

An Empirical Investigation of Job Analysis Reliability, Methods and Results

K. N. SHARMA AND P. N. KALRA

Indian Statistical Institute

Introduction

In order to select suitable workers for jobs, maintain fitness at work, develop a satisfactory training programme, eliminate unnecessary fatigue, reduce the rate of accidents, have a satisfactory job evaluation system, proper transfer and promotion of employees and full utilization of manpower in an industrial concern, objective information about the personnel is essential. The information should cover occupational activities and responsibilities, duties of workers and supervisory staff, working conditions and hazards that affect the efficiency of the workers and other supplementary information which may be required for job performance and job evaluation (10, 13). This information can be obtained in a comprehensive and objective manner by means of "job analysis."

Job analysis has been defined in different ways but the central idea in all the definitions is that job analysis is a scientific study of all the facts about a job revealing its content and modifying factors (13). For clear understanding it would be worthwhile to include two widely accepted definitions: Ralph C. David says, "A job analysis is an investigation and analysis of work assignment, and the conditions surrounding it, to determine its requirements from an organizational standpoint..... It is used by the personnel department to procure information regarding the job and the worker that will facilitate employment, promotion, transfer, and training" (9).

Job analysis has been defined by the Organization for European Economic Co-operation (10), "as a method of: (i) Breaking down facts about a job to determine its essential component features and the qualities required of the worker to perform it, and (ii) recording such facts in a convenient and usable way." It includes the contributions of both the employer, *i.e.*, tools, materials, pay and general working situations as well as the employee, *i.e.*, skill, intellectual capacity, previous experience and personal qualities (2).

It may be of interest to trace the development of the concept of job analysis. The early Time Study men were called "job analysts" by some industrial engineers. While referring to job study the Taylor group used the term "Time Study" and the Gilbreth group used "Motion Study." From 1909 to 1912 a job study included job classifying, job rating, hiring, transferring and promotion, *i.e.*, personnel functions. This trend was developed by E. O. Griffenhagen for the municipal service at the Commonwealth Edison Company, Chicago, and carried to similar

companies and government offices employing large clerical forces. In 1914 Harry A. Hopf classified clerical positions in banks and insurance offices. During World War I there was a rapid growth in the personnel movement and "job analysis" became one of its important activities. In 1920 the National Personnel Association defined job analysis as "a process which results in establishing the component elements of a job and ascertaining the human qualifications necessary for its successful performance." After 1922 every manufacturing company large enough to afford a personal staff was using job analysis as its main source of data for personnel work. Personnel department functions may be said to have grown up during 1922-29. During the period 1931-37 job analysis became fundamental and because it had also contributed to better classification, it served as the basis of systematic job evaluation. Since then it has been widely used in industrial concerns in America and Europe (9).

The job analysis method has become an essential part of industrial management and if followed properly, it can assist in increasing industrial productivity. Before we go into the discussion of the methods by which job analysis is done and the tools which are essential for this method, it will be appropriate to mention the job information needed. The basic job analysis formula consists of four steps *i.e.*, (i) What the worker does, (ii) How he does it, (iii) Why he does it, and (iv) What is involved in doing it (10). If this formula is used efficiently and carefully, many difficulties that are encountered in actual performance of a job, in establishing a job analysis programme can be solved. This formula emphasizes the need for the specification of the required job information. Information regarding job duties, performance requirements, working conditions and other relevant data is needed while preparing a job analysis programme. Every activity of a worker should be included in job duties and it should be kept in mind that the activity of the worker is specifically mentioned in the way the worker actually does it and not in the way it should or may be done. Performance requirements such as responsibility—supervisory as well as non-supervisory; job knowledge; mental application, *e.g.*, mental alertness, attention, concentration and planning; dexterity and accuracy and physical requirements should be clearly mentioned. Working conditions and hazards that affect the efficiency of the worker and the additional relevant data, *e.g.*, identification data, experience and training necessary for a particular job etc., should be gathered beforehand. (8, 9, 10)

The job analysis tools used to obtain this information are (10, 13): Job Specification, Employment Interview, Job Description, Job Variables, Job Families, Job Inventory and Occupational Classification System.

