

A COMPARISON OF THREE TESTS OF "GENERAL INTELLIGENCE"

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This study concerns itself with the examination of fifty-nine students of the Wharton School of Finance and Commerce of the University of Pennsylvania with three tests of "general intelligence." The purpose of the study is, 1: to measure the variability in performance of the members of a selected, homogenous group in a number of accepted tests of general intelligence, 2: to measure the relationship between success in each of these tests and school grades, the measures of academic success.

METHOD.

The Otis General Intelligence Test, the Army Alpha and the Morgan Mental Test were used in this investigation. The tests were given within a period of two months in the order in which they are mentioned. They were all given between eleven and twelve in the morning to the members of a class assembled for a lecture in Psychology. The men taking the tests were juniors and seniors in the Wharton School of Finance and Commerce of the University of Pennsylvania.

The average of the grades in all courses for a period of the academic year preceding the one in which the tests were given was taken as the measure of academic success. The grades given in the University of Pennsylvania are D (Distinguished), G (Good), P (Passed), N (Not passed) and F (Failed). A student who receives N in a course is entitled to a re-examination; a student who receives F is not allowed to take a re-examination but must repeat the course. The following numerical values were assigned to each of these grades:

D equals 85
G equals 75
P equals 65
N equals 55
F equals 35

For each student the total value of the grades for the year was obtained by multiplying each grade by the value assigned to it and finding the sum. This total was divided by the number of courses to give the average grade for the year. The minimum number

of courses taken during the year by any student was found to be 8; the maximum number was found to be 20 and the average 15.5.

RESULTS.

A TREATMENT AND ANALYSIS

1.—The variability of the performance in the test was first investigated by a study of the rank order displacements of the individuals in the group when one test is compared with the others. The results of this analysis are presented in Table 1, below:

TABLE I

TABLE OF RANK DIFFERENCES
INTELLIGENCE TESTS.

	Alpha-Otis		Alpha-Morgan		Otis-Morgan	
	No.	%	No.	%	No.	%
0- 5.5	30	50.9	20	33.9	17	28.9
6-10.5	10	16.9	11	18.7	15	25.5
11-15.5	8	13.6	12	20.3	7	11.8
16-20.5	6	10.0	6	10.0	6	10.0
21-25.5	2	3.4	5	8.5	6	10.0
26-30.5	2	3.4	2	3.4	4	6.8
31-35.5	1	1.8	2	3.4	1	1.8
36-40.5	0	0	0	0	2	3.4
41-45.5	0	0	0	0	1	1.8
46-50.5	0	0	1	1.8	0	0
51-55.5	0	0	0	0	0	0
56-58-	0	0	0	0	0	0
Total	59	100.0	59	100.0	59	100.0

The maximum displacement in rank of any given individual on the Army Alpha and Otis Test is 32.0. The minimum is 1.0. The average displacement is 8.1 and the median displacement is 5.5. The correlation of the tests by the rank difference method (Pearson formula) gives a coefficient of plus 0.76.

Between the results of the same individual on the Alpha Test and the Morgan Test there is greater discrepancy, on the average, than between the Army and the Otis Tests. The maximum rank order displacement between these two tests is 49.5; the minimum is 0.0. The average displacement is 11.2 and the median is 10.0. The co-efficient of rank and order correlation is plus 0.62.

The greatest rank order displacement exists between the Morgan Test and the Otis Test. The maximum displacement in this case is 46.0; the minimum is 0.0. The average is 12.3 and the median is 8.0. The value of the rank order co-efficient of correlation between these two tests is plus 0.51.

This analysis shows that there is less variability in the performance of the individuals of a selected group with the Army Alpha and the Otis Test than between Alpha and the Morgan Test. The greatest variability in performance comes when the same individ-

uals are given the Morgan Test and the Otis Test, the analysis of individual displacements and the low value of the co-efficient of rank and order correlation indicating that the chance for a given individual to be assigned to closely related positions in rank order distribution of the results of the two tests is a small one.

