52	32	68	—	80
86	52	70	56	48	74	72	70	74	70
87	46	50	58	64	68	52	68	66	—
88	40	38	44	48	60	52	66	68	66
89	60	60	—	—	—	—	—	—	—
90	72	72	82	80	96	100	96	92	102
91	72	78	90	84	88	90	88	—	—
92	44	—	52	60	60	60	70	64	—
93	52	44	52	64	—	64	64	72	68

CANCELLING 2: Original scores made in one minute by 88 children.

Ind.	2/4	2/5	2/8	2/9	2/10	2/11	2/15	2/16
1	96	84	92	112	130	122	132	146
2	70	82	84	—	90	88	74	92
3	62	74	78	92	86	94	98	94
4	58	72	78	86	82	92	88	92
5	78	82	—	—	86	84	100	60
6	—	—	—	—	—	—	—	—
7	—	62	70	78	80	94	84	78
8	50	—	62	72	76	—	64	62
9	112	108	118	122	116	118	118	130
10	52	56	60	52	60	70	62	74
11	80	80	80	81	94	89	76	118
12	80	96	100	112	108	112	110	112
13	96	108	90	130	140	140	122	120
14	94	102	112	118	114	112	92	104
15	78	70	90	88	94	114	98	106
16	88	74	96	112	106	126	100	100
17	80	52	76	96	100	100	104	118
18	66	74	78	90	82	88	76	90
19	76	84	78	88	92	88	104	96
20	74	78	82	94	92	88	92	98
21	66	78	94	96	98	104	108	122
22	58	82	84	74	—	94	96	92
23	58	76	80	96	102	100	108	110
24	70	78	92	96	90	100	118	102
25	66	86	104	80	106	92	118	122
26	56	66	76	88	76	88	84	88
27	72	86	80	100	100	100	100	118
28	46	60	68	86	96	98	96	102
29	70	102	88	90	112	53	122	112
30	46	54	—	54	60	62	76	82
31	68	76	74	74	80	76	78	82
32	78	74	80	88	106	106	110	114
33	88	94	98	120	122	134	132	134
34	66	72	86	88	96	108	—	—
35	40	64	60	64	64	66	68	66
36	52	56	66	80	94	94	96	100
37	62	74	84	94	104	104	114	110

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## CANCELLING 2 (continued)

Ind.	2/4	2/5	2/8	2/9	2/10	2/11	2/15	2/16
38	52	60	60	62	88	88	74	78
39	62	66	70	78	80	60	88	88
40	66	88	—	—	—	82	—	—
41	58	78	64	74	68	78	88	82
42	60	—	94	92	92	104	—	—
43	70	82	74	96	88	96	96	96
44	84	100	114	104	112	128	124	112
50	102	122	126	130	126	124	126	144
51	30	28	48	88	44	92	—	32
52	50	44	50	54	58	60	52	60
53	2	4	4	12	12	28	28	28
54	138	128	126	130	136	138	146	152
55	78	74	92	82	80	92	94	96
56	—	—	74	98	122	116	126	128
57	18	60	74	60	46	—	50	84
58	70	80	92	98	98	100	106	100
59	48	56	68	74	78	68	78	86
60	54	58	78	88	82	90	90	90
61	70	94	100	122	88	84	92	94
62	84	82	94	100	108	110	116	120
63	62	80	78	100	92	84	84	96
64	62	70	78	88	96	84	96	98
65	88	100	94	100	98	78	82	100
66	52	50	70	80	84	78	88	84
67	102	98	104	118	112	114	128	134
68	—	46	58	66	70	—	—	—
69	76	80	—	90	—	—	—	—
70	42	70	82	74	70	66	74	82
71	68	72	100	96	104	100	102	100
72	52	66	82	86	94	92	100	96
73	96	98	102	112	106	114	120	126
74	74	80	78	88	96	96	90	96
75	110	116	142	124	126	132	132	142
76	82	96	90	98	98	114	114	122
77	68	80	96	112	112	114	118	122
78	68	74	66	74	76	70	62	60
79	70	92	100	97	96	86	100	118
80	—	64	78	80	94	—	98	102
81	60	88	94	102	100	116	122	130
82	76	84	104	100	100	110	96	—
83	100	88	96	80	78	88	—	—
84	92	114	122	100	110	124	104	134
85	96	72	—	—	—	—	—	—
86	90	108	122	102	94	88	92	98
87	64	76	106	122	108	84	110	122
88	66	60	64	66	78	74	68	88
89	76	114	98	96	76	88	100	—
90	74	84	124	110	122	106	142	112
91	86	—	74	92	96	88	112	112
92	72	80	86	78	84	90	88	96
93	38	74	74	—	84	66	90	82
Ind.	2/17	2/18	4/20	4/21	4/22	4/23	4/26	4/27
1	150	160	154	170	184	178	176	163
2	96	98	96	102	106	112	122	122
3	108	104	114	110	134	138	110	138
4	160	100	94	88	92	100	106	104
5	98	106	116	112	122	116	120	134
6	—	—	—	—	—	—	—	—
7	74	100	92	92	78	110	102	122
8	82	82	84	162	96	108	118	116
9	126	128	140	156	156	168	170	162
10	60	74	84	82	86	88	90	96
11	116	126	94	130	134	130	114	140
12	112	122	—	—	—	—	132	138
13	146	142	144	154	150	160	154	156
14	104	120	126	126	126	122	142	148
15	134	104	102	98	112	120	134	148
16	104	118	—	124	126	132	132	134
17	118	114	104	96	84	—	92	126
18	98	98	104	100	92	106	104	126
19	92	100	96	96	98	88	112	112
20	96	114	98	120	108	132	122	126
21	122	130	146	114	118	144	142	126
22	118	118	132	96	90	—	124	114
23	116	122	104	110	112	122	122	122
24	106	110	114	114	128	106	128	117



