Effect of Education Level, Culture, Grade or Division and Age upon the General Ability Score

S. CHATTERJI, MANJULA MUKHERJEE & PRANAB CHAKRABORTY
Indian Statistical Institute, Calcutta

An attempt was made to examine the effect of educational level, culture, grade or division and age upon the scores on the General Ability Test statistically The applicants in the year 1968 to the various courses of the I. S.I. were considered in the study. The findings revealed that the above mentioned factors did not play an important role in making the performance on General Ability Test battery different.

INTRODUCTION

For the different academic courses offered by the Indian Statistical Institute (I.S.I.) each year selection tests are conducted to select groups of suitable candidates among a large number of applicants. For this purpose a battery of tests is administered on the candidates and they are selected on the basis of their (a) performance in the selection test (b) past academic records and (c) interview marks.

Since the courses are mathematics oriented, the mathematics knowledge and aptitude possessed by the candidate are examined by means of the selection test. In addition, a test of General Ability (G.A.) is included in the selection battery with the hope that such test would measure the potential ability of the candidates which is measured neither by the mathematics knowledge and aptitude test nor by the University examination.

DESCRIPTION OF THE GENERAL ABILITY TEST

Since the main purpose of using the test is the assessment of the potential scholastic ability of the candidates, it is desirable that the test score should not be influenced by the candidates educational achievement as far as possible.

The items included in this test battery may be classified into three categories.

(i) Verbal Reasoning (V.R.)

(ii) Quantitative Reasoning (Q.R.)

(iii) Data Interpretation (D.I.)

The test of V. R. includes disarranged sentences, drawing logical conclusions from several statements, coding of words etc. The test of Q. R. includes computation of series, simple arithmatical problems, spatial judgements etc. Since the courses are in statistics, the selected students have to deal with numbers and it is expected that the ability to handle data presented in a tabular or graphical form would be required by them to a great extent. Considering this, the third type of items is included in the test battery where the candidates are to derive various conclusions from a given set of data.

All these items are of the multiple choice type with four or five alternative answers. Most of the items have already been tried out and found to possess a sufficient degree of discriminating ability. They were also found to be suitable for the group on the basis of the difficulty value empirically obtained.

PURPOSES OF THE STUDY

The purposes of this study are discussed below.

(i) As stated earlier the G. A. test was included in the test battery for measuring those aspects which were neither covered by the mathematics test nor revealed by the past academic records of the candidates. So if the G. A. scores were found to be highly correlated with any one of the other aspects mentioned earlier, then it would result in only duplicating the information and hence there would be no necessity of including it in the test battery. To investigate this aspect is one of the purposes of this study.

Manuscript received on April 10, 1972.

(ii) In the year 1968 the same G. A. test was used for candidates applying for the different courses with varying edutional level. There was some controversy regarding the justification for following such a procedure. As mentioned earlier the items of the test was designed in such a way that they were expected to be more or less free from the influence of education level beyond a certain minimum standard. One of the purposes was to investigate whether the G. A. scores were more or less free from the effect of education level or not. For this purpose the G.A. score distribution of the various education groups were to be compared.

(iii) The G. A. test was administered on the applicants from different regions of India. In different geographical regions of India different types of social and cultural environment exist. So it is desirable that the test should be culture and environment free as far as practicable. In order to test this hypothesis the score distributions of the G.A. test of the candidates applying from different regions are proposed to be studied. This study is expected to throw some light on the reasons of variation in the G. A. score distribution which may be due to social and cultural factors influencing the candidates. This enquiry is justified from the point of view of making the G.A. test battery independent of social and cultural attributes as far as possible. It will also help in examining the fact whether the candidates appearing from any particular region get some advantage or disadvantage in this type of test used for selection.

(iv) The fourth purpose is to investigate the effect of Grade or Division upon the G. A. score distribution. If it is seen that there does not exist any significant difference between the G.A. score distribution of the candidates belonging to different Grade or Division while keeping their education level fixed, then it might be concluded that General Ability scores are not much influenced by prior achievement.

(v) Lastly, it is intended also to study the effect of age on the G. A. score by controlling the education level.