Industrial psychologists, industrial engineers and industrial executives have stated that job analysis is a method by which many important problems can be solved, leading to increased productivity, due to full utilization of manpower. This programme has been widely accepted and at present almost all the large indus-

trial concerns in foreign countries have employed trained job-analysts who are working quite successfully, but it is a matter of surprise that the literature does not reveal any scientific investigations establishing the reliability of the job analysis programme. The existing literature describes the theoretical approach and applicability of the programme, giving the background knowledge and the methods which are applied, and the specification of the fields in which the programme can successfully be carried out. This, however, is all theoretical and no statistical data are available to demonstrate the reliability of the programme.

Purpose of the study

This investigation had three objectives.

(A) To find out the reliability of the job analysis method under the following four headings :

- (i) Repeat Reliability, *i.e.*, reliability of the analysis done by the same individual on the same job at two different times.
- (ii) Inter-Analyst Reliability, *i.e.*, reliability of the analysis done on the same job by two different individuals.
- (iii) To find out differences, if any, in the reliability for different sets of characteristics, *i.e.*, physical, mental and personality.
- (iv) To see if reliability increases with practice in job analysis.

(B) To find out whether the time and money spent in carrying out the combined Analysis and Description Method are justified and if Analysis alone is not sufficient.

(C) To formulate a method for determining and studying the relative weight of physical, mental and personality requirements for different classes of jobs.

Methods

The following methods were employed for analysing the jobs :

- (1) *Analysis Method*: In this method the analyst rates the required characteristics on a rating scale, on the basis of his 'On-the-Spot' observation of the job.
- (2) *Description Method*: In this method the ratings are done on the basis of detailed description of the job given to him. He is not required to go and observe the job 'On-the-Spot.'
- (3) *Combined Description and Analysis Method*: This is a combination of the above two methods, where both the description and analysis are done by the same analyst on the basis of his 'On-the-Spot' study of the job. This method is most widely used.

A job analysis pro forma prepared in the Psychometric Unit of the Indian Statistical Institute was used. Physical, mental, and personality requirements were rated on a four point scale, as follows :

- A—The characteristic is required or true to a great extent.
- B—The characteristic is required or true to some extent.
- C—The characteristic is required or true to a little extent.
- D—The characteristic is neither required nor true.

The following characteristics are rated :

- (i) *Physical* : height, weight, muscular strength, eye-hand co-ordination, foot-eye-hand co-ordination, ability to move fingers rapidly and accurately, ability to move hands and arms, ability to move foot and leg, walking, jumping, running, crawling, climbing, standing, talking, throwing, pushing, pulling, accuracy of vision, accuracy of hearing, accuracy of taste, accuracy of smell, ability to discriminate colours, and accuracy of touch.
- (ii) *Mental* : ability to perceive form of objects, ability to perceive spatial relationship, ability to perceive speed of moving objects, ability to perceive mechanical relationship, ability to estimate size of objects, ability to estimate quality, ability to estimate quantity, ability to learn quickly, memory for details, memory for verbal directions, memory for written directions, ability to do logical reasoning, ability to make general discrimination, skill in oral expression, skill in written expression, accuracy in grammar, accurate spelling and vocabulary, skill in quick reading, accuracy in arithmetical computation, and ability to supervise others' work.
- (iii) *Personality* : persistence in repetitive work, carefulness, ability to work under hazards, ability to win co-operation and sympathy of others in work, concentration of mind, ability to behave gently with others, self-confidence, ability to understand the real causes of a failure, and ability to maintain good relationship with people outside the department.

