PREDICTION OF ACHIEVEMENT IN SCIENCE ON THE BASIS OF THE SCIENTIFIC CREATIVITY TEST SERIES

S.K. Majumdar

National Institute of Education,
National Council of Educational Research and Training, New Delhi

Even before the Delhi Higher Secondary (Science) Examination (1974) results and the National Science Talent Search Test (1974) results were out (the interview for the latter was still being held) a prediction for achievement in Science of a group of students appearing in these was made on 1st June, 1974 and submitted to the Head of the Department of Education in Science and Mathematics, National Council for Educational Research and Training (NCERT) by this author - based on the technique of topographical analysis of the scatterplot between the distribution of the newly developed Scientific Creativity Test scores and IQ of these subjects. The predictions came out to be highly significant. The study is detailed below:

PURPOSE OF THE STUDY

The study was undertaken to test, a priori, the predictive validity of the newly-constructed Scientific Creativity Test series that was being developed under the Department of Science Education (renamed, Department of Education in Science and Mathematics), NCERT for the purpose of utilization by the National Science Talent Search Scheme (now renamed National Talent Search Unit). The other purpose was to verify the validity of some basic postulates related to this study.

PROCEDURE

Tools The test-series utilized here consisted of Scientific Creativity Test - Parts I and II, containing 29 SI-factor subtests. These subtests were constructed keeping the psychometric construct of the concerned SI-factor intact and introducing contents from the areas of science, namely, - Physics, Chemistry, Biology and Mathematics. The test construct was detailed in a Monograph published by the NCERT (Majumdar 1973) and was presented in a paper read before the Nagpur session of the Indian Science Congress in 1974 (Majumdar 1974).

The other tests included in the test-series were an IQ-Test (Cattells' Culture Fair Test of pure "g", Scale 3, Forms A and B) and a Personality Test for Extraversion and Neuroticism (Maudsley Personality Inventory by Eysenck).

Population For the purpose of this study, the abovementioned test-series was administered to a group of 60 class XI Higher Secondary science students of

Lady Irwin Girls' Higher Secondary School, New Delhi, in July-August, 1973. The reason for choosing this school was that it had obtained the largest number of NSTS scholarships amongst all the schools in India during the last few years.

Criteria Two criteria came in handy for predictive validation - (1) The Delhi Higher Secondary (Science) Examination, 1974, and (2) National Science Talent Search Test, 1974. While all the subjects appeared in the former only about twenty appeared in the latter. Thus, the Higher Secondary (Science) Examination (1974) scores appeared to be a more suitable criterion for the purpose of determining the predictive validity.

IQ-Creativity Postulates The hypotheses for the prediction were based on the following postulates:

(1) The study of IQ-Creativity (DP) score relationship by Guilford (1967) and a replication of the same by this author (Majumdar, 1970) both showed a typical triangular scatterplot - indicating, in the words of Guilford that "although high IQ is not a sufficient condition for high DP ability, it is almost a necessary condition."

(2) The Gatzels-Jackson study (1962) that in spite of 23 points difference in mean IQ between the "High Creative (with low IQ)" the "High IQ (with low creativity)" groups were found to be equally superior in achievement scores.

(3) Anderson's (1960) Threshold Concept that beyond a cut-off point in IQ, it is Creativity that is more responsible for achievement.

Topographical Rank-Ordering for Prediction

On the basis of the three postulates above a synthetic approach had been made in putting forward the prediction hypotheses through the analysis of the scatterplot between Scientific Creativity (SC) Test scores and IQ. A topographical rank-ordering of the subjects based on the positions of the individuals on the said scatterplot, as well as the quadrant-wise analysis of the groups formed by the intersection of the mean lines of the two distributions, were taken recourse to.

The performance of the individuals being dependent on both SC score and IQ variables in manners described in postulates noted above, the best way considered to rank the individuals on the combined (IQ+SC)-score was to scan the scatterplot from top-right to bottom-left by a sliding tangent-form (slope form) making an angle θ with the X-axis inclined towards left of the diagram (Fig. 1), where $\theta = \tan^{-1} \frac{\text{Range of SC scores}}{\text{Range of IQ}}$.