2.—The second method of measuring the extent of variability in the performance of a group in a series of tests is *a* to divide the group into tertiles, higher, middle and lower and to compute the number of individuals assigned to the same tertile by the different tests; and *b* to divide the group into quartiles and compute in the same way, the number and percentage of individuals assigned to the same quartiles by the different tests. The results of such an analysis are presented in Charts 1 and 2.

CHART I COMPARISON OF TERTILE ASSIGNMENTS

Alpha-Otis-Morgan Tests.

Alpha Otis		Alpha - Morgan		Morgan - Otis	
Alpha	I	1	5	14	
	II	5	10	4	
	III	13	7	0	
	III	II	I		
Otis		Morgan		Morgan	
62.7 per cent.		50.8 per cent		52.5 per cent.	
in same tertile		in same tertile		in same tertile	

The chance that a given individual will be assigned to the same tertile by any two tests is 33½ percent. The highest percentage of individuals assigned to the same tertile by any two tests is 62.7% (Alpha and Otis), only twice the percentage assigned by chance. The lowest assignment is 52.8½, or only one and a half times the chance assignment. (Alpha and Morgan.)

Chart 1 shows not only the percentage of individuals assigned to the same tertile by two different tests but the detailed distribution among the tertiles. The first figure in Chart 1 shows that out of the twenty individuals assigned to 1, or the lower tertile in the Alpha Test, 1 or 5% is found in the 3 or highest tertile in the Otis Test; 5 or 25% are found in the middle tertile according to the Otis results and the remaining 14, or 70% are found in the 1, or lower tertile in the distribution of the results of the examination with the Otis Test. On the other hand by reading vertically up

from the figures on the abscissa it can be found that out of the 13 individuals assigned to 3 or the higher tertile by the Otis Test 13 or 68% are found in 3 or the higher tertile in the distribution of the Alpha results; 5 or 26.8% are found in the middle tertile in the distribution of the Alpha results and 1 or 5.2% in 1 or the lower tertile.

The remaining figures in this chart, and in the charts similar to it presented elsewhere in this report show in the same way the number of individuals of a given tertile or quartile in the distribution of results on one measure assigned to the various tertiles or quartiles in the distribution of the results on another measure.

b/—In addition to the division of the group into tertiles on each of the tests a division was made into quartiles. The results of this analysis are presented in Chart 2.

CHART II

COMPARISON OF QUARTILE ASSIGNMENTS

Alpha-Otis-Morgan Tests.

Alpha-Otis					Alpha-Morgan					Morgan-Otis							
Alpha	I	0	0	5	8	I	0	2	5	6	Otis	I	0	2	3	9	
	II	1	6	5	4	II	4	2	5	5		II	3	2	7	3	
	III	2	6	4	2	III	4	6	4	1		III	5	4	5	1	
	IV	12	3	1	0	IV	7	5	1	6		IV	6	6	1	2	
		IV	III	II	I			IV	III	II	I			IV	III	II	I
	Otis					Morgan						Morgan					
	52.5 per cent.					40.6 per cent.						44.0 per cent.					
	in same quartile					in same quartile						in same quartile					

The chance that any individual will be assigned to the same quartile by any two tests is 25%. The greatest percentage of individuals assigned to the same quartile by any two tests is 52.5% (Alpha and Otis). The smallest percentage is 40.6% (Alpha and Morgan). The chart shows the number of individuals assigned to a given quartile in a given test assigned to each of the quartiles by the other tests.

A survey of this analysis shows that with reference to the variability in the assignment to tertile and quartile the greatest difference exists between the Alpha and the Morgan Tests and the least difference between the Alpha and the Otis. Otis and Morgan show almost as much variability in the assignment of given individuals to tertile and quartile as do Alpha and Morgan. Only

in the case of the tertile assignment in Alpha and Otis is the percentage of assignments to same tertiles high enough to show that the tests measure somewhat similar abilities.