Ind.	2/17	2/18	4/20	4/21	4/22	4/23	4/26	4/27
25	128	112	—	—	—	—	—	—
26	92	90	98	100	88	106	102	108
27	114	118	104	118	110	126	126	138
28	108	108	124	118	116	124	126	134
29	124	130	166	142	160	140	150	134
30	82	84	88	94	84	94	96	90
31	84	80	74	84	102	98	100	100
32	104	112	—	108	132	140	150	152
33	136	134	124	128	122	120	122	112
34	—	—	—	—	—	—	—	—
35	88	88	78	110	104	114	112	122
36	106	142	102	106	102	—	128	132
37	126	121	120	124	88	126	108	130
38	88	90	88	96	116	100	96	100
39	100	103	100	104	102	112	108	112
40	—	—	—	—	—	—	—	—
41	96	88	100	88	98	102	102	90
42	94	100	106	98	110	110	118	118
43	102	100	108	96	110	116	108	108
44	136	144	136	112	138	122	134	144
50	148	144	146	142	146	160	154	170
51	72	34	46	10	86	74	96	90
52	62	66	72	78	80	78	78	76
53	—	—	12	28	30	—	—	30
54	146	150	158	140	172	158	182	168
55	94	106	98	104	100	98	108	120
56	126	144	138	148	142	176	—	—
57	50	54	66	88	88	110	84	90
58	108	112	108	120	130	130	126	132
59	96	88	92	104	96	120	100	76
60	92	88	92	86	104	112	108	110
61	84	112	100	118	106	114	114	106
62	124	142	128	132	124	130	144	140
63	104	104	108	130	132	136	128	136
64	96	98	94	—	98	98	98	106
65	98	100	84	—	—	—	108	116
66	96	90	92	94	96	116	118	114
67	140	138	134	146	152	170	148	152
68	84	92	76	88	92	100	90	102
69	—	—	—	—	—	—	—	—
70	88	88	90	100	90	102	92	100
71	112	106	112	112	122	130	—	100
72	110	110	128	122	128	134	132	138
73	130	134	121	130	140	146	136	144
74	98	106	98	102	108	110	104	104
75	150	130	150	132	160	178	172	162
76	140	162	116	136	134	148	128	144
77	142	136	140	164	146	150	140	152
78	88	94	82	100	104	128	112	112
79	134	136	—	128	126	138	126	118
80	110	118	108	110	108	122	126	140
81	118	128	134	146	142	122	122	130
82	124	—	136	142	121	148	148	148
83	—	—	106	102	120	120	62	68
84	140	140	160	156	168	174	184	186
85	—	120	32	20	60	50	84	92
86	106	86	106	108	104	102	102	122
87	112	98	102	114	130	142	132	128
88	86	96	90	102	98	112	112	124
89	—	—	—	—	—	—	—	—
90	122	126	150	172	168	178	160	160
91	120	122	104	98	112	104	114	108
92	98	96	86	96	102	96	96	98
93	96	—	80	90	110	86	—	86

CANCELLING 3: Original scores made in 1 minute by 88 children.

Ind.	2/4	2/5	2/8	2/9	2/10	2/11	2/15	2/16
1	124	128	126	132	138	154	150	164
2	86	80	102	—	100	106	116	122
3	90	90	94	90	112	116	106	120
4	78	92	94	98	100	100	102	100
5	92	96	—	—	108	126	128	126
6	—	—	—	—	—	—	—	—
7	74	72	88	98	92	98	110	116
8	68	—	76	82	92	—	88	92
9	108	106	128	128	124	126	132	134

78 *Correlation of Psychological and Educational Measurements*

Ind.	2/4	2/5	2/8	2/9	2/10	2/11	2/15	2/16
10	60	89	78	74	74	104	92	102
11	82	110	108	108	122	110	132	132
12	96	112	132	128	122	140	150	140
13	140	142	120	150	146	160	172	158
14	88	106	118	124	114	118	124	102
15	104	100	118	122	140	138	148	128
16	84	96	120	124	118	—	126	128
17	90	94	100	104	112	124	132	118
18	72	82	86	84	104	108	98	104
19	80	—	80	78	88	108	126	114
20	100	98	94	106	102	92	122	124
21	78	94	102	110	116	—	126	128
22	74	78	86	98	—	100	108	102
23	82	88	100	118	96	132	132	126
24	106	102	104	108	108	122	124	142
25	88	112	110	160	108	132	134	—
26	70	84	80	80	90	92	96	96
27	80	84	104	98	88	102	114	116
28	64	76	94	114	118	118	130	124
29	104	120	114	122	124	134	138	138
30	58	64	—	64	76	90	96	86
31	80	90	92	80	88	98	100	110
32	68	86	104	104	112	126	128	114
33	94	118	138	136	132	142	156	144
34	82	—	108	116	124	122	—	—
35	62	74	72	82	80	86	94	94
36	58	68	84	96	118	116	81	108
37	76	84	92	108	118	128	132	126
38	66	82	84	78	92	90	86	98
39	80	84	90	92	106	116	114	114
40	87	104	—	—	—	100	—	—
41	74	82	72	72	78	88	88	90
42	82	—	104	96	110	108	—	—
43	96	80	94	98	106	114	118	118
44	104	120	116	126	120	128	144	132
50	116	124	—	132	136	142	140	148
51	56	88	42	100	96	88	80	84
52	42	64	56	60	58	70	58	70
53	28	22	32	18	22	36	40	42
54	152	146	126	—	140	138	150	150
55	70	112	116	102	114	116	126	126
56	—	—	116	128	136	148	136	145
57	92	86	82	82	62	96	74	68
58	70	100	122	110	88	98	124	126
59	72	90	88	104	104	100	116	128
60	38	62	98	70	98	82	100	102
61	84	104	128	106	83	94	88	92
62	66	110	116	116	124	132	136	132
63	106	112	128	104	94	114	116	126
64	82	88	92	94	90	100	110	104
65	150	130	124	140	—	124	102	126
66	68	64	84	74	100	96	104	118
67	128	126	136	128	124	140	136	150
68	—	74	82	82	98	—	—	—
69	88	108	—	96	87	—	100	—
70	70	92	—	84	84	94	98	102
71	70	118	118	128	120	122	118	122
72	80	80	94	104	94	104	118	126
73	102	120	122	132	128	136	128	134
74	82	94	92	92	104	90	107	116
75	136	138	130	138	132	134	140	144
76	92	116	108	118	120	130	136	152
77	114	136	144	152	132	144	158	164
78	78	108	86	84	82	92	84	112
79	92	102	132	118	130	124	122	110
80	66	80	90	100	104	106	108	122
81	100	78	122	122	122	136	136	136
82	92	122	126	122	116	132	128	—
83	136	140	104	128	98	108	—	—
84	132	128	136	124	136	152	136	138
85	138	104	—	—	—	—	—	—
86	136	114	114	116	108	120	94	110
87	104	158	136	120	122	140	132	128
88	54	70	64	76	76	84	80	88
89	100	102	128	108	112	122	114	—
90	116	114	124	136	124	132	134	140
91	112	—	116	124	120	124	134	138
92	106	96	100	94	100	124	104	106
93	60	92	78	96	108	98	112	126