The underlying assumption, here, being that when both the distributions are normal, for a particular position of the tangent-form, all points on it will have the same combined (IQ+SC)-score. Even if the distributions are not both normal or have a somewhat curvilinear relationship this fact will remain more or less true. As the tangent-form is moved from right to left, the combined score at any position on it gets gradually reduced, and every individual's position as it comes upon the line, can be noted down in sequential rank.

Prediction Hypotheses based on IQ-SC Ranking

Hypothesis I: For the whole population, the IQ+SC topographical rank ordering will predict the outcome of any test of achievement in science and mathematics.

Hypothesis II: Similar rank orders for the quadrant-groups will predict similar outcomes of achievements within these groups.

The predictive validity for IQ and SC-scores, separately, in relation to achievements in HS (and NSTS) would also be found out.

The various quadrant-wise analysis of the groups formed by the intersection of the mean lines of the IQ and SC distributions in the scatterplot would also help verification of the postulates.

Personalistic postulates

(a) According to Cattell (1963), Golovin (1963) and various other authorities on the subject, extraverts are not likely to be Creative Scientists, or good achievers in science.

(b) Terman (1930, 1947) and Anne Roe (1953) found the talented and Creative Scientists to be stable and well-adjusted. According to both (Terman, 1947 and Roe, 1963) neurotic tendency is contrary to Creative Personality.

The above two postulates were to be verified in the light of the findings and valid conclusions drawn (Majumdar 1973, pages 15 to 19).

FINDINGS

The means and standard deviations of the various test-score distributions for the whole population are as follows:

	SC Test Scores	IQ	Neuro-ticism	Extra-version	HS Sc. marks	HS Total marks	NSTS (only awardees)
Mean	82.27	95.63	25.60	26.57	397.83	515.12	136.6
SD	21.10	13.50	7.65	7.45			

The detailed scores are to be found in Table 1.

The product-moment Correlations between the variables for the whole population (N=60) are as follows:

	IQ	HS Sc. marks	Neuroticism	Extra-version
SC Test Scores	** .54	** .60	** 0.52	0.03
IQ		** .53	+ 0.29	**0.57
HS Science marks			* 0.38	0.05

\+ Significant at .05 level
* Significant at .01 level
** Significant at .001 level

Re: Higher Secondary Examination in Science

It was found that the top 11 positions in the Higher Secondary (Science) Examination were obtained by the High SC - High IQ group (Quadrant I of the scatterplot).

Of the subsequent six positions (12th to 17th) two were obtained by the above group and the rest (four) by the High SC - Low IQ group (Quadrant II).

Thus all the top 17 positions go to the High SC - groups (Quadrants I and II). But none of these top positions go to the High IQ - Low SC group. (Fig. 1 indicates these.)

The means of the different test scores, and the number of NSTS awards for the four Quadrants are as follows:

	Population	SC Score Means	IQ Means	Neuroticism Means	Extraversion Means	HS Total Means	HS Sc. marks Means	NSTS No. of awards
Quadrant I (High SC - High IQ)	20	103.13	108.25	21.10	25.70	581.05	454.15 (13 top positions)	8
Quadrant II (High SC - Low IQ)	9	91.75	88.00	26.22	28.00	514.78	395.89 (4 top positions)	3
Quadrant IV (High IQ - Low SC)	9	68.31	106.11	28.89	26.11	498.78	390.45 (Nil)	Nil
Quadrant III (Low IQ - Low SC)	22	65.15	83.00	28.09	26.95	462.00	350.45 (Nil)	Nil
Total Population	60	82.27	95.63	25.06	26.57	515.12	397.83	11

Rank-Difference Correlations:

The rank-difference correlations between the marks of HS Science subjects and the topographical rankings based on IQ-SC Composite (Table - 2) is 0.61, significant at 0.001 level.

