CHAPTER VII

FACTOR ANALYSIS OF THE TEST DATA

7.1 INTRODUCTION

Factor analysis has highlighted very serious anomaly in psychological tests. This is a fact that any test measures more than one common factor to a substantial degree yields scores that are psychologically ambiguous and very difficult to interpret. What is worse is that almost all the tests have a complexity greater than one, that is, they measure more than one common factor (Guilford, 1954). He further adds that the fundamental variables or dimensions of human ability and human personality, in general, are still well within the unexplored territory reserved for psychologists. Thus, to search for the unitary trait of personality and to reveal the shortcomings of commonly used single score tests, the statistical procedure used is known as factor analysis. The present chapter focuses on the factor analysis of the IETAT data.

7.2 METHODS OF FACTOR ANALYSIS

There are several methods of factor analysis and all of them start with the same kind of data – a correlation matrix. The procedures for extracting factors that are most commonly used are given below:

(i) Principal component method of Hotelling

(ii) Principal axes method of Kelley

(iii) Summation method of Burt

(iv) Centroid method of Thurstone

The first two methods have much in common and the last two are also very common to each other. In addition to the process of extracting factors, Thurstone's centroid method provides rotation methods to arrive at meaningful factors.

Factor analysis is being used since long by researchers of western countries but rare in India and very less researchers have applied this technique to their researchers. During the pursuance of this research, the investigator had no knowledge about the factor analysis technique at all. Following the past researches related to psychological tests, the investigator decided to apply Thurston's centroid method to the present IETAT data and acquired a working knowledge of the technique. Even then it should be noted that the investigator's knowledge of the technique is mainly pertaining to the use of centroid method only.

7.3 THURSTON'S CENTROID METHOD OF FACTORING

L. L. Thurstone developed this method based on the matrix algebra. The term centroid is closely allied with its mechanical concept. In mechanics, the centroid is a point in a mass where the center of gravity is located. In factor analysis, the centroid of the endpoints of the test factors might be considered the location of the center of gravity of equal weights at the points. A centroid is then a center of gravity like mean in statistics.

The purpose of factoring a correlation is to account for the inter-correlations with fewer factors than there are tests. Thus factoring should be done so as to minimize the residuals after each factor has been determined. The main centroid axis is regarded as an approximation to the major principal axis of the factor configuration. The main centroid axis is so placed that it has zero projections on all the remaining coordinate axes. This fact leads to the theorem that "the sum of the coefficients in the correlation matrix is equal to the square of the sum of the first centroid factor loadings" permitting factoring through simple summational procedure after appropriate reflections (Thurstone, 1947). By reflecting, it is meant that each test factor retains its same length but it extends in the opposite direction. The general policy is to reflect one test vector at a time and note the results, then reflect the second one and so on.

The extraction of each factor loading reduces the residuals in the correlation matrix. The factoring process is ordinarily stopped when the standard deviation of the residuals is less than the standard error of a zero correlation.

According to Frutcher (1954), it is desirable to give a complete account of a factorial study so that the results can be verified and the computations can be checked.

The components to be factor analyzed are the information regarding the scoring formulas, reliabilities, conditions of administration, distribution, means, SDs and measures of Skewness and kurtosis is supplied at appropriate places in previous chapters.

This method was applied to the present IETAT data for the extraction of factors. The sample of 552 used for standardization of the test was used for the factor analysis also.

7.3.1 The Correlation Matrix

The inter-correlations of five sections were found out. In each case, the product-moment coefficient of correlation (r) was computed. The correlation matrix of the five variables prepared has been given in the following table 7.1.