## CANCELLING 3 (continued)

Ind.	2/17	2/18	4/20	4/21	4/22	4/23	4/26	4/27
1	156	168	174	172	178	182	182	180
2	112	122	129	129	124	138	132	136
3	132	128	139	132	138	136	138	144
4	112	122	114	107	116	114	112	116
5	124	131	138	140	144	138	140	140
6	—	134	—	—	—	—	—	—
7	108	120	118	120	118	130	122	128
8	108	128	124	118	128	132	132	144
9	144	136	142	150	138	152	150	154
10	98	116	160	118	118	116	116	128
11	128	—	—	132	140	126	128	180
12	152	148	—	—	—	—	162	140
13	156	164	172	160	172	176	176	184
14	130	118	136	132	136	128	128	136
15	148	128	140	140	142	146	164	154
16	132	128	146	118	138	142	144	142
17	128	124	116	130	122	—	124	128
18	114	108	114	106	116	126	126	128
19	112	116	106	98	112	112	124	124
20	136	136	132	140	144	148	158	148
21	128	132	134	130	140	138	140	150
22	110	106	122	108	128	—	116	155
23	124	138	118	132	134	132	132	130
24	124	132	130	126	132	136	144	136
25	148	140	—	—	—	—	—	—
26	112	110	110	120	122	132	118	126
27	116	116	124	136	138	144	140	134
28	128	138	138	136	134	142	136	150
29	128	146	168	148	142	144	166	148
30	96	108	102	112	110	94	116	122
31	108	108	100	108	120	122	126	118
32	128	124	136	132	148	142	168	170
33	144	152	150	140	144	142	134	142
34	—	—	—	—	—	—	—	—
35	100	102	112	116	132	128	134	132
36	104	148	136	132	140	—	138	158
37	128	136	134	130	—	130	126	—
38	102	98	120	112	106	118	122	126
39	118	120	124	116	126	126	132	128
40	—	—	—	—	—	—	—	—
41	106	98	110	98	108	112	108	100
42	118	126	124	110	128	124	136	140
43	120	118	128	124	120	126	124	120
44	146	142	152	132	138	148	136	156
50	150	150	148	162	158	172	176	176
51	40	46	68	76	70	96	104	90
52	70	72	84	82	74	90	84	86
53	—	—	26	30	46	—	30	—
54	140	162	156	172	176	180	146	142
55	118	128	124	116	122	132	138	138
56	148	154	142	162	154	164	—	—
57	72	88	104	102	116	128	112	116
58	124	130	126	128	132	134	144	148
59	126	132	132	138	148	160	144	150
60	110	—	100	104	122	116	128	114
61	116	96	114	106	108	104	112	108
62	144	150	134	140	142	134	142	140
63	122	124	138	142	152	150	150	162
64	122	114	98	—	118	122	126	118
65	126	—	120	—	—	—	142	140
66	112	126	122	122	136	136	138	132
67	150	150	148	160	172	172	168	188
68	90	98	100	102	112	124	108	122
69	—	—	—	—	—	—	—	—
70	104	114	104	120	116	122	116	124
71	126	116	122	128	138	136	—	142
72	128	132	128	132	136	142	142	150
73	123	136	136	138	142	146	146	150
74	124	122	—	122	120	120	106	110
75	136	148	146	166	158	168	156	152
76	154	128	126	132	134	144	146	160
77	170	178	190	196	—	183	190	200
78	114	108	120	126	126	132	132	128
79	142	140	—	138	130	148	152	154
80	114	122	114	120	126	134	128	142
81	136	136	140	162	150	144	150	144

80 *Correlation of Psychological and Educational Measurements*

Ind.	2/17	2/18	4/20	4/21	4/22	4/23	4/26	4/27
82	142	132	142	150	144	164	172	153
83	—	—	132	126	138	118	84	28
84	164	162	162	177	160	182	186	—
85	—	—	26	76	94	104	120	120
86	94	112	122	132	134	110	142	134
87	132	136	126	140	144	146	148	142
88	104	106	88	116	112	121	124	118
89	—	—	—	—	—	—	—	—
90	119	138	142	176	176	163	174	162
91	150	144	132	162	138	133	150	128
92	116	120	108	114	110	112	120	128
93	118	—	116	124	118	128	—	140

ADDITION: Original scores made in 10 minutes by 88 children.

