Special Paper

A STUDY OF PROCEDURES OF SELECTING AND CHANNELIZING SCIENTISTS FOR RESEARCH AND DEVELOPMENT. PART I

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1. Introduction

The selection of properly qualified persons for various types of work is a well-known problem, and it has received considerable attention. This is particularly important for scientific and development work, where the selection of the wrong kind of man can mean the difference between success and failure of a project. In general, there are three distinct techniques used for grading, namely (i) the written examination or test, or assessment based on grades obtained in the various academic examinations, (ii) the oral examination or interview by a board and (iii) the analysis of confidential reports by referees who have known the candidate and his work. Quite often, a combination of two of these may be utilized, but generally speaking the first technique is employed for the junior-most positions, while the third is of major value in selection of personnel for the senior and managerial type of appointments. The second technique, i.e. interview by a board, is used in conjunction with both these, and is thus probably the most frequently used tool in the selection of junior as well as senior scientific and technical personnel. One of the reasons for the obvious popularity of the interview technique is that, more than the other two, it affords a good method of assessing the entire personality of the candidate, which include several intangibles, such as drive and the ability to take in a new situation or even to tackle something he knows nothing about. It is therefore of some importance to examine the ways in which the results or findings of such a board can be made as highly objective and quantitative as possible.

The present communication gives a critical account of certain key-points in the system of interviewing and grading that have been tried out by the author, and presents a brief analysis of the improvements obtainable after introduction of certain innovations, as well as a correlation with examination grades. The data cover a series of interviews held in the four-year period 1963-1967, and a preliminary account is also given of correlation between academic grades and scientific advancement.

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2. Basic Ideas

The real problem is to give sufficiently accurate and objective grades to each of the candidates, so that they can be easily and unambiguously arranged in order of merit all the way down to those only slightly above average, at which level it really becomes somewhat difficult to distinguish between one and the other. Three basic ideas have been utilized in the particular techniques for selection by a board of four to ten being discussed here. These are: (a) putting down of a grading for each candidate *independently* by each member of the board, (b) working out the means of the gradings given by the various members to each candidate and arranging all the candidates in order of this mean grading, and (c) selecting incumbents for about 90% of the vacant posts by taking the top-most persons in this order of mean grading. This last can be done even regardless of the detailed specialities of the candidates, because it ensures that we get the best scientists for our work.

For putting down grades, a simple scale of ten was adopted, utilizing, instead of the numbers 1 to 10, the symbols given below:

1	2	3	4	5	6	7	8	9	10
D	C–	C	C+	B–	B	B+	A–	A	A+

When the grades given to any one candidate by the various interviewers are averaged, it becomes possible to obtain a finer subdivision than the scale of ten, *provided the individual grades are independent*. For example, a mean value half-way between A– and A would be given as A–0.5. This in effect gives a scale of 100 for comparing the various candidates.

3. Analysis of Some Interviews in 1963-64

We first present an analysis of some of the interviews for three categories of senior posts, namely Research Officer, Senior Research Officer, and Principal Research Officer, held in 1963-64. Tables 1 (a), (b) and (c) give a sampling of the interview data, showing the grades given to the candidates by the seven members of the interview committee, together with the mean grade calculated from these for each candidate. The last

column gives the overall spread of the individual grades given to each candidate, and the mean value of this spread is seen to be nearly $2\frac{1}{2}$ points on the scale of ten, i.e. $\pm 1\frac{1}{4}$ points above and below the mean grade. This itself is quite as good as can be expected, especially when it is borne in mind that some members of the interviewing committee will be consistently liberal in their gradings, while others will be stricter than average. An idea of the relative magnitudes of this consistent bias and of the random variation in the gradings can be obtained by making a further analysis.

Considering Table 1(b) for interviews of Senior Research Officers, a glance will show that the gradings of interviewer *A* are in general the most liberal, while those of *D* are the most strict. Accordingly, a tabulation has been made in the first and third rows of Table 2 of the deviations of the

TABLE 1(a).—PRINCIPAL RESEARCH OFFICERS—1964.

Candidates	Interviewers							Mean grade	Spread
	A	*B*	*C*	*D*	*E*	*F*	*G*		
1	A+	A	A	A–	A	A+	—	A+0.2	A– to A+ =2 units
2	B	B	C	B	—	B–	—	B –0.8	C to B =3 ,,
3	A	A	A	A–	—	A+	—	A	A– to A+ =2 ,,
4	B+	B+	B–	B+	—	B+	—	B+0.6	B– to B+ =2 ,,
5	A	A+	A+	—	A	—	A	A+0.4	A to A+ =1 ,,
									Mean =2.0 ,,

TABLE 1(b).—SENIOR RESEARCH OFFICERS—1964.