3.—The variability in the performance of a group of individuals a number of tests may be due to a disagreement among the authors of the test on the question of what constitutes general intelligence. As a result of such disagreements different material, testing different abilities, and weighted differently, may be included in the test. The extent to which the tests agree in the measurement of the same intelligence will be indicated in the co-efficient of correlation. Such co-efficients of correlation have been computed for these tests. These co-efficients, computed by the product moment method, are presented in Table 2, and Table 3

TABLE II

Coefficients of Correlations
Alpha, Morgan and Otis Tests

Morgan-Alpha	r 0.52±.071
Morgan-Otis	r 0.59±.061
Alpha-Otis	r 0.69±.048

TABLE III

Partial Co-efficients of Correlation

If Morgan equals 1	
If Alpha equals 2	
If Otis equals 3	
r _{12.3}	plus 0.21±.091
r _{13.2}	plus 0.37±.080
r _{23.1}	plus 0.54±.07

That similar elements are present in all three tests is revealed both by the value of the co-efficients of correlation between the tests and by the fact that when the influence of the elements of one test present in the other two is removed in the correlation of the other two tests, by the method of partial correlation, the resultant co-efficient of correlation between the two tests is greatly diminished. There is, however, a difference in the degree of similarity between the elements of the three tests. Alpha and Otis are most similar in the elements contained, with a co-efficient of correlation high enough to be of considerable significance. Morgan and Alpha are least similar. As a matter of fact the elimination of the elements common to Otis in the correlation of Morgan and Alpha reduces the co-efficient of correlation of Morgan and Alpha to plus .21±.091, much below the level of significance. In the same way the elimination of the elements common to Alpha in the correlation of Morgan and Otis reduces the co-efficient of

correlation of these two tests to plus $0.37 \pm .080$, also below the level of significance. The elimination of the Morgan elements in the correlation of Otis and Alpha does not affect seriously the value of the co-efficient of correlation between these two tests, demonstrating more conclusively the fact that, to a great similar extent elements are tested by Otis and Alpha. It is by reason of the similarity of the elements tested by the two that there is least variability in the performance of the group in these two tests.

B.—COMPARISON OF TEST RESULTS WITH SCHOOL GRADES.

The second part of the study was designed to measure the relationship between success in each of these tests and success in school, as represented in school grades. This part of the study was naturally suggested by the increased use of tests of "general intelligence" as criteria for college entrance, and purposes to give some slight additional evidence, of different accepted measures of "general intelligence" in predicting academic success.

The statistical treatment of these results parallels that given above, but in addition to test results, school grades are introduced and become the objective standard or criterion of comparison in each case.

1.—The difference in rank order assignment of the individuals of the group in each test as compared with school grades is given in Table IV below.

TABLE IV

TABLE OF RANK DIFFERENCES, INTELLIGENCE TESTS AND SCHOOL GRADES

Units of Rank Difference	Alpha School		Otis School		Morgan School	
	No.	%	No.	%	No.	%
0- 5.5	13	22.0	12	20.3	13	22.0
6-10.5	7	11.8	8	13.5	7	11.8
11-15.5	10	16.9	10	16.9	12	20.3
16-20.5	9	15.2	6	10.0	4	6.8
21-25.5	5	8.5	8	13.6	8	13.6
26-30.5	5	8.5	8	13.6	3	5.1
31-35.5	3	5.1	2	3.4	5	8.5
36-40.5	2	3.4	3	5.1	0	0
41-45.5	4	6.8	1	1.8	3	5.1
46-50.5	1	1.8	1	1.8	4	6.8
51-55.5						
Total	59	100.0	59	100.0	59	100.00

The maximum displacement of any individual in rank order when the Otis scores are compared with school grades is 49.0, the minimum being 0.5. The average displacement of the group is 17.4; the medium is 15.5. The co-efficient of correlation, by the rank order method, is plus 0.22.

Between the Alpha Test and the School grades the maximum displacement is 48.0. The minimum is 0.5. The average is 17.4

and the median is 15.5. The co-efficient of rank order correlation is plus 0.22.

In the comparison of Morgan Scores with school grades even greater discrepancy in rank order placement is revealed. The maximum displacement in this case is 49.0 and the minimum 0.0. The average is 20.8 and the median 15.5. The co-efficient of correlation by the rank order method between the two criteria is plus 0.13.

These results indicate that there is no greatly significant relationship between the scores on any of the tests and school grades. The average displacement in rank order between each of the test scores and the school grades is high, and the co-efficient of correlation is in each case, low. Of the three tests the Otis scores show the greatest relationship with school grades and the Morgan scores the least.