Ind.	2/4	2/5	2/8	2/9	2/10	2/11	2/15	2/16	2/17	2/18
1	64	71	85	80	91	98	96	91	103	117
2	31	42	29	—	36	48	39	41	51	45
3	53	57	57	60	70	82	77	74	78	84
4	22	42	34	40	39	45	40	48	36	43
5	20	29	—	—	27	26	30	38	32	38
6	—	26	25	30	28	27	25	—	42	47
7	30	38	34	29	38	29	42	48	35	43
8	23	—	20	19	24	—	22	24	27	30
9	29	42	41	50	44	55	60	67	63	60
10	9	9	4	8	4	6	12	5	10	18
11	15	13	18	17	14	20	20	18	12	—
12	13	14	14	17	25	26	31	20	23	26
13	65	71	63	83	96	98	90	87	99	97
14	63	70	65	73	79	79	72	73	84	85
15	17	28	28	37	28	30	34	32	43	43
16	37	38	40	49	32	40	42	44	49	48
17	14	13	18	18	18	27	23	31	32	31
18	39	40	48	52	52	54	53	68	61	69
19	57	53	52	66	54	53	60	77	86	83
20	38	20	44	46	56	59	47	70	59	70
21	13	22	13	18	23	30	23	27	20	31
22	26	28	32	37	—	34	32	38	40	43
23	38	48	39	48	55	55	58	59	63	59
24	42	45	48	57	54	63	47	60	52	58
25	34	36	41	45	49	61	64	63	50	65
26	38	45	42	24	40	40	46	31	45	53
27	38	42	20	39	52	41	48	50	54	60
28	13	15	18	26	24	25	25	19	18	26
29	30	33	36	28	29	33	39	37	40	32
30	38	48	—	51	53	51	57	56	60	62
31	9	15	13	16	18	20	11	21	15	31
32	27	28	33	40	36	39	28	42	45	54
33	40	52	57	53	65	69	57	67	68	70
34	40	47	48	48	61	65	—	—	—	—
35	25	31	28	37	42	42	39	38	41	41
36	28	27	20	20	26	22	23	21	25	23
37	45	55	60	57	58	73	73	68	69	70
38	13	23	15	23	21	21	22	21	25	22
39	33	35	36	43	41	42	45	46	52	57
40	34	33	—	—	—	45	—	—	—	—
41	24	31	25	22	30	33	27	30	32	33
42	71	—	63	64	69	71	—	—	63	76
43	40	56	62	63	61	65	64	69	83	81
44	24	31	23	29	26	28	30	32	35	41
45	29	34	30	36	27	35	41	37	48	51
46	61	74	78	77	80	85	73	89	87	80
47	61	44	54	59	63	64	59	56	65	67
48	23	27	26	28	27	25	33	28	—	—
49	28	38	42	42	40	49	40	55	61	53
50	22	36	33	38	37	38	37	39	45	47
51	—	23	18	15	22	17	23	23	27	27
52	13	15	19	23	18	24	22	27	23	24
53	41	53	54	52	50	58	40	67	69	70
54	25	55	36	31	38	36	37	43	38	38
55	16	20	15	24	12	21	24	25	23	27
56	21	30	20	25	25	32	31	34	28	29
57	52	74	74	76	86	81	83	86	94	94
58	22	21	34	29	28	29	35	23	24	16

Ind.	2/4	2/5	2/8	2/9	2/10	2/11	2/15	2/16	2/17	2/18
64	29	35	32	27	24	25	31	34	28	42
65	—	25	31	25	22	29	26	21	27	31
66	39	47	49	48	51	51	51	53	61	66
67	34	35	39	40	36	42	42	50	44	49
68	—	45	54	52	47	—	37	—	53	57
69	27	—	—	—	—	—	39	—	—	—
70	29	22	25	21	22	20	29	29	35	34
71	29	46	46	46	62	44	48	41	50	54
72	66	79	76	80	91	87	88	94	102	103
73	32	29	31	37	37	40	33	26	36	48
74	13	19	13	14	13	13	16	19	28	27
75	22	18	32	22	17	22	27	30	25	27
76	37	48	45	45	34	49	51	51	49	59
77	21	27	22	17	19	31	26	18	27	26
78	32	35	35	35	40	41	41	48	49	53
79	39	53	62	67	74	75	67	70	79	83
80	58	74	69	86	82	85	92	96	94	102
81	46	56	64	60	68	73	69	66	64	63
82	29	42	40	42	40	41	45	—	45	51
83	30	28	26	39	37	29	—	—	—	—
84	31	35	32	35	43	44	36	39	40	39
85	25	28	—	—	—	—	—	—	—	—
86	21	23	—	—	—	—	—	—	—	—
87	25	31	21	15	20	20	17	15	15	14
88	24	24	17	26	30	30	31	34	36	33
89	47	65	71	19	21	19	23	27	18	27
90	21	—	14	64	72	68	74	—	—	—
91	29	—	39	26	36	49	48	51	52	49
92	33	—	43	35	33	33	32	48	43	45
93	41	42	42	38	43	43	45	43	48	44
		47		44	45	42	42	39	49	—

Ind.	4/14	4/15	4/16	4/19	4/20	4/23	4/26	4/27
1	118	119	113	110	112	119	115	131
2	39	41	45	34	35	39	36	35
3	77	63	77	60	81	75	68	77
4	28	29	42	32	35	34	49	49
5	23	29	34	—	23	35	35	40
6	34	41	42	35	43	54	55	52
7	44	48	53	49	49	53	45	58
8	34	23	32	34	35	52	42	49
9	56	45	59	50	69	71	71	80
10	11	11	11	21	14	17	9	14
11	7	12	11	22	29	11	4	14
12	—	—	—	—	—	—	24	22
13	95	95	98	98	98	108	112	113
14	51	72	76	56	63	78	82	94
15	27	29	24	25	25	35	36	35
16	51	50	55	49	59	52	53	61
17	28	29	37	31	33	—	45	45
18	64	61	69	70	71	75	79	77
19	85	99	99	109	90	101	99	110
20	59	58	68	68	69	74	78	70
21	28	26	27	26	26	30	31	28
22	27	32	30	28	24	—	27	27
23	58	60	63	62	57	62	55	55
24	51	60	63	—	45	68	60	57
25	—	—	—	—	—	—	—	—
26	58	60	63	58	55	65	57	66
27	59	62	65	60	73	75	80	78
28	—	18	22	23	28	23	22	27
29	32	38	22	47	46	21	46	42
30	55	44	59	48	60	73	70	66
31	18	14	21	18	13	12	15	4
32	46	53	59	31	47	48	47	55
33	76	72	78	68	68	80	77	78
34	—	—	—	—	—	—	—	—
35	45	43	46	32	49	49	45	46
36	15	25	26	28	31	—	23	30
37	68	76	78	81	85	70	74	81
38	22	19	23	21	18	28	22	23
39	57	58	65	40	63	70	67	71
40	—	—	—	—	—	—	—	—
41	29	35	48	42	45	46	51	59
42	54	73	74	87	72	47	93	69
43	71	81	83	81	79	85	85	89
44	42	42	41	32	39	39	33	24
50	33	45	42	39	46	52	46	43

