

GENERAL AND SPECIFIC FACTORS
IN THE 1929-30 K.S.A.C.
FRESHMAN TESTS

by

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INTRODUCTION AND PROBLEM

In the fall of 1929 the members of the psychology staff of the Kansas State Agricultural College, under the direction of Dr. J. C. Peterson, tested the members of the Freshman Class with the following battery of nine tests:

1. Obstructed Reading Test
2. Word Relationship Test
3. Vocabulary Test
4. Peterson Uniform Test of Mental Performance:
Form Ba
5. Peterson Uniform Test of Intelligence: Form B1
6. Peterson Uniform Test of Mental Performance:
Form C
7. Ratio Test
8. Logical Relations Test
9. Numerical Relations Test

The immediate problem presented by this program was to find the degree of overlap in the tests, and thus work out a new combination of the tests which would give as good a correlation or better with college grades and which would require less time to give. Spearman's tetrad difference method of measuring or finding a common bond between pairs of variables was applied to the results of the tests.

METHOD OF PROCEDURE

Spearman's method is based on the theory that if four variables have one, and only one, common factor running through them, then every tetrad difference involving the correlation coefficients of these four variables will be equal to zero. Spearman has defined his tetrad differences in this manner:

$$T_{1234} = r_{12} r_{34} - r_{13} r_{24}$$

$$T_{1243} = r_{12} r_{43} - r_{14} r_{23}$$

$$T_{1342} = r_{13} r_{24} - r_{14} r_{23}$$

These three tetrads represent all the combinations of the four variables as the other three are the negative of the three given. Note the order of the subscripts in the subtraction. The first multiple contains the subscripts in the same order as those identifying the tetrad. The second multiple contains the subscripts arranged in this manner from the tetrad subscript: the first and third times the second and fourth. If this order is observed, tetrads may be found for any number of variables considered four at a time. When every tetrad difference equals zero and there are more than four variables, there is only one general factor for all of the variables. But when a tetrad does not equal zero, there is an indication that a common bond exists

between two of the variables involved in that particular tetrad. Then a further test for special bond should be applied.

Thus, in order to apply Spearman's method it is first necessary to find the correlation between each variable and all the others. Table I shows the correlations for each division (keeping the girls separate in the General Science Division) and the correlations for the entire group.

Table I. Table Showing Correlations for Each Division--and for Total of all Divisions

Variable	2	3	4	5	6	7	8	9
Reading	Word Relation	Vocabulary	Form Pa.	Form Bl	Form C	Ratio	Logical Relation	Numerical Relation
Reading	All .641	.626	.422	.496	.395	.311	.581	.288
	G.S.(B) .629	.637	.411	.443	.573	.418	.345	.314
	Vets. .646	.605	.267	.650	.382	.285	.432	.380
	Eng. .646	.634	.422	.482	.401	.319	.380	.306
	Agg. .620	.575	.341	.401	.228	.204	.346	.073
	H.E. .629	.623	.413	.502	.396	.332	.315	.381
	G.S.(G) .565	.574	.464	.543	.409	.333	.385	.367
Word Relation	All .607	.607	.422	.435	.343	.420	.439	.285
	G.S.(B) .620	.620	.458	.396	.369	.539	.396	.416
	Vets. .532	.532	.051	.251	.055	.433	.417	.032
	Eng. .593	.593	.421	.427	.357	.430	.405	.297
	Agg. .454	.454	.259	.291	.154	.257	.341	.022
	H.E. .606	.606	.509	.559	.432	.463	.473	.407
	G.S.(G) .694	.694	.445	.456	.286	.385	.538	.523

Variable	2	3	4	5	6	7	8	9
1	Word Relation	Vocabulary	Form Ba	Form Bl	Form C	Ratio	Logical Relation	Numerical Relation
Vocabulary								
3								
All	.368	.398	.309	.297	.521	.242		
G.S.(B)	.337	.338	.298	.420	.269	.238		
Vets.	.082	.375	.127	.072	.114	.106		
Enf.	.399	.371	.373	.293	.355	.261		
AFB.	.261	.311	.172	.168	.200	.157		
H.E.	.348	.443	.263	.335	.295	.323		
G.S.(G)	.409	.417	.245	.314	.418	.251		
Form								
4								
All	.655	.693	.507	.454	.552			
G.S.(B)	.658	.772	.577	.473	.616			
Vets.	.509	.657	.319	.018	.552			
Enf.	.633	.675	.509	.428	.498			
AFB.	.653	.685	.517	.431	.496			
H.E.	.654	.693	.443	.442	.564			
G.S.(G)	.692	.646	.502	.513	.519			

