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THE RELATION OF ACCURACY IN SENSORY DISCRIMINATION TO GENERAL INTELLIGENCE

By PROFESSOR EDWARD L. THORNDIKE, DR. WILFRID LAY and Mr. P. R. DEAN.¹

The purpose of this paper is to present certain new data concerning the relationship mentioned in the title and to show the bearing of these data upon the conclusions set forth by Spearman in his *General Intelligence Objectively Determined and Measured* which appeared in this *Journal* (Vol. XV, No. 2) in April, 1904.

THE ORIGINAL MEASURES

The measurements from which conclusions will be drawn were made by Dr. Lay upon 37 young women students in a normal school and by Mr. Dean upon 25 high school boys (all in the 3rd year of the high school course). The 37 young women drew each 90 lines, 30 as nearly as possible equal to a 100 mm. standard, 30 as nearly as possible equal to a 75 mm. standard and 30 as nearly as possible equal to a 50 mm. standard. They also each filled 16 boxes with shot, 8 as nearly as possible equal to a 100 g. standard and 8 as nearly as possible equal to a 200 g. standard. Each one rated all the rest in order of merit for general intellect, using each her own conception of what general intellect was as the basis of grading. Eight of the professors in the normal school also graded each of them (with a few exceptions in the case of three of the teachers) in the same way. Their scholastic records in the normal school were also used as measures. I use the average deviation from the standard as the measure of inaccuracy in the case of the tests with lines and weights. Some reasons might be adduced for choosing the variability around the individual's constant error instead, but there are far weightier reasons against doing so.

The 25 boys drew lines similarly except that some drew fewer than the 90 while others drew more; made up weights

¹ The shares of the authors in this research were as follows: The original measurements were taken by Dr. Lay and Mr. Dean, who also calculated some of the deviation measures and correlations. The remaining calculations were made by Professor Thorndike who was also responsible for the research and for the account of it here given.

similarly; were estimated similarly by 6 of their own members and 4 of their teachers.

The lines were drawn and the weights made up under the same conditions for all students within each group. The tests covered several days for each individual, so that spurious correlation from fatigue, temporary illness, etc., was reduced to a small amount. Within each group differences of age and maturity are for our purpose so slight as to be negligible. The median deviation of the young women in age was only 10 months and that of the boys only about one year.

We have then for the women fairly accurate measures of accuracy of discrimination of these lengths, accuracy of discrimination of these weights, intellect as judged by one's fellow students and intellect as judged by one's teachers. Such measures from two random halves of the scores correlate to .665, .504, .915, .72 and .62 respectively, which means that the measures used from the entire scores for each individual would correlate with other similar sets to about .8, .7, .9½, .9 and .8 respectively.

In the case of the boys the opinions of intellect of fellow pupils and teachers were combined. We have then for the boys fairly accurate measures of discrimination of these lengths, discrimination of these weights, intellect as judged by one's teachers and fellow students, and scholarship. Such measures from two random halves of the scores correlate to .691, .722, .869 and .873 respectively, which means that the measures used would correlate with other similar sets to about .8, .8, .9½ and .9½ respectively. The "raw" correlations from which we have to argue are consequently subject to only very moderate "attenuation" from chance variations in the obtained measures from the true measures for which they stand. The number of cases is sufficient to determine close correlations with a very small margin of probable deviation from the true result. When the relationship is only slight, the reliability of the result is, of course, much less, but is still sufficient to prevent insecurity in any of the general conclusions which are of interest.

To these conclusions I proceed at once, referring the specialist in mental relationships to the detailed table at the close of this paper.

THE MEASURES AS SAMPLES OF 'INTELLECT' AND OF 'SENSORY DISCRIMINATION'

Intellect as judged by teachers and intellect as judged by fellow students are much the same thing. The raw correlation in the case of the woman students is .85. This becomes about .95 when allowance is made for the inadequacy of the original

nation' and 'General Intelligence' which works out with great approximation to *one* or *absoluteness*."

The measurements obtained in the present investigation do not in the least support this hypothesis. The correlation between whatever is common to (A) drawing 50, 75 and 100 mm. lengths accurately and (B) making weights equal to 100 g. and 200 g. standards and whatever is common to (C) intellect as judged by fellow-students and (D) intellect as judged by teachers does not come out as 1.00 but as .26 or .15 according as we apply the first or second of Spearman's correction-formulæ. When, in the case of the high school pupils, the two measures of general intellect taken are (C) combined student's and teacher's estimates and (D) school marks, the correlation comes out .29 and .22 by the two methods.

That is, the most probable relation between the factor common to all sensory discriminations and the factor common to intellect judged in these three ways is, from our data, not 1.00, but .23.