The following seven jobs were analysed :—

Sl. No.	Job	Brief Description
1.	Turning	... Turning out various mechanical parts on a Lathe Machine driven by electricity.
2.	Monocasting	... A job in the Printing Press, in which letters are composed from molten lead metal.

- | | | |
|----|----------------------|---|
| 3. | Sorting | ... An operational job on I.B.M. and Hollerith machines involving the sorting of punched cards in serial or any other order. |
| 4. | Tabulating | ... Copying and tabulating data from punched cards using I.B.M. and Hollerith machines. |
| 5. | Calculating punch | ... Various types of arithmetic calculations are done on punched cards using I.B.M. and Hollerith machines. |
| 6. | Assistant (Clerical) | ... A typical clerical assistant in an office, doing correspondence, maintaining files, records, etc. |
| 7. | Computation | ... Hard and electric Computing Machines (Facit) are used for doing various types of calculations and applying formulae to data supplied. |

The data obtained for the above 7 jobs were analysed for purposes (a) and (c), *i.e.*, reliability and weightage, and data from three jobs, Nos. 1, 2, and 4 above were analysed for purpose (b), *i.e.*, effectiveness of the various methods. All jobs were analysed by two analysts working independently, and each analyst repeated his analysis after an interval of time, to ensure independence between the first and the second analysis. The jobs were analysed in the same sequence.

Repeat reliability was found by computing the product moment correlation between the first and the second ratings of each analyst separately for each of the 7 jobs, and then taking the mean of the correlations to obtain a single index of reliability. Fisher's Z transformation was used to average the correlations. Inter-analyst reliability was found by computing the product-moment correlation between the ratings of the two analysts for all the 7 jobs and the mean of the correlations was similarly found. The correlations were computed and averaged separately for physical requirements, mental requirements and personality requirements.

The effectiveness of various methods was studied by having three identical jobs analysed by the three different methods. Each method was applied by two analysts. The methods are noted below with their abbreviations.

- | | | |
|----|---|-------|
| 1. | Combined Analysis and Description Method .. | AD |
| 2. | Analysis Method | ... A |
| 3. | Description Method | ... D |

In this way each job was analysed by 6 individuals. Inter-correlations between the ratings done by three different methods were computed according to the following design, separately for each job and set of characteristics.

		AD & A		AD & D		D & A	
		Rater		Rater		Rater	
		I	II	I	II	I	II
Rater	I	r_1	r_2	r_1	r_2	r_1	r_2
	II	r_3	r_4	r_3	r_4	r_3	r_4

The mean of r_1 , r_2 , r_3 and r_4 was taken as an index of inter-correlation between two methods for one job. These indices were further averaged and an overall index of inter-correlation between two methods was obtained separately for physical, mental and personality characteristics. All averaging was done by the z transformation (6). These were compared and the differences were tested for statistical significance by the method given by Hotelling (14), the formula for which is explained below :

Let X = rating done by method A.

Y = rating done by method D.

Z = rating done by method AD

then significance of difference between r_{XZ} and r_{YZ} is calculated by

$$t = (r_{XZ} - r_{YZ}) \sqrt{\frac{(N-3)(1+r_{XY})}{2(1-r_{XY}^2 - r_{YZ}^2 - r_{XZ}^2 + 2r_{XY}r_{XZ}r_{YZ})}}$$

l having "student's" distribution with $N-3$ degrees of freedom.

For purposes of assigning weights, the 7 jobs were divided into three classes representing mechanical, clerical, and computational (using I.B.M. and Hollerith machines). Those characteristics which received ratings AA, AB, BA, BB, considering both first and repeat ratings, were regarded as important. The number of such important characteristics was counted for physical, mental, and personality requirements. The mean of the numbers of important characteristics as rated by two analysts for each class of jobs, was taken as the weight for that group. The relative weight was found by percentages, equating the total of the three sets of requirements for each group to 100.