THE SAMPLE AND DATA

The applicants in the year 1968 for admission to the various courses of the I.S.I. are considered in this study. All the applicants may be classified into the following three groups on the basis of the course they applied for and accordingly on the basis of their level of education.

(A) Applicants for the Bachelor of Statistics Course—minimum academic qualification required is that he/she has passed the Higher Secondary examination with Mathematics as one of the subjects.

(B) Applicants for the Master of Statistics Course—minimum academic qualification required is that he/she must be a graduate (Honours or Pass) with Mathematics as one of the subjects.

(C) Applicants for the Research Course—minimum academic qualification required is that he /she must have a Master degree either in Mathematics or in Statistics. A few applied for Research Course in Econometrics having Master degree in Economics.

Besides these three major categories, there were applicants for Diploma in SQC or in Computer Science and most of these applicants were graduates in Engineering or Technology (B.E. or B. Tech.).

All the applicants took the same General Ability test.

The following data were available for all the candidates.

(i) Scores on the three separate parts of the General Ability test viz., V. R., Q. R., and D. I. (Hereafter these three parts of G. A. are referred as subjects). The maximum possible score on these three subjects are the same.

(ii) Marks obtained or division earned at the last Pre-College or University Examination passed. For H.S./P.U., M.A./M.Sc. & B. E./B.Tech. division I and II have been taken into account while for B.A./B.Sc. four categories namely division I, division II, Pass and Distinction have been considered.

(iii) Each applicants age was also available.

(iv) University from which the applicant passed the last examination.

METHODOLOGY USED

Instead of considering the difference in the mean values for each subject of G.A. separately, all the three subjects have been taken into account simultaneously to study the difference in the two mean vectors arising out of two education level or two regions as the case may be. This results in the switch over from univariate analysis to multivariate analysis.

To test the hypothesis that the difference in population means (simultaneously for all characters) are zero, Hotelling's test which is same as Mahalanobis D^2 test have been used (Mahalanobis P. C., (1936); Rao, C. R.) Two types of distance are defined on the basis of the character under consideration. When the difference in the mean vectors due to different education level is measured it is interpreted as the 'Education Distance' while in case of regional difference it is attributed to the 'Region Distance' or 'Culture Distance'

In order to group the candidates regionwise keeping their education level fixed, the geographical location of the university from which they have taken their last examination has been considered. It was observed that students from 35 universities applied for the course. Instead of considering them separately since that would result in groups of small size and as such not much confidence could be placed on the obtained results—three major groups of universities were formed on the basis of their geographical locations namely (A) North India (B) South India and (C) East India. A few number of candidates hailed from West Indian universities and due to the small number of cases, they were deleted from the analysis.

For the analysis of the effect of Grade or Division upon the G.A. scores a non-parametric test has been used. Specifically the purpose was to test whether the two independent samples (one for Division I another for Division II) have been drawn from populations with the same distribution. The Kolmogorov-Smirnov two sample test (Siegal, S.) have been used for this purpose.

The Kolmogorov-Smirnov two-sample test compares the two sample cumulative frequency distributions and determine whether the maximum difference (D) between the two relative cumulative frequency distributions of scores less than or equal to X, indicates that they have been drawn from two populations one of which is stochastically larger than the other.

Instead of using directly Kolmogorov—Smirnov D as test statistic it has been shown Good-

$$X^2 = 4\,D^2 \cdot \frac{n_1\ n_2}{n_1 + n_2} \quad .. \quad .. \quad .. (a)$$

man, L. A., (1954) that has a sampling distribution which is approximated by the chi-square distributions with d.f. = 2. So the significance of an observed value of D may be determined by solving (a) for the observed value of D, n_1 and n_2 and refering to the chi-square distribution with d.f. = 2. (n_i is the size of the i-th sample, $i = 1, 2$).

The null hypothesis H_0 and the alternative H_1 are formulated below:

H_0 : Candidates belonging to Division I score same as that of candidates belonging to Division II.

H_1 : Candidates belonging to Division I score more than the candidates belonging to Division II.