Variable	2	3	4	5	6	7	8	9
1	Word Relation	Vocabulary	Form Ba	Form Bl	Form C	Ratio	Logical Relation	Numerical Relation
Reading								
Form Bl	All			.729	.493	.497	.514	
5	G.S.(B)			.721	.534	.448	.450	
	Vets.			.697	.342	.295	.559	
	Eng.			.777	.518	.505	.497	
	AGB.			.648	.466	.384	.447	
	H.E.			.759	.489	.536	.584	
	G.S.(G)			.622	.491	.612	.615	
Form C	All			.477	.406	.536		
6	G.S.(B)			.582	.434	.585		
	Vets.			.206	.054	.620		
	Eng.			.479	.451	.518		
	AGB.			.391	.297	.400		
	H.E.			.516	.406	.641		
	G.S.(G)			.457	.369	.525		

If a chart of the multiplications of correlations needed is worked out first, the task involved in finding the tetrad differences is reduced to a minimum. The variables are considered in pairs. The correlation of one pair is multiplied by the correlation between all other pairs of variables. Table II is a sample of such a chart and contains a few of the products used in this study.

Table II. Correlation Multiplications

$r_{12} r_{34}$	.235888	$r_{23} r_{45}$	.397535	$r_{49} r_{56}$	.387828
$r_{12} r_{35}$	.243708	$r_{23} r_{46}$	.421865	$r_{49} r_{57}$	.262276
$r_{12} r_{36}$	.193039	$r_{23} r_{47}$	.307749	$r_{49} r_{58}$	.264404
$r_{12} r_{37}$	.190377	$r_{23} r_{48}$	.275578	$r_{49} r_{67}$	.253764

After the multiplications are worked out, they may be substituted in the equations for the tetrad differences and a table showing these differences made as is shown in Table III.

Table III. Values of Tetrads

$T_{1234} = r_{12} r_{34} - r_{13} r_{24} =$	.235888 - .264172 =	.028284
$T_{1243} = r_{12} r_{43} - r_{14} r_{23} =$	.235888 - .256154 =	.020266
$T_{1342} = r_{13} r_{42} - r_{14} r_{32} =$	.264172 - .256154 =	.008018

In a similar manner the three tetrads for all of the variables considered four at a time could be worked out. Examination of the three tetrads for each four variables shows that they are not the same. There might be some chance influence that would make one difference the largest and one the smallest. For this reason the median tetrad difference is chosen as the most representative of the tetrad differences of these four variables. This is done for all sets of four variables and the results tabulated. Table IV shows such a tabulation.

Table IV. Table of Tetrads

Four Variables	Three Tetrads			Designation of Smallest Tetrad	Variables having a Second Factor
	Largest	Median	Smallest		
1234	.028284	.020266	.008018	1342	12 or 34
1235	.052364	.028762	.023602	1235	15 or 23
1236	.041696	.021917	.019779	1236	16 or 23
1237	.074143	.072543	.001600	1273	13 or 27
1238	.069053	.043547	.025506	1283	13 or 28
1239	.023288	.019694	.003594	1392	12 or 39
1245	.236285	.210543	.025742	1452	12 or 45

The last column of Table IV is significant in that it serves as a foundation for the rest of the work in this method. It will be noticed that these pairs of variables having a second factor are determined from the designation

of the smallest tetrad. The first and last variable number of the subscript form the first pair, and the two middle variable numbers form the second pair. In the next table, Table V, the two numbers in the captions of the columns indicate two of the variables involved in a tetrad difference, as given in the last column of Table IV. The entries in the column give the median value of the three tetrad differences arising from a certain four variables. For example, in Table IV the median tetrad difference for the variables 1234 is .020266. Since the smallest tetrad difference is T1342, this indicates a special bond between 12 or 34. Accordingly the .020266 is written in Table V (only part of original table) once in column 12 and a second time in column 34. The same manner of entry is followed for all the other median tetrad differences of Table IV. The sum of the median tetrad differences arising from each pair of variables is quite important because the larger the sums of the columns, the greater the indication of a special bond between the variables indicated in the captions.