The rank-difference correlations within groups are as follows:

HIGH SC - HIGH IQ GROUP (N=20)
(QUADRANT I)

Between SC and HS Science marks	0.66 Significant at 0.001 level
Between (IQ+SC) and HS Science marks	0.65 Significant at 0.01 level
Between IQ and HS Science marks	0.36 Not Significant at 0.05 level

HIGH CREATIVE GROUPS (N=29)
(QUADRANTS I & II)

Between SC & HS Sc. marks	0.61 Significant at 0.001 level
Between IQ & HS Sc. marks	0.51 Significant at 0.01 level

HIGH IQ GROUPS (N=29)
(QUADRANTS I & IV)

Between SC & HS Sc. marks	0.52 Significant at 0.01 level
Between IQ & HS Sc. marks	0.16 Not Significant

Re: National Science Talent Scheme Test Results:

Of the 11 NSTS awards obtained by this population, the High SC-High IQ group secured 8 awards, and the High SC-Low IQ groups obtained 3. The other groups obtained none.

Within the NSTS group (N=11) the rank-difference correlations were as below:

Between SC & HS Sc. marks	0.77 Significant at 0.01 level
Between (IQ & SC) & HS Sc. marks	0.70 Significant at 0.01 level
Between IQ & HS Sc. marks	0.60 Significant at 0.05 level

But the rank-difference correlations between NSTS test scores and all the other test scores were not significant:

Between NSTS & SC	0.16 Not Significant
Between NSTS & (IQ+SC)	0.18 Not Significant
Between NSTS & IQ	0.25 Not Significant
Between NSTS HS Sc. marks	0.36 Not Significant

DISCUSSION

The first hypothesis regarding the prediction of Achievement in science for the whole population on the basis of topographically-determined rank-order (IQ+SC) was found to be valid in respect of Higher Secondary Science marks. The Predictive Validity of 0.61 is highly significant (at 0.001 level) and is highest when compared to that of IQ or SC alone.

The second hypothesis regarding topographically-determined rank-orders within groups as predictors, is valid only in the case of High SC-High IQ group, the Predictive Validity being 0.65, which is significant at 0.01 level. In other Quadrant groups, however, the correlations were not significant (within the NSTS group its correlation with HS Sc. subjects is 0.70, which is significant at 0.01 level).

Predictive Validity of SC Test

The SC test scores were equally good, or in a way even better predictor of Higher Secondary Science marks. While for the whole group the Predictive Validity is 0.06 significant at 0.001 level, for the High Creative (Quadrants I and II) is 0.61 at the same significant level. Again while the Predictive Validity for High IQ groups (Quadrants I and IV) is 0.52, that for the High SC-High IQ group is 0.66 (both significant at the 0.001 level) and that for the NSTS group is 0.77 (significant at 0.01 level). For the other Quadrants, the correlations were not significant.

Predictive Validity of IQ Test

IQ had a low Predictive Validity in the whole population as a whole and had no significant Predictive Validity in any of the Quadrants taken separately or even in Quadrants I and IV taken together. However, it had a Predictive Validity of 0.50 significant at 0.01 level in the High Creative groups, Quadrants I and II taken as a whole.

Predictive Validity of NSTS Tests

The NSTS tests, had no significant Predictive Validity with respect to SC, (IQ+SC) or IQ scores, considered here. No valid conclusion could be drawn from this since the sample under consideration was unfortunately very small. Nevertheless all NSTS awardees were amongst the top HS achievers, and all were High Creatives at the same time.

The performance of the Quadrant-wise groups have some special characteristics. As expected, the High SC-High IQ (Quadrant I) group has definitely performed very well, acquiring 13 out of the top 17 positions, in HS Exam., and 8 out of the 11 NSTS awards. To our utter surprise, however, the High SC-Low IQ group (Quadrant II) comes next in performance acquiring the balance of top HS positions and NSTS awards. While the High IQ-Low SC group (Quadrant IV) gets none, even though the former group has a mean IQ of 88 and the latter a mean IQ of 106.

Regarding the postulates that were verified in this study, the following points are noteworthy:

(1) We obtained a triangular-type scatterplot between IQ and SC scores as expected.

(2) The Getzels-Jackson cut-off points were higher. Thus the fact that achievements of High SC-Low IQ group is superior to that of the High IQ-Low SC group suggests that the Getzels-Jackson postulate needs modification that both groups are equally superior in Achievement. (Getzels-Jackson cut-off points were higher.)

(3) The Anderson Threshold Concept that beyond a cut-off point of IQ, it is Creativity that is responsible for achievement remains perfectly applicable in our study as amongst the High Creatives groups (Quadrants I and IV) SC score has a Predictive Validity of 0.52 for achievement in science subjects whereas IQ has (0.16) a no significant predictive validity.