82 *Correlation of Psychological and Educational Measurements*

## ADDITION (continued)

Ind.	4/14	4/15	4/16	4/19	4/20	4/23	4/26	4/27
51	98	104	102	91	92	103	93	106
52	—	—	—	—	—	—	—	—
53	28	87	31	41	35	—	—	35
54	53	61	57	51	58	70	63	72
55	35	35	37	31	42	49	40	48
56	25	25	27	28	32	30	—	—
57	20	18	24	—	25	22	22	30
58	71	70	82	75	77	89	80	87
59	51	47	38	43	55	59	56	60
60	27	29	25	26	29	30	35	24
61	25	—	61	26	25	33	31	26
62	85	98	93	97	101	110	118	121
63	30	33	42	26	31	35	25	32
64	—	25	35	16	32	35	41	24
65	27	31	32	57	32	—	29	23
66	69	57	64	57	66	65	64	74
67	49	58	52	54	64	59	55	73
68	57	—	65	59	64	56	66	72
69	—	—	—	—	—	—	—	—
70	31	32	33	31	33	38	31	38
71	29	48	49	40	48	47	—	51
72	86	88	81	78	97	100	97	103
73	40	45	45	45	49	54	47	54
74	24	23	31	24	31	35	30	42
75	27	31	31	24	33	36	38	28
76	59	61	57	48	50	64	61	66
77	20	23	19	29	17	25	33	32
78	41	39	38	34	39	39	51	45
79	87	88	94	80	—	108	105	103
80	98	97	102	98	108	120	120	122
81	61	72	72	64	71	76	68	78
82	45	45	47	54	54	51	54	56
83	22	42	34	24	40	42	35	37
84	41	46	43	37	46	48	44	39
85	26	30	—	28	28	45	35	41
86	16	25	20	17	19	22	23	20
87	33	32	32	—	25	35	31	44
88	27	31	31	33	38	39	34	31
89	—	—	—	—	—	—	—	—
90	62	62	73	69	68	56	73	63
91	38	49	—	—	42	53	52	58
92	44	54	58	—	47	50	51	58
93	38	43	52	45	61	65	—	56

COPYING ADDRESSES: Original scores made in 10 minutes by 88 children.

Ind.	2/19	2/23	2/24	2/25	2/26	3/1	3/2	3/3	3/4	3/5
1	7	10	19	18	18	16	17	17	19	15
2	15	19	13	21	22	21	18	—	22	26
3	3	9	10	17	14	16	16	17	18	18
4	10	10	14	17	13	15	13	11	14	15
5	16	18	19	24	22	—	23	21	22	24
6	3	7	7	9	11	11	16	—	6	11
7	1	8	5	11	13	15	8	12	14	20
8	13	14	17	20	20	20	15	20	23	25
9	13	19	17	21	18	20	14	16	22	26
10	9	11	10	12	16	12	10	19	12	17
11	5	11	14	—	22	22	17	25	25	28
12	5	11	—	16	15	14	10	16	12	19
13	15	21	25	23	20	25	22	26	25	29
14	12	12	9	14	14	13	18	17	13	15
15	9	8	9	15	16	16	15	17	13	24
16	11	10	15	16	19	18	17	21	19	24
17	13	12	11	17	17	19	9	15	16	18
18	13	14	14	24	22	25	19	19	23	23
19	5	13	11	16	18	18	15	16	18	23
20	11	16	33	19	20	17	20	17	23	28
21	9	12	9	12	12	15	15	13	8	12
22	11	5	12	17	16	14	18	15	15	24
23	11	12	8	—	14	21	16	17	13	22
24	17	19	19	24	24	23	20	23	25	25
25	15	15	17	18	23	18	19	21	17	24
26	12	13	17	20	18	21	18	19	18	20
27	15	17	20	25	25	26	26	29	31	29
28	9	11	10	14	14	13	16	18	13	19
29	15	20	20	27	22	21	26	24	26	29