For the study of the effect of age on the score of G.A., candidates belonging to a particular educational level were grouped into three age groups—low, medium and high. To determine the age intervals for these three groups a 3-point scale of age was used on the basis of the age distribution of the group. The top and the bottom groups consisted of 23% of the cases each.

After the scores of the candidates have been sorted into these three age groups, a two-way analysis of variance (ANOVA) (with unequal number of observations per cell) was employed at each education level. To avoid complication instead of using a Mixed or 'Random' model, fixed model was assumed to carry out the ANOVA.

The following hypotheses are examined:

(*a*) That there is no main effect of Age.

(*b*) That there is no main effect of Subject.

(*c*) That there is no interaction between Age and Subject.

RESULTS AND DISCUSSION

It is observed from Table 1 that among the different parts of G.A. test battery, Quanti-

TABLE 1

The correlation coefficient of the Mathematics test with the three subject scores of the General Ability test at each level of Education.

Level of Education	Subject	V.R.	Q.R.	D.I.	D.I.
H.S. P. U.	(N=168)	0.47	0.49	0.61	0.61
B.A., B.Sc.	(N=180)	−.020	0.22	0.06	0.06
M.A., M.Sc.	(N=120)	0.43	0.45	0.42	0.42
B.E., B. Tech.	(N= 77)	0.32	0.71	0.23	0.23

tative Reasoning correlates maximum with mathematics. This high correlation between Quantitative Reasoning and mathematics is in conformity with the nature of the these two subjects. At the B.A., B.Sc. level each of the parts viz. Verbal Reasoning, Quantitative Reasoning and Data Interpretation shows the minimum correlation with mathematics when compared with the other level of education. Wide variation in the correlation at the different levels of education is also found to be present e.g., correlation coefficient of verbal reasoning varies from −.20 to +.47 that of Quantitative Reasoning from +.22 to +.71 and .06 to .61 is the range for the correlation coefficient of Data Interpretation. This reveals that mathematics test is not uniformly highly correlated with all the three parts of G.A. at the varying levels of education. The necessity of the inclusion of G.A. test battery in the selection test programme is indicated as well as justified from the above result.

The mean score and S. D. for all the three subjects (V.R., Q.R. and D.I.) at the different level of education are shown in Table 2. From Table 2 it is apparent that the mean values of all the three subjects show an increasing trend as the level of education increases. Amongst the different education levels under consideration at B. E., B. Tech. level the mean score of each subject record the maximum while minimum is attained by the H. S., P.U. group. No such consistent trend or pattern is observed in case of S. D—neither at education level nor subject-wise. In order to examine whether the observed mean score differ significantly at the different education level Mahalanobis D^2 was used. The values of the Mahalanobis D^2 and the test statistics which is a function of D^2 and the number of observations in the two samples belonging to the two educational level to be compared are shown in Table 4. The high significant difference is observed in case of comparison between B.A., B.Sc., and M.A. MSc., levels. The difference between B.E., B.Tech. and M.A., M. Sc., is at the lowest level of significance. H. S., P. U. and B.E., B.Tech. show no significant difference in their performance. Amongst the different comparable levels where significant difference have been found except at B.A., B.Sc., and M.A., M. Sc., in all other cases the differences are not highly significant, the upper 5% value of F (with $\nu_1 = 3$ and $\nu_2 = \infty$) being equal to 2.60. While keeping this observation in consideration it may not be unjustified to conclude that though significant differences have been exposed still they are not very high. There takes place some sort of screening from

TABLE 2

Mean and S. D. of scores at different Education Level

Education Level	Mean			S.D.		
	V.R.	Q.R.	D.I.	V.R.	Q.R.	D. I.
H. S. & P. U.	17.00	14.06	11.60	5.11	4.43	2.73
B.A. & B. Sc.	19.08	15.10	12.50	4.66	4.45	5.71
B. E. & B. Tech.	21.02	16.37	14.14	3.84	4.33	2.80
M. A. & M. Sc.	20.18	15.22	12.83	4.71	4.69	2.59

H.S./P.U. to graduate level and from graduate level to post-graduate level. The possibilities are that those having less ability and lesser interest tend to drop out in large number as we go up the education ladder. This may be the reason for the slight differences that is being observed in some cases. This proposition leads to the conclusion that as far as G. A. scores on the three parts are concerned not much difference in the performance of the persons belonging to the different education level may be attributed from the practical point of view.