Personality of High Achievers and Creatives

Regarding the relationships with the personality variables, Extroversion and Neuroticism; we should note the following:

Neuroticism has high negative correlations with SC scores and HS (Sc) scores, being 0.52 and 0.38, significant at both 0.001 and 0.01 levels. With IQ, the correlation is 0.29 which is significant at 0.05 level.

Extroversion has very low negative correlations with SC scores and HS (Sc) scores, being 0.03 and 0.05 respectively. Whereas it has a high negative correlation with IQ (0.57), which is significant at 0.001 level.

We can say then that the High Creatives and High Achievers in the field of science are generally stable and not extroverts.

Conclusion

The Scientific Creativity Test is a very good predictor of Scientific Achievements. High SC score generally, and High SC+High IQ particularly, go with talent in the field of Science. The talented in the field of Science (High Creatives and High Achievers) are also generally highly stable (very low in Neuroticism) and not extroverts (rather low in Extroversion).

As the three variables: SC Test Scores, IQ and Neuroticism were all found to be very good predictors of Scientific Achievement, it will be worthwhile to find out the multiple correlations and multiple regression equations based on these variables for prediction of achievement or performance in the field of Science.

Fig. 1 - IQ-SC scatterplot (indicating performance in NSTS and HS Sc. examinations).

Table 1 - Score Table for the whole population (Lady Irwin HS School, Class XI Sc. 1973-74).

Table 2 - IQ-SC Composite Rank-Order of the whole population (Lady Irwin HS School, Class XI Sc. 1973-74).

Table 3 - Score Table for Quadrant I

Table 4 - Score Table for Quadrant II

Table 5 - Score Table for Quadrant IV

Table 6 - Score Table for Quadrant III

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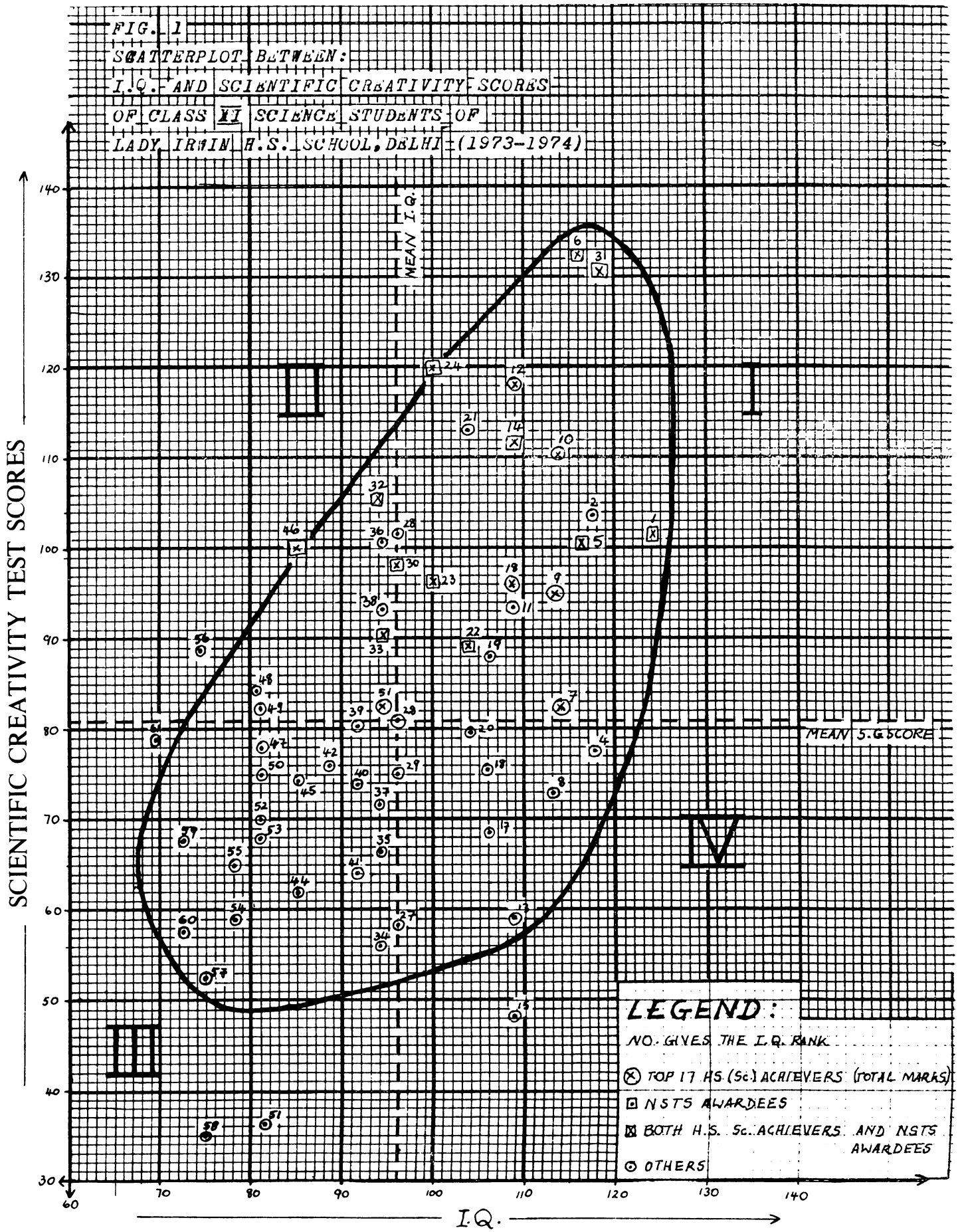
FIG. 1
SCATTERPLOT BETWEEN:
I.Q. AND SCIENTIFIC CREATIVITY SCORES
OF CLASS XI SCIENCE STUDENTS OF
LADY IRWIN H.S. SCHOOL, DELHI (1973-1974)
SCIENTIFIC CREATIVITY TEST SCORES
I.Q.
MEAN I.Q.
MEAN S.C. SCORE
I
II
III
IV
LEGEND:
NO. GIVES THE I.Q. RANK
TOP 17 H.S. (Sc.) ACHIEVERS (TOTAL MARKS)
NSTS AWARDEES
BOTH H.S. Sc. ACHIEVERS AND NSTS AWARDEES
OTHERS