Results

The values of r representing repeat reliability are given separately for each job and set of requirements in Table 1, each analyst being listed separately. The corresponding values of z are also given making apparent the process of finding the mean correlation at the bottom of the Table.

TABLE I
Repeat Reliability

Sl. No.	Characteristics		Physical N = 24		Mental N = 20		Personality N = 9	
	Jobs	Rater	r	Z	r	Z	r	Z
1.	Turning :	1	.86**	1.29	.84**	1.22	.62	.73
		2	.88**	1.38	.76**	1.00	.88**	1.38
2.	Casting :	1	.69**	.85	.52*	.58	.71*	.89
		2	.88**	1.38	.69**	.85	.76*	1.00
3.	Sorting :	1	.90**	1.47	.70**	.87	.94**	1.74
		2	.94**	1.74	.62**	.73	.92**	1.59
4.	Tabulation	1	.86**	1.29	.77**	1.02	.84**	1.22
		2	.81**	1.13	.88**	1.38	.94**	1.74
5.	Calculating punch	1	.82**	1.16	.86**	1.29	.96**	1.95
		2	.85**	1.26	.73**	.93	.90**	1.47
6.	Assistants (clerical)	1	.79**	1.07	.85**	1.26	.83**	1.19
		2	.84**	1.22	.95**	1.83	.95**	1.83
7.	Computa- tion.	1	.99**	2.65	.93**	1.66	.97**	2.09
		2	.86**	1.29	.85**	1.26	1.00**	5.00
Total				19.18		15.88		23.82
Mean Z				1.37		1.13		1.70
Mean r			.88**		.81**		.94**	

*p < .05

**p < .01

Table 2 gives the values of inter-analyst reliability separately for each job and set of characteristics and also the mean correlation for each set of characteristics separately.

TABLE 2
Inter-Rater Reliability

Job	Characteristics					
	Physical N = 24		Mental N = 20		Personality N = 9	
	r	Z	r	Z	r	Z
1. Turning ...	.74**	.95	.71*	.89	.63	.74
2. Monocasting ...	.66**	.79	.32	.33	.57	.65
3. Sorting ...	.53**	.59	.18	.18	.72*	.91
4. Tabulation ...	.49*	.54	.41	.44	.69*	.85
5. Calculating Punch ...	.53**	.59	.57**	.65	.68*	.83
6. Assistant (clerical) ...	.78**	1.05	.85**	1.26	.91**	1.53
7. Computation ...	.92**	1.59	.40	.42	.91**	1.53
Total ...		6.10		4.17		6.85
Mean Z ...		.87		.60		.98
Mean r ...	.70**		.54*		.75*	

**p < .01

*p < .05

In Table 3 the jobs are listed in the order in which they were analysed and the progress of reliability can be seen for the three sets of requirements.

TABLE 3
Showing the Improvement in Reliability of Job Analysis with Practice

Jobs Characteristics	Turn- ing (1)	Cast- ing (2)	Sort- ing (3)	Tabu- lation (4)	Calcu- lating Punch (5)	Assis- tant (6)	Com- puting (7)
Physical (N = 24)...	.87**	.81**	.92**	.84**	.89**	.81**	.96**
Mental (N = 20) ...	.80**	.62**	.66**	.83**	.80**	.91**	.90**
Personality (N = 9)	.78*	.74*	.93**	.90**	.94**	.91**	.99**

**p < .01

*p < .05

Table 4 (A, B and C) present respectively for physical, mental and personality requirements, the mean values of inter-correlations between the three different methods, giving the inter-correlations separately for each job.