Ind.	2/19	2/23	2/24	2/25	2/26	3/1	3/2	3/3	3/4	3/5
30	17	20	25	23	25	21	22	23	24	28
31	10	13	—	15	17	14	13	12	17	11
32	14	17	18	20	21	12	16	25	63	29
33	7	8	13	14	19	13	13	13	15	18
34	—	—	—	—	—	—	—	—	—	—
35	14	18	15	18	20	19	17	19	30	25
36	10	14	9	13	14	19	18	17	18	18
37	13	18	21	21	21	21	13	15	21	28
38	11	11	10	14	15	14	15	14	17	17
39	12	16	14	19	18	17	18	14	17	23
40	—	—	—	—	—	—	—	—	—	—
41	14	11	17	18	16	19	17	20	20	21
42	19	21	25	25	23	26	29	21	30	29
43	12	5	12	19	20	11	17	19	16	20
44	11	—	—	17	—	16	10	15	16	20
50	15	20	18	23	25	—	19	26	24	30
51	12	18	19	19	24	10	16	20	25	24
52	2	—	6	14	14	12	11	11	13	15
53	—	15	16	18	19	19	18	22	23	27
54	10	13	21	21	23	19	27	23	21	27
55	6	12	12	16	16	20	20	16	16	23
56	6	13	17	17	19	20	16	24	24	25
57	11	12	17	14	15	16	15	13	19	19
58	13	15	15	17	16	19	16	20	20	20
59	10	13	11	16	18	19	15	18	17	21
60	13	14	15	17	19	16	18	20	19	23
61	9	11	10	12	16	11	12	12	15	19
62	19	20	21	23	23	19	29	17	24	23
63	6	11	13	12	17	15	14	10	18	21
64	13	18	22	19	24	22	22	22	22	23
65	9	8	7	—	9	15	14	5	9	13
66	10	5	8	11	15	16	10	16	15	18
67	13	12	12	15	19	20	17	19	14	21
68	8	16	13	16	23	18	18	19	—	24
69	—	—	—	—	—	—	—	—	—	—
70	12	14	14	18	19	23	15	20	23	19
71	10	11	14	14	18	18	15	19	16	25
72	12	17	20	21	18	17	19	22	18	24
73	10	10	5	13	13	14	12	12	10	16
74	8	14	13	17	19	16	18	15	14	21
75	5	7	9	14	19	17	10	19	16	20
76	21	19	23	27	26	24	29	28	31	31
77	11	15	20	22	21	23	22	21	24	24
78	11	15	19	11	19	19	13	16	19	24
79	10	12	17	20	19	—	13	19	14	20
80	10	16	16	17	21	18	15	19	20	21
81	20	34	23	25	26	27	29	28	17	26
82	12	19	20	21	22	20	21	19	17	26
83	—	10	17	22	18	—	22	19	19	25
84	8	15	14	18	18	12	18	19	19	28
85	—	—	—	—	9	—	10	13	14	17
86	11	8	8	9	15	19	12	17	10	20
87	8	10	16	17	16	15	18	17	14	23
88	5	8	11	15	14	17	10	16	13	16
89	—	—	—	—	—	—	—	—	—	—
90	13	18	15	16	19	22	17	21	19	27
91	11	17	15	20	18	18	19	18	22	25
92	15	18	21	22	21	22	19	22	20	25
93	12	16	19	18	—	—	19	26	21	25

  

Ind.	4/14	4/15	4/16	14/9	4/20	4/21	4/22	4/23	4/26	4/27
1	18	30	21	21	21	19	24	26	22	21
2	26	28	28	25	25	28	26	30	30	32
3	18	22	19	20	21	19	23	22	21	22
4	18	19	14	18	18	20	15	16	18	25
5	19	26	26	—	22	24	28	25	24	26
6	14	13	12	13	16	18	15	16	18	19
7	19	13	17	21	21	16	15	20	22	22
8	28	30	27	26	28	28	32	32	34	39
9	26	28	25	22	26	20	28	29	21	29
10	17	21	18	18	18	15	16	18	23	22
11	24	26	25	34	26	31	31	34	25	34
12	—	—	—	—	—	—	—	—	16	13
13	27	29	24	32	31	31	31	34	38	34
14	23	19	21	23	21	19	15	23	25	21
15	21	22	22	20	21	21	22	25	26	25
16	17	21	20	16	25	22	23	24	24	29

84 *Correlation of Psychological and Educational Measurements*

## COPYING ADDRESSES (continued)

Ind.	4/14	4/15	4/16	4/9	4/20	4/21	4/22	4/23	4/28	4/27
17	19	17	19	17	19	20	19	—	24	22
18	26	27	25	26	22	26	28	31	31	32
19	21	20	13	18	21	22	24	21	28	27
20	23	22	26	27	24	28	31	25	33	29
21	18	16	17	14	18	17	16	17	16	18
22	24	24	18	18	21	16	22	—	28	27
23	21	23	20	19	21	22	25	26	25	25
24	30	27	29	—	29	32	34	35	36	38
25	—	—	—	—	—	—	—	—	—	—
26	20	26	24	24	23	24	27	29	28	28
27	29	27	35	32	32	26	37	37	39	35
28	—	18	19	24	21	21	19	28	25	19
29	27	30	29	22	30	36	37	31	34	39
30	24	26	30	26	29	27	27	31	32	32
31	18	19	20	15	20	19	19	25	24	22
32	30	28	28	18	24	27	27	28	33	31
33	17	20	19	10	20	19	21	21	22	17
34	—	—	—	—	—	—	—	—	—	—
35	22	26	23	27	30	25	26	29	31	28
36	19	18	15	14	20	21	23	—	24	24
37	25	23	23	23	24	24	25	23	25	21
38	16	15	15	14	19	19	18	20	20	22
39	17	23	21	20	22	22	20	22	26	26
40	—	—	—	—	—	—	—	—	—	—
41	20	20	19	17	20	23	23	21	24	18
42	31	29	32	30	33	34	37	34	38	32
43	14	17	18	15	21	17	21	24	24	21
44	20	22	20	20	23	22	23	23	25	27
45	33	28	34	26	33	32	26	30	34	34
46	98	26	28	22	22	29	23	26	27	30
47	68	16	18	17	21	18	21	20	22	19
48	28	29	25	26	24	23	34	—	—	31
49	53	51	21	22	24	26	28	29	28	31
50	35	35	18	18	21	21	14	20	18	24
51	25	25	25	23	23	27	32	30	—	—
52	20	18	19	14	20	21	20	22	20	27
53	71	76	23	28	24	26	30	29	36	31
54	51	47	17	15	23	15	25	25	23	25
55	27	29	21	18	23	20	21	23	22	21
56	25	—	14	14	15	15	18	18	17	17
57	85	98	18	29	28	31	30	26	29	28
58	30	33	18	19	21	18	25	18	23	21
59	—	25	25	25	25	—	23	28	28	20
60	27	31	17	13	15	—	—	—	19	17
61	69	57	19	20	21	18	19	20	21	24
62	49	58	19	19	18	29	24	25	30	24
63	57	61	24	23	20	21	23	26	24	27
64	—	—	—	—	—	—	—	—	—	—
65	31	32	25	23	26	25	24	27	21	30
66	29	48	17	25	26	20	26	21	—	23
67	86	88	21	21	21	26	24	26	29	27
68	40	45	18	14	18	18	21	18	19	22
69	24	23	21	18	21	19	24	22	21	23
70	27	31	26	23	22	22	28	30	31	28
71	59	61	29	28	32	28	34	35	36	36
72	29	23	24	23	26	26	26	27	29	28
73	41	29	21	19	23	—	22	24	28	30
74	87	88	27	23	—	23	26	21	27	26
75	95	97	23	19	—	28	26	21	27	30
76	61	72	30	36	36	40	28	32	32	31
77	45	45	27	27	25	30	24	29	29	30
78	22	42	26	21	19	24	31	31	30	30
79	41	46	19	29	25	26	29	32	24	28
80	26	30	—	15	16	22	18	23	29	22
81	16	25	10	11	21	19	25	23	22	18
82	33	32	20	—	17	14	23	23	22	25
83	27	31	16	15	14	17	15	19	21	14
84	—	—	—	—	—	—	—	—	—	—
85	62	62	23	25	23	31	29	31	31	29
86	38	49	—	—	—	22	25	26	24	25
87	44	54	24	—	25	25	28	26	25	25
88	38	43	27	22	25	23	26	27	—	28