Candidates	Interviewers								Mean grade	Spread
	A	*B*	*C*	*D*	*E*	*F*	*G*	*H*		
1	A–	A–	B+	B	B+	A	A		A– 1.3	B to A =3 units
2	B+	B	B+	B	B	B+	B+		B+0.6	B to B+ =1 ,,
3	B	C	B–	C–	C	C+	B		C+1.1	C– to B =4 ,,
4	B+	B	B+	B+	B	A	C		B+0.4	C to A =6 ,,
5	—	D	C+	C	C–	D	C		C– 0.8	D to C+ =3 ,,
6	B	B/C	B	C+	B+	C	D		C+1.2	D to B+ =6 ,,
7	A	A–	A+	B+	B+	A+	B+		A– 0.7	B+ to A+ =3 ,,
8	B	C+	B	B–	B	B+	B		B– 0.2	C+ to B+ =3 ,,
9	B+	B	A	B	B+	B+	B+		B+1	B to A =3 ,,
10	—	—	—	B	B+	—	—		B+0.5	B to B+ =1 ,,
11	A–	B+	B+	—	B+	B+	B	A	B+1.4	B+ to A =2 ,,
12	B	A	B–	—	B+	B	B	—	B+0.5	B– to A =4 ,,
13	B–	B–	B–	—	B–	C+	B–	—	B– 1.2	C+ to B– =1 ,,
14	B	B	B	—	—	C	C	—	B– 1.2	B to C =3 ,,
15	B–	C+	D	—	—	C+	C+	—	C+1.4	D to B– =4 ,,
16	A	A–	A	—	—	B+	B+	A+	A– 0.7	B+ to A+ =3 ,,
										Mean =3.1 ,,

grades given by *A* and *D* from the mean grades calculated for the committee as a whole (in the last column of Table 1(b)), along with a middle row giving similar deviations for interviewer *B*, who was, in the main, closest to the average of the committee. The last column of Table 2 gives the means of the three sets of deviations, and shows that interviewer *A* is consistently liberal to the extent of giving grades 0.7 units (on a scale of ten) *higher* than the average for the committee. Also, his grades scatter around this level by ±0.6 units, which thus gives a measure of the consistency of his evaluations. As against this, the last entry in the last column of Table 2 shows that the grades given by the interviewer *D* are consistently *lower* than the average by 0.7 units, and his scatter about this level is ±0.8 units. Similarly, the grades of interviewer *B* are found to be only 0.1 unit below the average level, but show a scatter of ±1.0 unit about the mean.

4. Estimates of Reliability and Stability of Mean Grading

From the foregoing analysis, it can be concluded that the gradings of any one interviewer scatter by about ±0.8 unit (on a scale of ten) around *his mean standard*, which may itself lie anywhere from 0.7 to −0.7 unit away from the average standard set by the committee as a whole. This is really satisfactory, indeed, when we consider that the successive steps in the individual grades are just one unit. We can now deduce that if there are *n* interviewers composing the committee, then the relative reliability of the means of their gradings will be measured by

$$\pm 0.8/\sqrt{n} \text{ units}$$

on a scale of ten. For a committee of six members, this gives a reliability of ±0.3 units, showing that

TABLE 1(c).—RESEARCH OFFICERS—1964 (LAHORE).

Candidates	Interviewers A	B	C	D	E	F	G	Mean grade	Spread
1	D	D	—	C–	C+	B	—	C–	D to B =5 units
2	B+	B+	—	B+	—	B	—	B+0.8	B to B+ =1 ,,
3	A–	B+	—	A–	B+	A–	A–	A–1.3	B to A– =1 ,,
4	B+	B	B+	B+	B	B+	—	B+0.7	B to B+=1 ,,
5	A+	A	A	A–	A	A+	—	A+0.2	A– to A+=2 ,,
6	—	B	B–	—	—	B+	—	B	B– to B+=2 ,,
7	B+	B+	A	B+	B+	A	A–	A–1.3	B+ to A =2 ,,
8	A–	B+	B+	B	A	B+	B+	B+1.2	B+ to A =2 ,,
9	A–	A	A–	A	B+	A	A	A–0.9	B+ to A =2 ,,
10	A	B+	B+	B	B+	B+	A	B+1.3	B+ to A =2 ,,
11	B+	C+	B+	—	B+	B+	B+	B+0.5	C+ to B+ =3 ,,
									Mean =2.1 ,,

TABLE 2.— DEVIATIONS OF GRADES GIVEN BY INTERVIEWERS A, B AND D.