Table 3, represents the mean and S. D. of scores of each subject, regionwise, at the different education levels. The regions considered are East, South and North. It is observed that at each region and education level the mean score of V. R. is maximum while D. I. score the minimum, Q. R. lying in between these two subjects. If the mean score is taken to be an indicator of the difficulty level of the subject concerned — no change in the difficulty level of the subjects is observed due to education or region effect. Table 5 shows the Regional Distance Function and the value of the appropriate test statistics at each level of education. The difference in the mean vectors are found to be insignificant expect in case of North & South and South & East at H. S., P. U. level. In these two cases the differences are found to be significant at 5% level but insignificant at 1% level. Since in most of the cases no significant differences is observed the conclusion may be drawn that region or culture has no effect on the score of the three different parts of G.A. In other words cultural differences do not influence ability as measured by the three parts of G.A. The insignificant difference of the performance at the different levels of education shown by the candidates belonging to the three main regions of India shows one more aspect of the G.A. test apart from its culture-free characteristics. It can safely be used for an all India selection programme where the test battery should possess the desired characteristics to do justice to all the candidates so that they are not victimized by the difference in their academic training if there be any.

The differences (D) between the empirical distribution functions of scores in each part

TABLE 3

Region-wise Mean and S. D. at different Education Level.

Education Level	Region / Subject	Mean			S.D.		
		East	South	North	East	South	North
H.S., P. U.	V.R.	16.34	18.37	18.76	4.98	5.02	5.92
	Q.R.	14.02	13.82	14.86	4.16	4.99	4.78
	D. I.	11.50	10.92	12.82	2.58	3.04	2.78
B. A., B. Sc.	V.R.	18.53	19.90	18.94	4.53	4.55	5.15
	Q.R.	14.90	15.23	15.52	4.20	4.57	4.96
	D.I.	12.37	12.42	12.88	3.23	3.67	2.87
B.E., B. Tech.	V.R.	21.07	20.84	20.25	3.90	4.11	1.01
	Q.R.	16.80	15.76	15.33	3.78	4.40	4.04
	D.I.	14.31	13.48	14.87	2.64	3.05	0.54
M.A., M. Sc.	V.R.	18.63	21.89	20.65	5.10	3.69	3.65
	Q.R.	14.54	16.29	15.05	4.84	5.39	4.10
	D.I.	12.36	12.84	13.31	2.45	3.15	2.46

TABLE 4

Education Distance Function between successive education level

Levels of Education	Distance	Value of Test Statistics
H. S., P. U. & B. A., B. Sc.	0.1894	5.4544**
B. A., B. Sc. & B.E., B. Tech.	0.2361	4.2109**
B. E., B. Tech. & M.A., M. Sc.	0.2587	4.0032**
B.A., B. Sc., & M.A., M. Sc.	0.7062	16.3627**
H.S., P. U., & M. A., M. Sc.	0.2265	5.2480**
H.S., P. U. & B. E., B. Tech.	0.0494	0.8623

**Significant at 1% level.

TABLE 5

Regional Distance Function at different Education Level

Level of Education	Regions	Distance	Value of Test Statistics
H. S., P. U	North—South	0.4545	3.3560**
	South—East	0.4781	3.2658**
	East—North	0.2308	1.1906
B. A., B. Sc	North—South	0.0704	0.4312
	South—East	0.0306	0.2076
	East—North	0.0536	0.6441
B. E., B. Tech.	North—South	0.3226	0.3599
	South—East	0.1557	0.8613
	East—North	0.4472	0.5084
M. A., M. Sc	North—South	0.2085	0.9493
	South—East	0.5890	2.4403
	East—North	0.3424	0.2566

**Significant at 1% level.

TABLE 6

Difference (D) between the Empirical Distribution functions of the scores obtained by the First and Second (I, II) Divisioners at each education level and for each subject of the G. A. test Battery.