TABLE 4

A. Mean Correlations and Z values for Physical Characteristics

N = 24

Jobs	Methods	A and AD		D and AD		A and D	
		Z	r	Z	r	Z	r
Turning9300	.73**	.80	.67**	.76	.64**
Monocasting9550	.74**	.6175	.55**	.8125	.67**
Tabulation	...	1.0325	.77**	.72	.62**	.87	.70**
Mean97	.75**	.71	.61**	.81	.67**

B. Mean Correlations and Z Values for Mental Characteristics

N = 20

Jobs	Methods	A and AD		D and AD		A and D	
		Z	r	Z	r	Z	r
Turning5375	.49*	.675	.59**	.2700	.26
Monocasting4925	.45*	.335	.33	.5125	.47*
Tabulation4425	.41	.505	.46*	.2250	.22
Mean49	.45*	.50	.46*	.34	.33

C. Mean Correlations and Z Values for Personality Characteristics

N = 9

Jobs	Methods	A and AD		D and AD		A and D	
		Z	r	Z	r	Z	r
Turning9025	.72*	.4325	.40	1.1350	.81**
Monocasting	...	1.0275	.77*	.98	.75*	2.1350	.97**
Tabulation37	.35	.785	.65	.7375	.63
Mean77	.65	.73	.62	1.34	.87**

*p < .01

**p < .05

In Table 5, the differences of inter-correlations between A and AD, D and AD are given separately for each job, along with their respective degrees of freedom and t values. Their level of significance is also indicated.

TABLE 5
Tests of Significance for differences between Inter-correlations for
Three different methods

Characteristics	df	difference in r between A and AD and D and AD	t	levels of significance
Physical ...	21	.14	1.22	20%
Mental ...	17	.01	.03	Not significant
Personality ...	6	.03	.17	Not significant

Weights and relative weights for physical, mental and personality characteristics for three different classes of jobs are given in Tables 6 and 7 respectively. The classification is as follows :

<i>Class</i>	<i>Jobs included</i>
Mechanical ...	... Turning and Monocasting
Clerical ...	... Assistant (clerical) and computation.
Computational (I.B.M. and Hollerith machines) ...	... Sorting, Tabulating and Calculating.

TABLE 6
Weights of Different Characteristics for the classes of jobs

Characteristics Group	Physical	Mental	Personality
Mechanical ...	4.5	5.25	3.5
Machine calculation ...	3.83	4.00	3.17
Clerical ...	2.75	6.	3.75

TABLE 7
Relative weights of Different Characteristics for 3 Classes of Jobs

Characteristics Group	Physical	Mental	Personality
Mechanical ...	33.96	39.62	26.42
Machine calculation ...	34.82	34.36	28.82
Clerical ...	22.	48.00	30.

Discussion

A perusal of the Tables on reliability reveals that job analysis by the combined analysis and description method, shows high repeat reliability and is, therefore, yielding consistent results. The tables also show that if at least two persons analyse the jobs independently, high reliability is not only obtained but objectivity is also achieved. This is more marked in the case of mental characteristics. It is seen that ratings done on physical and personality characteristics have higher reliability than those on the mental characteristics. Need for greater care in the rating of mental characteristics is thus indicated. The improvement in reliability observed with more practice points to the importance of employing only trained and experienced men for job analysis.

On the basis of our findings we recommend the job analysis method as a safe and reliable method for use in practical situations. Although such detailed analysis as has been done here may not be warranted for reasons of time and economy, it is yet desirable that the ratings done by one analyst should be checked, at least in a sample of cases, by another analyst making the same ratings independently of the first. This will ensure both reliability and objectivity of the data.

Comparing the three different methods of Job Analysis, it is seen from Table 5 that the differences of the inter-correlations between A and AD and D and AD are not statistically significant when tested by Hotelling's formula. From this we may conclude that analysis and description are contributing almost equally to the combined method, and with such results dependence upon analysis alone or description alone may not be advisable. In the case of mental characteristics, the inter-correlations between A and D are quite low, while their inter-correlations with AD are almost equal, a fact which adds to the importance of using both sources of information in arriving at the final analysis.