Table 7.1

Inter-Correlations of Five Sections, Illustrating the Condition of Simple Proportionality in a Correlation Matrix (N=552)

Sr. No.	Section	I	II	III	IV	V
1	Awareness about Inclusive Education	--	- 0.1422	- 0.0876	0.4060	- 0.5846
2	Perceived Ability to Identify Disabilities	- 0.1422	--	0.2825	- 0.2394	0.2265
3	Perceived Ability to Teach SwSN	- 0.0876	0.2825	--	- 0.5989	0.0424
4	Perceived Ability to Adapt Inclusive Teaching Methods	0.4060	- 0.2394	- 0.5989	--	- 0.2917
5	Skills to Manage Inclusive Classroom	- 0.5846	0.2265	0.0424	- 0.2917	--
		- 0.4084	**0.1274**	**- 0.3616**	**- 0.7240**	**- 0.6074**

7.4 THE ANALYSIS

As stated earlier, Thurston’s Centroid method applied to present test data for extraction of factors. The detailed step by step process of factoring suggested by Guilford was followed by the investigator. The details of the steps followed are not described here but the matrices obtained from the steps are given in the following.

Stage I: Extraction of First Centroid Factor

One of the simple methods of estimating the commonality of a test is to conjecture it to be equal to the highest correlation of that test with any other variable in the correlation table. The highest correlation in each column has been inserted in the principal diagonal cell of following table 7.2, in parentheses.

Table 7.2

Correlation Matrix

Section	I	II	III	IV	V
I	(0.4060)	-0.1422	-0.0876	0.4060	-0.5846
II	-0.1422	(0.2825)	0.2825	-0.2394	0.2265
III	-0.0876	0.2825	(0.2825)	-0.5989	0.0424
IV	0.4060	-0.2394	-0.5989	(0.4060)	-0.2917
V	-0.5846	0.2265	0.0424	-0.2917	(0.2265)

Reflecting the variables II, III and V for maximizing the positive sum of the table or residual correlations, the residual coefficient given in the following table 7.3 was obtained.

Table 7.3

Extraction of the First Centroid Factor from the Correlation Matrix

Section	I	II*	III*	IV	V*	$\sum$ r
I	(0.4060)	0.1422	0.0876	0.4060	0.5846	**-0.0364**
II*	0.1422	(0.2825)	0.2825	0.2394	0.2265	**0.4099**
III*	0.0876	0.2825	(0.2825)	0.5989	0.0424	**-0.0791**
IV	0.4060	0.2394	0.5989	(0.4060)	0.2917	**-0.3180**
V*	0.5846	0.2265	0.0424	0.2917	(0.2265)	**-0.3809**
E	**1.6264**	**1.1731**	**1.2939**	**1.942**	**1.3717**	**7.4071=T**
mE	**0.5976**	**0.4310**	**0.4754**	**0.7136**	**0.5040**	**2.7216=$\sqrt{T}$**
$\frac{1}{\sqrt{T}}$ = 0.3674 = m **mT = -2.7216**						

The first-factor matrix was, then, prepared and given in the following table 7.4.

Table 7.4

First Factor Matrix

First Factor Loading		**0.5976**	**0.4310**	**0.4754**	**0.7136**	**0.5040**
		I	**II**	**III**	**IV**	**V**
0.5976	**I**	0.3571	0.2576	0.2840	0.4264	0.3012
0.4310	**II**	0.2576	0.1858	0.2049	0.3076	0.2175
0.4754	**III**	0.2840	0.2049	0.2260	0.3392	0.2396
0.7136	**IV**	0.4264	0.3076	0.3392	0.5092	0.3597
0.5040	**V**	0.3012	0.2175	0.2396	0.3597	0.2540

Stage II: Computation of the First Factor Residuals

After obtaining the first-factor matrix, the first residual matrix was prepared which is given in the following table 7.5.

Table 7.5

First Residual Correlation Matrix

Section	**I**	**II**	**III**	**IV**	**V**	$\sum$ **r**
I	(0.0489)	-0.1154	-0.1964	-0.0204	0.2834	0.0001
II	-0.1154	(0.0969)	0.0776	-0.0682	0.0090	-0.0001
III	-0.1964	0.0776	(0.0565)	0.2597	-0.1972	0.0002
IV	-0.0204	-0.0682	0.2597	(-0.1032)	-0.0680	-0.0001
V	0.2834	0.0090	-0.1972	-0.0680	(-0.0275)	-0.0003
$\sum$ **r**	0.0001	-0.0001	0.0002	-0.0001	-0.0003	-0.0002