Education Level	Subject	D^s	X^s
H.S. & P. U. (I, II)	V.R.	.1865	4.8288
	Q.R.	.1663	3.8296
	D.I.	.2666	9.8656**
B.A. & B. Sc., (I, II)	V.R.	.2748	4.6416
	Q.R.	.3800	8.8776*
	D.I.	.2362	3.4306
B. A. & B.Sc., (Pass, Distinction)	V.R.	.2182	3.5909
	Q.R.	.1818	2.4971
	D.I.	.1670	2.1048
B.E. & B. Tech. (I, II)	V.R.	.3536	8.0200*
	Q.R.	.4303	11.8824*
	D.I.	.3085	6.1080*
M.A. & M. Sc., (I, II)	V.R.	.1625	2.4140
	Q.R.	.1458	1.9385
	D.I.	.1637	2.4506

**Significant at 1% level. *Significant at 5% level.

obtained by the candidates belonging to a particular education level and the X^2 value for these different D'S are shown in Table 6. An observation of these figures reveals that in case of B.A., B.Sc. considering those with Pass or Distinction, and M.A., M.Sc. no significant differences are observed in any subject. This leads to the acceptance of the hypothesis that candidates belonging to Division I score same as that of candidates with Division II. The observed difference is significant at the 5 % level in D.I. and V.R. and at the 1 % level in Q.R. for B.E., B.Tech. group. Slight differences are observed between the Division I and Division II at B.A., B.Sc. and H.S., P.U. levels. The obtained differences are significant at the 1 % level for D.I. and 5% level in Q.R., for the H.S., P.U. and B.A., B.Sc. groups respectively. An overall assessment of these differences indicate that not much difference in performance of the I-Divisioners and II-Divisioners exists though in some cases significant differences are observed. In support of the above assessment it may be pointed out that out of 15 observed differences only in three cases the differences are significant at the 5% level and in two cases they are significant at the 1 % level. As the placement of the candidates in different divisions or grades is due to the different level of achievement on the part of the candidate it may be concluded that the score on G.A. test battery is not highly influenced by the different levels of achievement in their academic career.

TABLE 7

Mean values of scores obtained by the candidates belonging to the High, Middle and Low age group at each Education Level.

Education Level	Subject	Mean score at age group		
		High	Middle	Low
H. S. & P. U.	V.R.	16.78	16.97	17.16
	Q.R.	13.33	14.17	14.27
	D.I.	11.31	11.68	11.58
B.A. & B. Sc.	V.R.	19.20	18.93	19.85
	Q.R.	15.45	14.91	15.66
	D.I.	13.40	12.20	12.81
B.E. & B. Tech.	V.R.	21.60	20.89	21.92
	Q.R.	16.66	15.74	16.92
	D.I.	13.13	14.31	14.59
M. A. & M.Sc.	V.R.	20.44	19.43	21.57
	Q.R.	15.40	15.10	15.33
	D.I.	12.82	12.67	13.29

The two-way analysis of variance used for studying the effect of Age and Subject (test) and their interaction upon the mean score of the three parts of G.A. at each education level is shown in Table 8. The mean of scores at the different education level and age group are also given in Table 7. It is observed that at each education level and age group, mean score on V. R. is the maximum while minimum is for D. I. Mean score of Q. R. lies in between the mean scores of V. R. and D. I. No uniform or consistent pattern of variation in the mean score of the three subjects is observed among the different age groups. The variance ratio test at each education level (shown in Table 9) indicates insignificant effect of age upon the mean score of each subject or test at all the levels of education—while highly significant effect of subject is observed at all the levels of education. The interaction between Age and Subject is also insignificant at all the levels of education.

TABLE 8

Two-way Analysis of Variance at different educational level.