Table V. Median Tetrad Differences Allocated
to the Pairs of Variables from
which They may have Arisen

12	13	14	15	16	17	18	19
.020266	.072543	.016052	.028762	.021917	.014851	.083465	
.019694	.043547	.051878	.043426	.048913	.043220	.066908	
.210543	.227502		.024371	.031984	.033266	.076373	
.278805	.289710		.046964	.036729	.046349	.036122	
.147747	.192048		.055904			.077026	
.105756	.145996		.095586			.070359	
.219476	.227048						
.294681	.303090						
.107695	.161509						
.100833	.151903						
1.505494	1.812699	.067930	.295013	.139543	.137686	.412153	0

The columns labeled 12, 13, 23, 45, 46, 56, 69, and 79 contain a number of tetrad differences, the sum of which, in each case, is quite large. This is important because the larger the sum, the greater an indication of a special bond. The results of this table give strong indication of a special bond between these tests:

- 12 Reading and Word Relation
- 13 Reading and Vocabulary
- 23 Word Relation and Vocabulary
- 45 Ba and B1
- 46 Ba and C
- 56 B1 and C
- 69 C and Numerical
- 79 Ratio and Numerical

Likewise a small sum in a column indicates that the probability of a special bond between the two variables in the caption of the column is small. The columns 14, 19, 24, 25, 26, 36, 37, and 39 had a small total difference so giving evidence of no special relationship between the following tests:

- 14 Reading and Form Ba
- 19 Reading and Numerical Relation
- 24 Word Relation and Form Ba
- 25 Word Relation and Form B1

- 26 Word Relation and Form C
 36 Vocabulary and Form C
 37 Vocabulary and Ratio
 39 Vocabulary and Numerical
 Relation

Further tests to prove the existence of the common bonds indicated must be made in the following manner. Take two pairs of two variables, each pair having a strong indication of special bond, and also one other variable. These five variables may be called, a, b, c, d, and e. Substitute e in turn in the tetrad abcd for each of the other four variables.

		<u>Condition (1)</u>	<u>Condition (2)</u>
Tabed	Tabde	≠ 0	≠ 0
Tabce	Tabec	≠ 0	= 0
Tabde	Tabed	≠ 0	= 0
Taecd	Taede	= 0	≠ 0
Tbecd	Tbedc	= 0	≠ 0

When condition (1) is met, the common bond is between variables a and b. When condition (2) is met, the common bond is between c and d. Then take the pair of variables having a common bond and use them as the a and b variables. Take another pair of variables without an indication of common bond, calling them the c and d variables, and apply the same test, using for the e variable each of the other vari-

ables f, g, h, i, j, k, l, etc. If condition (1) is met in each case, the proof that there is a common bond between the variables a and b is conclusive.

In applying this test, the tetrad will seldom equal zero exactly, but it may be called zero if it is within the limit established by the standard deviation for the entire population of tetrads. Spearman has derived the following formula for the standard deviation of such a population:

$$S.D. = 2 \left(\frac{r^2 (1-r)^2 - (1-R)S^2}{N} \right)^{\frac{1}{2}}$$

$$r = \text{mean of all the } r\text{'s} \quad = .450$$

$$s^2 = \text{variance of the } r\text{'s} \quad = .01474$$

$$R = 3r \frac{(n-4)}{(n-2)} - 2r^2 \frac{(n-6)}{(n-2)} \quad = .790715$$

$$n = \text{number of variables} \quad = 9$$

$$N = \text{size of population of tetrad differences} \quad = 379$$

For this study and the values given above, the standard deviation was calculated to be $\pm .026058$

RESULTS AND CONCLUSION

After thoroughly testing each pair of variables that had given evidence of a special bond, proof was found for the existence of a special bond between these tests:

12 Reading and Word Relation

13 Reading and Vocabulary

23 Word Relation and Vocabulary

45 Ba and Bl

79 Ratio and Numerical

In shortening the number of tests given, care must be taken to make the reduction without omitting any of the factors that differentiate dull from bright students. However, the reduction would occur in those tests which do have special factors between them. The particular test chosen would depend on the correlation of the test with criteria, the correlation of the test with other tests to be given in the battery, the nature of the test desired, the amount of time available, and other similar factors. To get the best possible team of tests the methods of partial and multiple correlations of the test with criteria must be used. In this study no attempt has been made to consider criteria or their importance. The chief concern has been in finding what tests do have special factors existing between them, so that the reduction might be made by omitting one of those tests. Since there is a special relationship between Reading and Vocabulary, Reading and Word Relation, Vocabulary and Word Relation, a reduction in the number of tests given could be made by omitting one or two of these tests, keeping in mind the other factors that must be considered in making this choice. Likewise Ba or Bl may be used, and either Ratio or Numerical. However, a new battery of tests

constructed from the 9 original tests should have to include Form C and the Logical Relation Test as these two tests in no case gave proof of having a special bond with any of the other tests. The following might well be used as the foundation for a new battery of tests:

- (1). Reading or Word Relation, or Vocabulary
- (2). Form Ba, or B1 of the Uniform Test of Mental Performance
- (3). Form C of the Uniform Test of Mental Performance
- (4). Logical Relations Test
- (5). Ratio, or Numerical Relations Test

REFERENCES

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