Table 2

Rank order of the whole population of class XI science students (Sec. A and B, Lady Irwin Girls School) topographically located in the scatterplot between IQ and Scientific Creativity Test Scores

Rank order	Serial No. in order of IQ	Rank order	Serial No. in order of IQ
1.	(3)	31	(46)
2.	(6)	32	(31)
3.	(1)	33	(29)
4.	(2)	34	(15)
5.	(12)	35	(39)
6.	(10)	36	(37)
7.	(5)	37	(40)
8.	(14)	38	(35)
9.	(9)	39	(42)
10.	(24)	40	(27)
11.	(21)	41	(41)
12.	(16)	42	(48)
13.	(4)	43	(43)
14.	(11)	44	(49)
15.	(7)	45	(45)
16.	(8)	46	(34)
17.	(19)	47	(47)
18.	(23)	48	(56)
19.	(22)	49	(50)
20.	(32)	50	(52)
21.	(26)	51	(44)
22.	(30)	52	(53)
23.	(36)	53	(55)
24.	(18)	54	(61)
25.	(20)	55	(54)
26.	(17)	56	(59)
27.	(38)	57	(57)
28.	(22)	58	(60)
29.	(13)	59	(51)
30.	(28)	60	(58)

Table - 1

Test Results of Class XI (1973-74) Science Students of Lady Irwin Higher Secondary School, New Delhi