HANDWRITING: Original scores made in 4 minutes by 88 children.

Ind.	2/19	2/23	2/24	2/25	2/26
1	63	70	62	56	63
2	87	80	80	82	72
3	83	81	78	71	77
4	66	62	68	62	67
5	76	81	79	65	66
6	80	75	70	66	60
7	65	64	79	78	72
8	66	61	55	47	33
9	85	81	62	65	68
10	58	57	61	49	46
11	81	81	60	54	54
12	80	80	68	50	—
13	107	95	81	68	85
14	67	79	85	58	61
15	54	59	46	39	45
16	86	82	65	65	77
17	55	55	49	48	46
18	63	60	70	70	59
19	64	65	61	55	55
20	70	79	67	59	64
21	55	70	65	66	54
22	75	67	75	68	73
23	71	67	60	53	54
24	68	75	72	58	65
25	63	68	52	53	59
26	64	59	59	53	64
27	78	79	72	76	83
28	75	79	74	72	66
29	75	81	84	73	64
30	55	61	63	55	51
31	75	79	75	54	—
32	83	90	97	87	85
33	81	90	82	68	68
34	—	—	—	—	—
35	70	61	70	61	72
36	101	89	75	69	73
37	73	96	70	63	73
38	51	46	54	43	50
39	68	74	58	56	53
40	—	—	—	—	—
41	83	81	81	75	57
42	101	80	79	76	75
43	73	81	68	69	73
44	69	75	—	—	—
45	92	86	92	69	88
46	51	75	84	76	77
47	79	75	—	—	—
48	60	54	—	—	—
49	—	—	85	61	76
50	85	78	78	84	71
51	69	51	76	77	50
52	95	89	90	76	94
53	69	87	60	59	60
54	71	65	65	58	48
55	69	85	75	67	66
56	80	78	66	63	60
57	61	55	51	41	49
58	91	74	74	68	68
59	83	54	61	54	59
60	78	74	75	63	57
61	91	85	78	69	82
62	81	72	79	74	60
63	99	96	96	94	75
64	82	75	82	79	80
65	—	—	—	—	—
66	66	67	79	64	73
67	66	68	67	64	58
68	75	75	64	66	70
69	84	79	75	74	72
70	74	74	69	65	45
71	86	79	66	80	72
72	84	79	75	66	73
73	74	74	69	65	72
74	86	79	78	66	45
75	98	104	89	82	76
76	72	66	70	60	74
77	68	65	65	52	64
78	84	83	75	82	68
79	95	93	79	62	70
80	69	100	98	92	96
81	80	73	84	76	75
82	—	—	71	62	69
83	83	82	78	71	69
84	—	82	78	72	71
85	67	65	63	60	68
86	75	75	79	72	79
87	68	69	69	66	69
88	69	69	69	66	66
89	67	67	67	67	67
90	65	65	65	65	65
91	66	66	66	66	66
92	67	67	67	67	67
93	68	68	68	68	68
94	69	69	69	69	69
95	70	70	70	70	70
96	71	71	71	71	71
97	72	72	72	72	72
98	73	73	73	73	73
99	74	74	74	74	74
100	75	75	75	75	75
101	76	76	76	76	76
102	77	77	77	77	77
103	78	78	78	78	78
104	79	79	79	79	79
105	80	80	80	80	80
106	81	81	81	81	81
107	82	82	82	82	82
108	83	83	83	83	83
109	84	84	84	84	84
110	85	85	85	85	85
111	86	86	86	86	86
112	87	87	87	87	87
113	88	88	88	88	88
114	89	89	89	89	89
115	90	90	90	90	90
116	91	91	91	91	91
117	92	92	92	92	92
118	93	93	93	93	93
119	94	94	94	94	94
120	95	95	95	95	95
121	96	96	96	96	96
122	97	97	97	97	97
123	98	98	98	98	98
124	99	99	99	99	99
125	100	100	100	100	100

86 *Correlation of Psychological and Educational Measurements*

## HANDWRITING (continued)

Ind.	2/19		2/23		2/24		2/25		2/26	
85	—	—	—	—	—	—	—	—	59	67
86	86	85	72	76	73	61	70	72	65	72
87	73	78	76	80	76	64	42	70	50	57
88	58	54	65	48	56	51	64	54	59	70
89	—	—	—	—	—	—	—	—	—	—
90	70	58	84	76	84	75	63	57	81	89
91	91	89	75	73	64	66	86	83	74	79
92	84	80	75	76	78	78	85	79	89	89
93	79	71	78	69	79	72	75	80	—	—