Interviewers	Candidates 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Mean
A	+0.3	+0.4	+1.9	+0.6	—	1.8	+0.7	+0.2	+0.0	—	+0.6	—0.5	+0.2	+1.2	+0.6	+0.7	+0.7 ±0.6
B	+0.3	—0.6	—1.1	—0.4	—0.2	+0.3	—0.3	—1.8	—1.0	—	—0.4	+2.5	+0.2	+1.2	—0.4	—0.3	—0.1 ±1.0
D	—1.7	—0.6	—2.1	+0.6	+0.8	+0.2	—1.3	—0.8	—1.0	—0.5	—	—	—	—	—	—	—0.7 ±0.8

such a committee can quantitatively assess the merits of the various candidates within 0.3 parts in 10, i.e. within 3%. Of course, the assessments of this committee will differ by a small amount from those of another similar committee, or even the same committee with one member less and with an additional member. An estimate of the magnitude of these variations of standard from committee to committee can also be made from the data analysed above, and is readily seen to be nearly equal to the foregoing estimate of $\pm 0.8/\sqrt{n}$ units, which thus provides the measure of the reliability and stability of the mean gradings.

5. Correlation of Interview Results with Academic Grades

There remains the interesting matter of comparing and correlating the results of the above interview grading technique with the academic grades

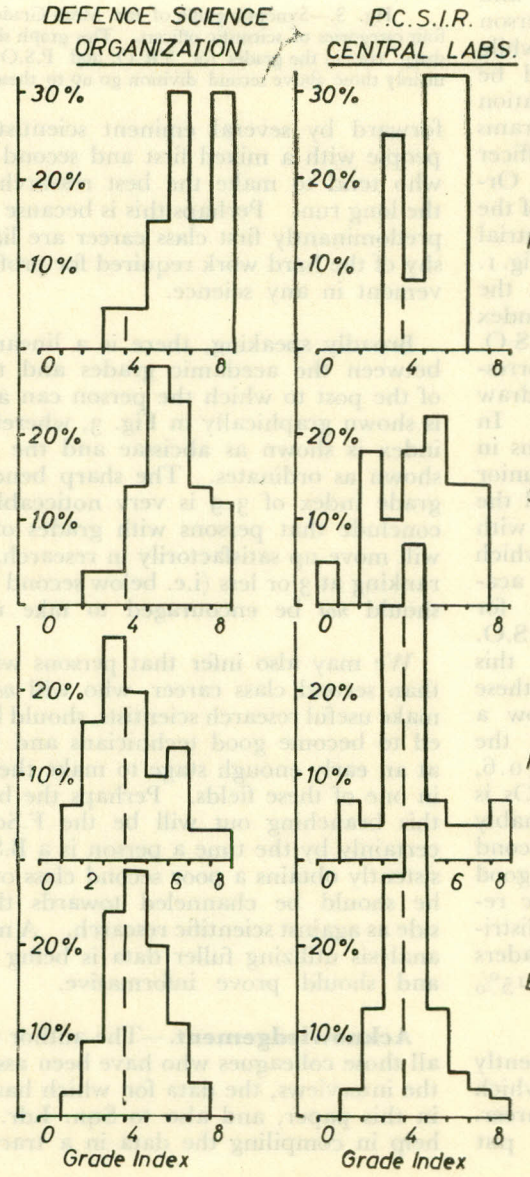
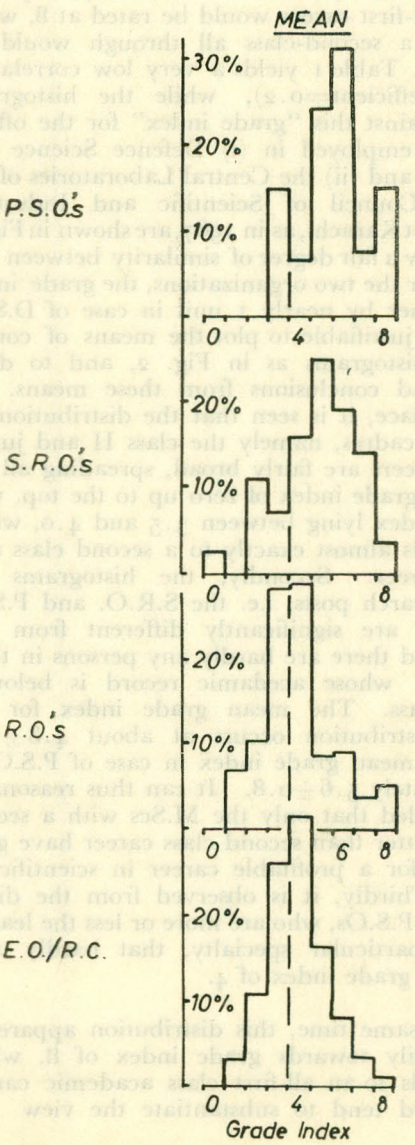