2. In order further to examine the relationship between success in each of these tests with academic success an analysis was made of the variability in tertile and quartile assignments of each test as compared with tertile and quartile assignments made on the basis of an array of school grades.

a/—The analysis of tertile assignments is presented in Chart 3 below.

CHART III

COMPARISON OF TERTILE ASSIGNMENTS

Tests and School Grades

Morgan - School Grades				Alpha - School Grades				Otis - School Grades						
Morgan	I	7	5	6	Alpha	I	5	7	8	Otis	I	4	5	9
	II	6	8	7		II	7	6	6		II	8	7	7
	III	8	6	6		III	9	6	5		III	9	7	3
	III	II	I			III	II	I			III	II	I	
School Grade				School Grade				School Grade						
in same tertile 37.3 per cent.				in same tertile 38.9 per cent.				in same tertile 42.3 per cent						

In view of the well defined tendency of school administrators to divide children of the same chronological age or of the same peda-

gological age into three classes, on a basis of differences in mental endowment, for purposes of education, the comparison of tertile displacements between test scores and school grades is particularly significant. On the basis of chance alone $33\frac{1}{3}\%$ of those examined would be assigned to the same tertile by both school grades and test scores. In the charts above, as it has been stated before, the numbers enclosed in heavy lines represent the number of individuals assigned to the same tertile both by school grades and test scores.

By the Morgan test and school grades 37.3% of the individuals examined are assigned to the same tertile; by the Army Alpha Test and school grades 38.9%; by Otis scores and school grades 42.3%. In each case the variability in assignment to tertiles is high, the percentage of parallel assignments being in no case very much higher than the chance assignment. Of the three, however, the Otis scores parallel most closely the assignment by school grades.

b/—In Chart 4 below is presented the analysis of quartile assignments when tests scores are compared with school grades.

CHART IV COMPARISON OF QUARTILE ASSIGNMENTS Tests and School Grades

Morgan - School Grades		Alpha - School Grades		Otis - School Grades	
Morgan	I	3	3	2	6
	II	5	4	5	1
	III	4	5	4	3
	IV	3	4	3	4
	IV	III	II	I	
School Grades		School Grades		School Grades	
32.2 per cent.		32.2 per cent		28.8 per cent.	
in same quartile		in same quartile		in same quartile	

There is a twenty-five percent chance that individuals will be assigned to the same quartile by a given test score and school grade. In the case of the Morgan test 32.2% of those tested are placed in the same quartile to which they are assigned in the distribution of school grades. The same percentage, 32.2%, are assigned to the same quartiles by Alpha score and school grades, and 28.8% by Otis scores and school grade.

The charts also show how many individuals assigned to a given

tertile or quartile by test is assigned to each of the school grade quartiles and conversely, the number of those assigned to a given tertile or quartile by school grade assigned to each of the tertiles in the distribution of test results.

A summary of the results shows that no well defined tendency for those rating either high or low in school grades to rate high or low in any of the tests. There is a vague suggestion of such a grouping in the case of the Otis Test and school grades, 50% of those in Tertile 1, the lower tertile in this test being in the lower tertile in school grades, and 47% of those in the higher tertile in the test being in the higher tertile in school grades, but even here the percentages are not particularly significant, and they are less significant in the case of the other tests.

3.—In order to determine whether similar elements are involved in success in each of these tests and academic success in the Wharton School as portrayed in school grades, the scores in each test were correlated with school grades by the product moment method. The co-efficient of correlation so obtained are presented in Tables 5 and 6 below

TABLE V.

Co-efficients of Correlation	
Test Scores and School Grades	
Morgan-School Grades	r plus 0.06
Alpha-School Grades	r plus 0.21
Otis-School Grades	r plus 0.24

TABLE VI.

Partial Co-efficients	
If Morgan equals 1	
If Alpha equals 2	
If Otis equals 3	
If School G equals 4	
r 14 23 equals	—0 .09
r 24 13 equals	+0. 04
r 34 12 equals	+0 11
By the method of multiple correlation	
R 4:123 equals	Plus 0.252

In no case is the correlation between test scores and school grades significant. The elimination of the elements common to the other two tests in the correlation of any test with school grades diminishes the value of the co-efficient of correlation of the test with the school grades. Altho all the co-efficients are insig-

nificant in value the highest co-efficient is given by the correlation of Otis scores with school grades.