Ind.	3/1		3/2		3/3		3/4		3/5	
1	69	63	59	64	66	54	61	57	59	69
2	63	66	63	67	—	—	74	55	57	66
3	67	62	72	77	62	66	73	77	72	81
4	64	61	59	65	61	60	58	55	59	63
5	—	—	66	78	69	70	68	64	78	74
6	59	59	64	62	—	—	51	45	56	53
7	59	68	63	66	65	71	69	56	66	63
8	44	51	35	41	48	26	44	36	32	46
9	81	71	73	85	74	75	78	81	75	80
10	40	43	53	62	59	58	55	59	67	77
11	45	56	58	66	55	63	46	54	60	62
12	58	75	64	80	75	79	75	86	83	96
13	82	83	104	162	89	107	105	91	101	113
14	64	62	61	61	52	61	59	66	63	69
15	42	45	45	47	49	51	38	40	39	48
16	66	64	66	69	68	60	67	71	68	79
17	42	50	51	51	48	47	48	51	45	50
18	61	63	60	66	58	59	63	61	58	68
19	66	75	61	75	64	68	71	68	62	64
20	55	64	64	75	59	70	61	69	57	60
21	59	69	54	64	66	73	66	60	65	68
22	73	70	62	77	68	77	65	50	70	72
23	51	51	63	61	69	67	67	70	66	58
24	47	63	56	79	53	60	55	54	52	66
25	58	61	59	67	58	67	63	53	64	76
26	38	58	54	58	52	63	51	44	56	68
27	81	85	79	93	75	78	63	81	83	80
28	75	75	62	64	62	77	81	68	73	72
29	66	61	53	100	69	60	62	84	68	101
30	34	51	41	48	52	50	45	42	61	64
31	53	56	59	77	45	71	50	38	49	79
32	78	92	86	83	95	88	90	84	81	90
33	67	69	57	75	52	51	47	51	56	62
34	—	—	—	—	—	—	—	—	—	—
35	75	74	72	78	77	90	68	59	67	69
36	61	78	70	86	77	76	82	74	85	79
37	55	62	64	80	61	65	64	72	73	87
38	49	45	48	50	49	44	51	46	54	57
39	69	71	57	70	55	59	61	56	56	64
40	—	—	—	—	—	—	—	—	—	—
41	74	75	78	73	62	67	75	69	55	60
42	63	57	67	84	45	55	66	68	62	76
43	72	79	49	39	41	59	76	71	68	76
44	70	68	71	73	75	76	74	69	62	69
45	72	89	79	87	81	95	74	93	65	69
50	56	62	53	70	40	69	43	64	62	70
52	55	57	55	56	55	60	50	46	47	52
53	55	62	49	58	55	65	62	59	66	73
54	87	87	66	74	61	71	67	67	71	74
55	58	65	54	55	62	55	59	49	61	48
56	95	106	102	100	94	100	104	90	69	73
57	61	53	42	50	41	50	45	39	41	41
58	63	69	63	53	70	71	69	62	63	61
59	72	82	68	83	63	63	84	65	39	76
60	69	63	55	65	62	65	71	56	67	77
61	43	51	49	51	51	49	50	51	50	65
62	78	78	71	77	73	75	72	72	76	81
63	61	71	39	58	55	47	47	48	53	49
64	64	65	68	67	61	71	75	72	66	73
65	75	91	66	86	65	86	80	80	82	84
66	70	79	62	81	60	71	72	72	70	80

Ind.	3/1		3/2		3/3		3/4		3/5	
67	84	77	71	70	80	82	66	67	68	79
68	95	95	60	—	91	99	98	61	71	76
69	—	—	—	—	—	—	—	—	—	—
70	75	75	60	71	65	77	73	71	62	70
71	58	51	38	51	60	62	53	58	44	76
72	67	55	69	75	70	71	70	64	67	75
73	66	65	60	75	71	81	67	60	62	68
74	76	72	49	58	58	62	58	55	61	71
75	87	79	81	57	83	105	73	82	53	94
76	28	95	78	—	100	91	102	91	86	80
77	78	84	71	82	68	76	71	76	75	85
78	53	55	51	55	52	58	48	49	55	56
79	69	37	42	51	50	51	47	49	58	61
80	84	78	79	84	71	66	73	76	80	82
81	97	104	97	93	95	88	100	86	84	98
82	73	72	68	71	63	61	64	73	68	78
83	—	—	57	65	79	79	64	79	79	88
84	66	60	50	60	46	56	40	46	63	80
85	72	67	61	37	62	60	61	58	57	55
86	68	63	62	69	57	73	84	53	73	80
87	58	64	40	50	59	60	60	60	66	71
88	61	54	49	59	60	60	52	55	60	65
89	—	—	—	—	—	—	—	—	—	—
90	84	97	59	74	58	83	72	61	64	87
91	74	75	63	67	63	62	72	70	74	74
92	84	95	90	89	83	99	84	84	84	81
93	82	76	65	76	55	74	77	82	70	73



## VITA

WILLIAM ANDERSON McCALL. Born, Wellsville, Tennessee, 1891.

Educational Record: Cumberland College, Williamsburg, Kentucky, 1907-11, B.S. 1911. Part-time student, Lincoln Memorial University, Harrogate, Tennessee, 1911-13, A.B. 1913. Teachers College, Columbia University, 1913-16; Research Scholar in Education, 1914-15; A.M. and Master's Diploma in Education, 1914.

Professional Record: Instructor in Psychology, Lincoln Memorial University, 1911-13. Psychological Investigator for the New York State Commission on Ventilation, 1914-16. Lecturer in Educational Psychology, Columbia University, 1915.

Previous Publications: A monograph: "Ventilation in Relation to Mental Work," Columbia University Contributions to Education, Teachers College Series, written in collaboration with Dr. J. C. Chapman and Dr. E. L. Thorndike.

"The Effects of Outside Air and Recirculated Air upon the Intellectual Achievement and Improvement," *School and Society*, Vol. III, No. 71; with E. L. Thorndike and G. J. Ruger.