Serial No. (IQ Rank)	SC Test score (Parts I & II)	IQ (Culture Fair)	MPI		Higher Secondary Examination Marks					Total	Science subjects	NSTS Scores
			Extra-version	Neuro-ticism	English	Physics	Chem.	Biology	Maths			
1.	101.75	124	32	21	144	135	123	121	139	662	518	140
2.	102.75	117	28	24	100	116	114	93	123	546	446	
3.	132.25	117	9	10	164	130	132	134	135	695	531	158
4.	77.75	117	28	24	110	101	95	98	115	519	409	
5.	100.50	116	16	28	127	124	118	127	128	624	497	141
6.	132.50	116	39	7	131	125	123	118	139	636	505	130
7.	82.75	113	32	24	123	124	114	120	121	602	479	
8.	73.75	113	32	28	95	71	81	96	78	421	326	
9.	94.50	113	10	19	136	116	129	128	140	649	513	
10.	110.25	113	36	21	145	127	126	112	140	650	505	
11.	93.25	109	18	24	106	49	60	81	33	329	223	
12.	118.25	109	7	17	137	129	123	120	124	633	496	
13.	59.00	109	31	29	114	90	103	105	114	526	412	
14.	112.00	109	30	20	125	119	134	126	126	630	505	131
15.	48.25	109	22	30	107	87	89	94	104	481	374	
16.	96.00	109	36	36	125	125	121	113	130	614	489	
17.	68.00	106	22	38	122	82	89	101	104	498	376	
18.	75.25	106	32	32	117	121	103	93	106	540	423	
19.	87.25	106	30	23	107	778	93	101	69	448	341	
20.	80.00	103	24	24	91	107	105	96	124	523	423	
21.	113.50	103	38	10	115	89	102	104	119	529	341	
22.	89.00	103	33	30	122	76	85	79	83	455	432	
23.	95.75	100	20	20	119	110	122	118	134	603	414	
24.	119.50	100	20	17	145	145	123	124	140	677	333	
*25.	-	100	-	-	115	87	92	97	74	465	484	139
26.	101.25	100	21	17	138	112	91	89	107	537	532	140
27.	58.00	96	21	24	109	92	95	107	117	520	411	
28.	81.00	96	31	29	105	75	89	105	106	480	375	
29.	74.75	96	23	31	110	78	95	83	95	461	351	
30.	98.50	96	33	25	124	119	137	123	137	622	498	132
31.	81.25	94	36	36	106	129	111	122	122	590	484	

* Not considered for computations.

Table - 1 (Continued)

Serial No. (IQ Rank)	SC Test score (Parts I & II)	IQ (Culture Fair)	MPI		Higher Secondary Examination Marks					Total	Science subjects	NSTS Scores
			Extra-version	Neuro-ticism	English	Physics	Chem.	Biology	Maths			
32.	106.00	94	29	21	131	108	115	125	109	588	457	114
33.	90.25	94	32	21	124	109	99	99	127	588	434	
34.	55.75	94	24	29	104	68	67	80	100	419	315	
35.	66.75	94	29	36	116	92	105	103	92	508	392	
36.	101.25	94	25	17	116	83	100	117	118	534	418	
37.	70.75	94	27	21	103	67	82	83	81	416	313	
38.	91.75	94	27	33	127	59	82	91	72	431	303	
39.	80.50	91	32	36	103	81	82	99	84	449	346	
40.	74.00	91	32	17	108	99	119	106	125	557	449	
41.	64.50	91	30	28	142	83	81	80	79	465	323	
42.	75.00	88	24	23	118	86	94	104	88	490	372	
43.	69.75	88	25	39	130	86	94	95	80	485	355	
44.	62.25	85	24	20	116	80	104	90	100	490	374	
45.	74.50	85	20	32	95	71	77	81	75	399	304	
46.	100.25	85	20	25	123	115	124	106	141	609	486	146
47.	77.50	81	34	18	114	70	75	92	63	414	300	
48.	84.00	81	33	32	116	64	73	94	64	411	295	
49.	82.00	81	22	18	114	63	81	90	101	439	325	
50.	75.50	81	26	17	115	70	74	92	76	427	312	
51.	35.50	81	26	30	108	108	101	83	96	496	388	
52.	70.00	81	35	38	118	107	106	100	118	549	431	
53.	67.00	81	26	37	108	103	99	97	100	507	399	
54.	59.25	78	23	30	103	91	92	82	90	458	350	
55.	65.75	78	18	18	99	104	101	101	139	544	445	
56.	89.00	75	28	33	112	74	94	112	81	473	361	
57.	52.00	75	38	24	114	74	103	84	91	466	352	
58.	34.75	75	17	32	93	39	37	50	68	287	194	
59.	66.25	72	24	24	130	77	84	95	81	467	337	
60.	56.25	72	25	26	119	86	93	90	103	491	372	
61.	79.75	70	34	43	93	59	96	75	57	380	287	