Some interesting facts emerge from the study of Tables 6 and 7, which are contrary to general expectation. For example, mechanical jobs do not get the highest weights for physical requirements, and mental requirements are found to be more important. In the case of computational jobs, using I.B.M. and Hollerith machines, physical requirements are found to be as important as the mental ones. Personality requirements are found to be almost equally important for all jobs. This brings home the importance of scientifically studying the jobs rather than depending upon common sense notions. The method developed for finding the weights may be usefully employed in other studies.

Summary

Job analysis is the basic tool of Industrial Psychology and scientific Factory and Business Management. It is widely used for a number of purposes, such as selection and training of personnel, job classification, and job evaluation. The basis of this concept is the job analysis formula which involves four steps, *i.e.*, (i) 'What the worker does', (ii) 'How he does it', (iii) 'Why he does it', and (iv) 'What

is involved in doing it'. Job analysis can be done by three different methods, namely 'Analysis Method', 'Description Method' and 'Combined Analysis and Description Method'. The third method is widely used, although it involves more time and money.

An investigation which was carried out in order to test the reliability of the job analysis and all the three methods has been reported. Reliability of job analysis has been tested under four headings, namely, Repeat Reliability, Inter-Analysis Reliability, differences in reliability for different sets of characteristics and progress on reliability with practice. Repeat reliability and Inter-Analyst reliability have been found to be high. Ratings on physical characteristics and personality characteristics are seen to be more reliable than those on the mental ones. An increase in reliability has been observed with practice in job analysis.

It has been shown that analysis and description contribute almost equally to the combined analysis and description, indicating that the time and money spent in carrying out the Combined Method are justified.

A method has been formulated for determining the relative weights of physical, mental, and personality characteristics for various classes of jobs.

Acknowledgments

We gratefully thank Dr. (Mrs.) Rhea S. Das for her constant guidance during this project. Our thanks are also due to Messrs. T. K. Sen, A. P. Purohit, K. P. Bhattacharya, J. K. Verma and P. P. Garg who co-operated wholeheartedly in this project. We acknowledge the co-operation of the authorities of the Indian Statistical Institute, Calcutta, where the entire work was done.

REFERENCES

1. BELLOWS, R. M.: *Psychology of personnel in business and industry*. London, Staples Press, 1956.
2. BURT, H. E.: *Principles of employment psychology*. New York, Harper, 1942.
3. FINE, S. A.: Functional job analysis. *J. Person. Adm. Industr. Relat.* 1955, 2, 1-16.
4. FORD, E.: Job analysis as a tool of productivity. *Time and Motion Study*, 1957, 6 (5) 48-56.
5. FRYER, D. H. AND EDWIN, R. H.: *Handbook of applied psychology*. Vol. I, New York, Rinehart, 1950.
6. GARRETT, H. E.: *Statistics in psychology and education*. New York, Longmans Green, 1957.

7. GHISELLI, E. E. AND BROWN, C. W. : *Personnel and industrial psychology*. New York, McGraw-Hill, 1948. .
 8. LOUDEN, J. K. AND NEWTON, T. G. : *Job analysis*. New York, Funk and Wagnalls, 1948.
 9. LYTLE, C. W. : *Job evaluation methods*. New York, Ronald Press, 1954.
 10. ORGANISATION FOR EUROPEAN ECONOMIC CO-OPERATION : *Job analysis : a tool of productivity*. (Project No. 231). Paris European Productivity Agency of O.E.E.C., 1956.
 11. RYAN, T. A. AND SMITH, F. C. : *Principles of industrial psychology*. New York, Ronald Press, 1954.
 12. THORNDIKE, R. L. : *Personnel selection*. New York, John Wiley, 1949.
 13. VITELES, M. S. : *Industrial psychology*. New York, W. W. Norton, 1932.
 14. WALKER, H. M. AND LEV, J. : *Statistical Inference*. London, Constable, 1953.
 15. WILLIAMS, J. A. C. : Pre-interview selection and job analysis. *Time and Motion Study*, 1957, 6 (9), 36-42.
-