Fig. 1.—Histograms showing the frequency of occurrence of various academic levels, as indicated by the grade index, for four categories of scientific officers in (i) the Defence Science Organization, and (ii) the Central Laboratories of Pakistan Council of Scientific and Industrial Research.



Fig, 2.—Corresponding mean histograms for the data from the two organizations. The patterns for P.S.O. and S.R.O. are seen to be distinct from those for the two lower grades.

obtained by the candidates in their several High School and University examinations. This can be studied either by calculating correlation coefficients for the persons in Table 1, or better by constructing histograms of the persons selected/promoted to various categories of research in any one or two organizations. These correlations and histograms would be plotted against the mean academic grade of the candidate or some "grade index" corresponding to this, such as for example 0 for each third division, 1 for each second division and 2 for each first division. In this way, a person with an all-first career would be rated at 8, while one with a second-class all through would be rated at 4. Table 1 yields a very low correlation (mean coefficient=0.2), while the histograms plotted against this "grade index" for the officer categories employed in (i) Defence Science Organization and (ii) the Central Laboratories of the Pakistan Council of Scientific and Industrial Research at Karachi, as in 1967, are shown in Fig. 1. These show a fair degree of similarity between the patterns for the two organizations, the grade index being higher by nearly 1 unit in case of D.S.O. It is quite justifiable to plot the means of corresponding histograms as in Fig. 2, and to draw some broad conclusions from these means. In the first place, it is seen that the distributions in the lower cadres, namely the class II and junior class I officers are fairly broad, spreading all the way from grade index of zero up to the top, with a mean index lying between 3.5 and 4.0, which corresponds almost exactly to a second class academic career. Secondly, the histograms for senior research posts, i.e. the S.R.O. and P.S.O. categories, are significantly different from this pattern and there are hardly any persons in these categories whose acedamic record is below a second class. The mean grade index for the S.R.O. distribution occurs at about 4.8 ± 0.6, while the mean grade index in case of P.S.Os is approximately 5.6 ± 0.8. It can thus reasonably be concluded that only the M.Scs with a second class or better than second class career have good prospects for a profitable career in scientific research. Thirdly, it is observed from the distribution for P.S.Os, who are more or less the leaders in their particular specialty, that hardly 15% are below grade index of 4.

At the same time, this distribution apparently falls steadily towards grade index of 8, which corresponds to an all-first class academic career. This would tend to substantiate the view put forward by several eminent scientists that it is people with a mixed first and second class career who tend to make the best research workers in the long run. Perhaps this is because those with a predominantly first class career are liable to fight shy of the hard work required for proficient achievement in any science.

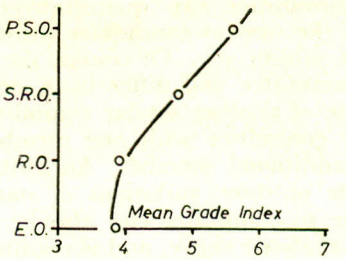


Fig. 3.—Synoptic graph of the Mean Grade Index for the four categories of scientific officers. This graph shows clearly the sharp rise in the grades for S.R.O. and P.S.O., showing that mainly those above second division go up to these posts.

Broadly speaking, there is a linear correlation between the acedamic grades and the seniority of the post to which the person can aspire. This is shown graphically in Fig. 3, wherein the grade index is shown as abcissae and the post held is shown as ordinates. The sharp bend just above grade index of 3.9 is very noticeable. We can conclude that persons with grades of 5 or more will move up satisfactorily in research, while those ranking at 3 or less (i.e. below second class career) should *not* be encouraged to take up research.

We may also infer that persons with a poorer than second class career, who will *not* in general make useful research scientists, should be encouraged to become good technicians and technologists at an early enough stage to make them proficient in one of these fields. Perhaps the best stage for this branching out will be the F.Sc. level, but certainly by the time a person is a B.Sc. and consistently obtains a poor second class or third class, he should be channeled towards the technical side as against scientific research. A more detailed analysis utilizing fuller data is being undertaken, and should prove informative.

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