Table - 3

Quadrant I

(High IQ and High SC)

Quadrant Rank Order	IQ scores	Neuro-ticism	Extra-version	SC scores	HS Total	HS Science subjects	NSTS scores
1.*+	117	10	9	132.25	695	531	158
2.*+	116	7	39	132.50	636	505	130
3.*+	124	21	32	101.75	662	518	140
4.+	109	17	7	118.25	633	496	
5.+	113	21	36	110.25	650	505	
6.	117	24	23	102.75	546	446	
7.*+	116	28	16	100.50	624	497	141
8.*+	109	20	30	112.00	630	505	131
9.+	113	19	10	94.50	649	513	
10.*+	100	17	20	119.50	677	532	140
11.	103	10	38	113.50	529	414	
12.+	109	36	36	96.00	614	489	
13.	109	24	18	93.25	329	223	
14.+	113	24	32	82.75	602	479	
15.	106	23	30	87.25	448	341	
16.*+	100	20	20	95.75	603	484	139
17.	103	30	33	89.00	455	333	
18.	96	17	21	101.25	537	399	
19.*+	96	25	33	98.50	622	498	132
20.	96	29	31	81.00	480	375	
Means	108.25	21.10	25.70	103.13	581.05	454.15	

* NSTS awardee
\+ Top 17 HS (Sc.) Achiever

Table - 4

Quadrant II

(High SC and Low IQ)

Quadrant Rank Order	IQ scores	Neuro-ticism	Extra-version	SC scores	HS Total	HS Science subjects	NSTS scores
1.*+	94	21	29	106.00	588	457	134
2.	94	17	25	101.25	534	418	
3.	94	33	27	91.75	431	303	
4.*+	94	21	32	90.25	558	434	114
5.*+	85	25	20	100.25	609	486	146
6.+	94	36	36	81.25	590	484	
7.	81	32	33	84.00	411	295	
8.	81	18	22	82.00	439	325	
9.	75	33	28	89.00	473	361	
Means	88.00	26.22	28.00	91.75	514.78	395.89	

* NSTS awardee
\+ Top 17 HS (Sc.) Achiever

Table - 5

Quadrant IV

(High IQ and Low SC)

Quadrant Rank Order	IQ scores	Neuro-ticism	Extra-version	SC scores	HS Total	HS Science subjects	NSTS scores
1.	117	24	28	77.75	519	419	
2.	113	28	32	73.75	421	326	
3.	106	32	32	75.25	540	423	
4.	103	24	24	80.00	523	432	
5.	106	38	22	68.00	498	376	
6.	109	29	31	59.00	526	412	
7.	96	31	23	74.75	461	351	
8.	109	30	22	48.25	481	374	
9.	96	24	21	58.00	520	411	
Means	106.11	28.89	26.11	68.31	498.78	390.45	

Table - 6

Quadrant III

(Low SC and Low IQ)

Quadrant Rank Order	IQ scores	Neuro-ticism	Extra-version	SC scores	HS Total	HS Science subjects	NSTS scores
1.	91	36	32	80.50	449	346	
2.	94	21	27	70.75	416	313	
3.	91	17	32	74.00	557	449	
4.	94	36	29	66.75	508	392	
5.	88	23	24	75.00	490	372	
6.	91	28	30	64.50	465	323	
7.	88	39	25	69.75	485	355	
8.	85	20	24	62.25	490	374	
9.	85	32	20	74.50	399	304	
10.	94	29	24	55.75	419	315	
11.	81	18	34	77.50	414	300	
12.	81	17	26	75.50	427	312	
13.	81	38	35	70.00	549	431	
14.	81	37	26	67.00	507	399	
15.	78	18	18	65.65	544	445	
16.	70	43	34	79.75	544	445	
17.	78	30	23	59.25	458	350	
18.	72	24	24	66.25	467	337	
19.	75	24	38	52.00	466	352	
20.	72	26	25	56.25	491	372	
21.	81	30	26	35.50	496	388	
22.	75	32	17	34.75	287	194	
Means	83	28.09	26.95	65.15	462	350.45	