The correlation of the combined tests with school grades by the method of multiple correlation gives a co-efficient of plus 0.252, indicating that not even the battery of three tests has great significance in the prediction of academic success in the Wharton School.

CONCLUSIONS.

1.—The discrepancy in the results of individual members of the group on the different tests of "general intelligence" leads to the conclusion that the mental ability measured by each of these tests is not the same. They are all called tests of "general intelligence" but it cannot be concluded from this investigation that there is a similar complex or pattern of abilities measured by the three tests.

2.—Greater similarity in the individual elements of the test exists between the Otis and Alpha tests than between the Morgan tests and either of the first two. With regard to the mental factors involved in performance, the Morgan test and the Alpha test show the greatest dissimilarity.

3.—The comparison of test results with academic grades indicates that none of these three tests of "general intelligence" can be used in the prediction of academic standing in the Wharton School. It is possible, of course, that in the examination of an unselected group of applicants for entrance into the Wharton School the potential failures might be picked by one or all of these tests, but the statistical analysis presented in this report throws no light upon this problem.

DISCUSSION OF RESULTS.

The most important problem raised by these results is that of determining which of these three tests measures that which we are calling "general intelligence." It is quite possible that this problem will not be solved until we are able to agree upon a definition of "general intelligence." No attempt will be made to give such a definition in this article or to determine which of these tests is the best measure of "general intelligence." The purpose of this article is merely to point out the great discrepancy in the standing of the individual members of a group on three tests which are presumably designed to measure the same mental ability. The fact that there is greater discrepancy in the individual standing of the

members of the group when the Morgan test is compared with the Alpha and Otis than when these two tests are compared with each other, is in itself, no indication that the Morgan test is less a test of "general intelligence" than are the other two tests. The fact that none of the tests correlate with academic standing is not necessarily a sign that any or all of the tests do or do not measure "general intelligence." The finding of this study are only of importance in so far as they point out the need for evaluating very carefully tests which are proposed for the measurement of "general intelligence" for purposes of education, selection of workers in industry, or for general experimental purposes

The absence of significant correlation, rank order assignment, and tertile and quartile assignment between test results and school grades is significant only in so far as it points out the necessity for determining exactly to what extent the abilities required for success in any test of "general intelligence" are factors in determining academic standing in any of the schools of a University. It is quite possible that the ability measured in the tests used in this investigation are not the same as those required for success in a specialized school of business such as the Wharton School of Commerce and Finance of the University of Pennsylvania. A careful comparison between test results and the success and failure of individuals selected for each of the specialized schools of the University is necessary in order to determine the value of a given test of "general intelligence" as part of the Entrance Requirements of any University. The comparison of test results and academic standing of the pooled data from the different schools of the University is not sufficient. The pattern or group of abilities or the general competency required in one school is undoubtedly different than those required in another, and a test of "general intelligence" which is applied successfully in the prediction of academic success in one school may be altogether useless for prediction of academic success in another. It may be necessary for the psychologist to introduce in his thinking on this subject a concept of what might be called **specialized general intelligence** or **specialized performance pattern** or **ability-group-pattern** representing the pattern of specific mental ability necessary for success in a given specialized field such as engineering, business, etc., —the professions such as distinguished from the high commercial jobs, etc. That there is some recognition of such a problem is indicated in the appearance of such tests as the "Thurstone Test for Engineering Aptitude" and the "Otis Test of General Intelligence for Business Institutions" and the reported plan of the

School of Business Administration of Harvard to use a special test of "general intelligence" as part of its entrance requirements.

The desirability of making further investigations along this line is pointed out to some extent by the absence of correlation between the test results and academic standing in the Wharton School. In view of the purpose of this article merely to present some additional statistics on three tests of "general intelligence" in order to point out the need of evaluating more carefully proposed measures of "general intelligence" the further discussion of this problem will be left to another article.