After obtaining first residual correlation matrix, it is necessary to decide whether to proceed further for extracting the second factor. Thus, to find out the maximum number of factors that uniquely determines m variables, the following formula, given by Fruchter (1954), has been applied.

$$r = \frac{2n + 1 - \sqrt{8n + 1}}{2}$$

where, r = number of factors

n = number of variables = 5

$$r = \frac{2 \times 5 + 1 - \sqrt{8 \times 5 + 1}}{2}$$

$$r = \frac{10 + 1 - \sqrt{40 + 1}}{2}$$

$$r = \frac{11 - \sqrt{41}}{2}$$

$$r = \frac{11 - 6.4}{2}$$

$r = 2.3$ i.e. 2 [Two]

Stage III: Extraction of the Second Centroid Factor

The use of formula given by Fruchter (1954) suggests the possibility of the presence of a second centroid factor. Thus the extraction of second centroid factor has been done as below.

Variables II, III and IV were reflected so as to maximize the positive sum of the table of first residual correlations.

Table 7.6

Extraction of the Second Centroid Factor from the First Residual Correlation Matrix

Section	I	II*	III*	IV*	V	$\sum r$
I	(0.2834)	0.1154	0.1964	0.0204	0.2834	**0.8990**
II*	0.1154	(0.1154)	0.0776	0.0682	0.0090	**0.3856**
III*	0.1964	0.0776	(0.2597)	0.2597	0.1972	**0.9906**
IV*	0.0204	0.0682	0.2597	(0.2597)	0.0680	**0.6760**
V	0.2834	0.0090	0.1972	0.0680	(0.2834)	**0.8410**
E	**0.8990**	**0.3856**	**0.9906**	**0.6760**	**0.8410**	**3.7922=T**
mE	**0.4616**	**0.1980**	**0.5087**	**0.3471**	**0.4319**	**1.9473=$\sqrt{T}$**
$\frac{1}{\sqrt{T}}$ **= 0.5135 = m** **mT = -1.9473**						

7.5 CRITERIA FOR SIGNIFICANT FACTORS

There are no exact criteria for testing the significance of the factor obtained. Vernon (1953) has listed as many as twenty-five criteria for testing the significance of the factor. This criterion takes into account N (size of the sample) and is dependent on the loadings of only two variables that is sufficient to establish a factor rather than on the entire matrix.

The rule is:

I. The product of the two highest factor loadings is found out.
   Here it is, $0.5087 \times 0.4616 = 0.235$

II. The standard error of a correlation coefficient of zero, for the type of correlation and size of the sample being used, is found out. It is $\frac{1}{\sqrt{N}}$ for the Pearson product-moment correlation (r).
   $\frac{1}{\sqrt{N}} = \frac{1}{\sqrt{552}} = \frac{1}{23.49} = 0.043$
   Twice of it, is = 0.086

III. If the product (0.235) found in step I does not exceed twice the standard error (0.086) found in step II, the factor is probably not significant.

Here, the product of two highest factor loadings (0.235) is greater than twice the standard error (0.086), and hence the factor concerned is present. Thus, based on the formula given by Frutcher, it is found that there are only two factors that could be identified which are:

(i) Knowledge about inclusive education, and

(ii) Attitude towards teaching CwSN.

The other components included in the list in the beginning viz. (ii) perceived ability to identify disabilities, (iv) perceived ability to adapt inclusive teaching methods and (v) skills to manage inclusive classroom, could be well included under the factor knowledge about inclusive education and attitude towards teaching CwSN. Basically, the factor 'knowledge about inclusive education' factor includes perceived ability to identify disabilities and the factor 'attitude towards teaching CwSN' includes variables perceived ability to adapt inclusive teaching methods and skill to manage inclusive classroom. Hence, there is enough justification to conclude that there are only two factors that could be identified.

The factor analysis showed presence of two factors viz. knowledge about inclusive education and attitude towards teaching CwSN. The factors thus extracted are common factors which have appreciable loadings on all other sections. The possibility regarding the interpretation of these two factors is that knowledge about inclusive education and attitude towards teaching CwSN are most important factors for measuring inclusive education teaching aptitude.