It is perhaps best to wait for further and fuller measurements of the relation in question before attempting to explain the difference between this result and Spearman's. But one fact may be noted now. With young children a test designed to measure sensory discrimination may easily become, to a considerable degree, a measure of ability to understand instructions, that is, of one feature of general intellect.

The variety of measures taken and the elaborate corrections made by Spearman make a detailed comparison step by step of his and the present research difficult and in the end unproductive. The essential differences are (1) that Spearman does not give measures of the reliability of his measures of any species of sense discrimination or of any but a few of his measures of intellect and (2) that his material is complicated by age and sex.

The theoretical importance of Spearman's conclusion lies in the support which it would give, if verified, to the hypothesis that the efficiency of what may be called the general mammalian foundation of the central nervous system is closely correlated with what may be called the specifically human neurone-connections. The present results support the contrary hypothesis, that the efficiency of a man's equipment for the specifically human task of managing ideas is only loosely correlated with the efficiency of the simpler sensori-motor apparatus which he possesses in common with other species.

Spearman's other main conclusion is "*that all branches of intellectual activity have in common one fundamental function (or group of functions), whereas the remaining or specific elements of the activity seem in every case to be wholly different from that*

in all the others." This is, of course, contradicted by the correlation of .23 instead of 1.00, and also by the fact that we obtain a much higher correlation between discrimination of lengths and discrimination of weights than between either one of them and general intelligence. From our figures the correlations, if perfect original measures were at hand, would be about .15, .25 and .50 respectively for accuracy in drawing lines with general intelligence, accuracy in making up weights with general intelligence and accuracy in drawing lines with accuracy in making up weights.

I may add that other studies of correlation made by my students and myself are unanimous in contradicting Spearman's ingenious hypothesis of one sole common element as the cause of all positive correlations. We find, for example, that efficiency in marking A's on a sheet of printed capitals, efficiency in finding circles or hexagons or isosceles triangles on a sheet of printed geometrical forms and efficiency in finding misspelled words are in adults all very closely intercorrelated (to .8 or more), but are by no means so closely correlated to general intellect. In general there is evidence of a complex set of bonds between the psychological equivalents of both what we call the formal side of thought and what we call its content, so that one is almost tempted to replace Spearman's statement by the equally extravagant one that there is *nothing whatever* common to all mental functions, or to any half of them.

I regret that it is out of question to print the original measures. But as the record of each individual of the 62 measured comprises 90 numbers representing errors in drawing lines, 16 numbers representing errors in estimating weights, 10 or 42 rankings in estimating weights, 10 or 42 rankings in intellect and from 12 to 30 marks for scholarship, the total table would require nearly 10,000 entries. The table of correlations follows. Column I gives the results from the women students; Column II gives the results from the high school boys.

TABLE I									
ACTUALLY OBTAINED ("raw") CORRELATIONS:					PEARSON COEFFICIENTS				
								I	II
1.	Scores from half of the	100, 75 and 50 mm. lines	with scores from the other half					.665	.69
2.	"	"	"	100 and 200 gram weights	"	"	"		
3.	"	"	"	pupils' impressions of intellect	"	"	"	.505	.72
4.	"	"	"	teachers' impressions of intellect	"	"	"		.915
5.	"	"	"	academic records	"	"	"	.72	
6.	"	"	"	combined pupils' and teachers' impressions of intellect with scores from the other half	"	"	"		.87
					"	"	"		.87

TABLE I—Continued

	I	II
Scores from all the lines with scores from all the weights	.52	.25
" " " " " " " " pupils' impressions of intellect	.25	
" " " " " " " " teachers' " " "	.12	
" " " " " " " " pupils' and teachers' impressions of intellect combined	.055	
" " " " " " " " academic records	-.01	
Scores from all the weights, with scores from all the lines	.52	.25
" " " " " " " " pupils' impressions of intellect	.235	
" " " " " " " " teachers' " " "	.08	
" " " " " " " " pupils' and teachers' impressions of intellect combined	.205	
" " " " " " " " academic records	.21	
Scores from all the pupils' impressions of intellect with scores from all the teachers' impressions of intellect	.85	
Scores from all the pupils' and teachers' impressions of intellect with scores from entire academic records	.54	
Scores from all the lines and weights with scores from all the teachers' and pupils' impressions of intellect combined	.165	
Scores from all the lines and weights with scores from combination of teachers' impressions, pupils' impressions and academic records	.145	

COEFFICIENTS CORRECTED FOR CHANCE VARIATIONS IN THE ORIGINAL MEASURES BY THE SPEARMAN METHODS OF CORRECTION

- (A) The factor common to accuracy in lines and accuracy in weights with the factor common to pupils' impressions of intellect and teachers' impressions of intellect .20
- (A) As above, with the factor common to the combination of teachers' and pupils' impressions and academic scholarship. .255
- The most probable correlation between "general discrimination" and "general intelligence" is thus .23.