Level of Education	Source	s.s.	d.f.	s.s.	Source
H. S. & P.U.	Age (Unadjusted)	23.8611	2	23.9207	Age (Adjusted)
	Subject (Adjusted)	2477.5370	2	2477.4774	Subject (Unadjusted)
	Interaction	7.4534	4	7.4534	Interaction
	Between Cells	2508.8515	8	2508.8515	Between Cells
	Within Cells (error)	7432.0172	498	7432.0172	Within Cells (error)
	Total	9940.8687	506	9940.8687	Total
B.A. & B. Sc.	Age (Unadjusted)	55.9544	2	55.8101	Age (Adjusted)
	Subject (Adjusted)	3954.7180	2	3954.8623	Subject (Unadjusted)
	Interaction	14.9055	4	14.9055	Interaction
	Between Cells	4025.5779	8	4025.5779	Between Cells
	Within Cells (error)	7526.5466	531	7526.5466	Within Cells (error)
	Total ...	11552.1245	539	11552.1245	Total
B.E. & B. Tech.	Age (Unadjusted)	52.3922	2	50.8911	Age (Adjusted)
	Subject (Adjusted)	1913.3042	2	1914.8053	Subject (Unadjusted)
	Interaction	33.2937	4	33.2937	Interaction
	Between Cells	1998.9901	8	1998.9901	Between Cells
	Within Cells (error)	2460.8472	219	2460.8472	Within Cells (error)
	Total	4459.8373	227	4459.8373	Total
M.A. & M. Sc.	Age (Unadjusted)	60.2860	2	60.1708	Age (Adjusted)
	Subject (Adjusted)	3315.3480	2	3315.4632	Subject (Unadjusted)
	Interaction	41.3243	4	41.3243	Interaction
	Between Cells	3416.9583	8	3416.9583	Between Cells
	Within Cells (error)	4428.8205	348	4428.8205	Within Cells (error)
	Total	7845.7788	356	7845.7788	Total

TABLE 9

Variance-Ratio Test at different Education Level.

Level of Education	Source	d.f.	m.s.	F.
H. S. & P. U. ...	Age (Adjusted)	2	11.9604	0.8014
	Subject (Adjusted)	2	1238.7685	83.0067**
	Interaction	4	1.8634	.1249
	Error	498	14.9237	
B. A. & B. Sc. ...	Age (Adjusted)	2	27.9050	1.9687
	Subject (Adjusted)	2	1977.3590	139.5041**
	Interaction	4	3.7264	.2629
	Error	531	14.1742	
B.E. & B. Tech. ...	Age (Adjusted)	2	25.4455	2.2645
	Subject (Adjusted)	2	956.6521	85.1364**
	Interaction	4	8.3234	.7407
	Error	219	11.2367	
M.A. & M. Sc. ...	Age (Adjusted)	2	30.1430	2.3685
	Subject (Adjusted)	2	1657.6740	130.2538**
	Interaction	4	10.3311	.8118
	Error	348	12.7265	

**Significant at 1% level.

CONCLUSION

This study was intended to examine the effect of administering the same G.A. test battery on a board spectrum of education level, region or culture and Age.

The main findings revealed by this study may be listed as follows.

(1) Wide variation in the performance of the candidates with different academic background on the G.A. test battery does not exist.

(2) The test of Mathematics used in the selection test battery is not highly correlated with the different parts of the G.A. administered at the various education level, except in two cases out of twelve.

(3) The culture-effect or the difference in the standard of education at the different Universities, if there be any, are also found not to play an important role in making the performance on G.A. test battery different.

(4) The effect of Age, with respect to the group concerned is also found to be insignificant, and as such no age bar on the part of the candidate is seen to be necessary to be imposed.

In view of the above findings it may be concluded that—

(i) The inclusion of G.A. test battery in a selection test is justifiable as it is not duplicating those aspects which the Mathematics test or the past academic records indicate.

(ii) The use of the same G.A. test on the candidate from different Universities having different educational and regional background. is also justified as the differences obtained to these factors are not large enough to affect the selection procedure adversely.

REFERENCES

GOODMAN, L. A. (1954)—Kolmogorov Smirnov tests for *Psychological Research*. Psychol. Bull. 51, 160-168.

MAHALANOBIS, P. C. (1936)—On the generalized distance in statistics. Proc. Nat. Inst. Sci. India, 12, 49-55.

SIDNEY SIEGAL,—*Non-parametric Statistics for the behavioural Sciences*. P. 127, McGRAW-Hill Book Company, Inc.

RAO, C. R.—*Linear Statistical Inference and its Applications*. New York : John Wiley & Sons Inc. 480.