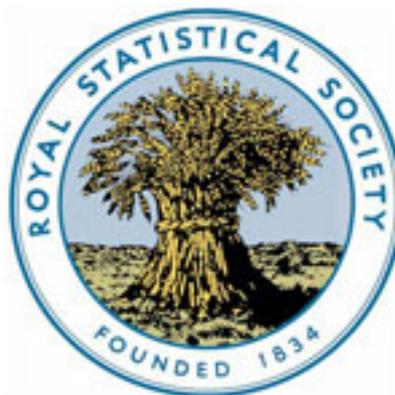


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## USES AND ABUSES OF FACTOR ANALYSIS

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Factor analysis, if used cautiously and with a full understanding of its underlying logic, can illuminate many fields of research. It is a statistical method, based on correlation analysis, for combining a number of measured variables into a smaller number of groups of variables: the groups are the factors. They are in no way absolute and the basis of their choice is partly subjective: they constitute a hypothesis that requires to be tested. Examples are given to show the fruitfulness of factor analysis.

PROFESSOR T. L. Kelley, in his *Fundamentals of Statistics*,<sup>6</sup> has pointed out that 'there are two occasions for resort to statistical procedures, the one dominated by a desire to prove a hypothesis, and the other by a desire to invent one. This has led to distinct schools of statisticians, both lying within the general field of scientific endeavour.' Factor analysis may be used for either of these purposes; it may be useful in suggesting hypotheses, and it may be useful in testing hypotheses.

If factor analysis is not differentiated from other statistical methods by its purpose, we must look for some other distinguishing mark. This has been provided by Professor M. G. Kendall's<sup>7</sup> division of methods of multivariate analysis into *analysis of dependence* (analysis of variance and covariance, regression and confluence analysis, discriminant analysis), and *analysis of interdependence* (correlation analysis, association and contingency analysis, component analysis). 'In the latter we are interested in how a group of variates are related among themselves, no one being marked out by the conditions of the problem as of greater prior importance than the others, whereas in the analysis of dependence we are interested in how a certain specified group (the dependent variates) depend on the others.' Factor analysis plays its part in the analysis of interdependence, and is indeed a logical and historical outgrowth of the work of Galton and Karl Pearson on correlation analysis. (It is not always realised that we owe the original formulation of factor analysis to Pearson and not, as is often believed, to Spearman.)

Statistical procedures are created to solve certain scientific problems; the nature of these problems must be clearly understood if we are to avoid misapplication of such procedures. Most orthodox statistical methods give an answer to the question of the level of confidence at which a given set of differences disproves the null hypothesis; this type of question arises naturally in fields where contrasted groups and

treatments can be clearly and easily identified. Such methods are widely used in psychology when questions are raised involving sex or class differences, the effects of certain types of therapy or education, or the prediction of success or failure on clearly denoted criteria. Unfortunately, not all questions which may be legitimately raised can be answered by means of these orthodox procedures, and indeed some of the most fundamental questions in psychology precede in point of time the possibility of applying the procedures. In order to apply the *t*, *F*, or *chi squared* tests or any of their equivalents we must have identified the groups (whether of people or of test scores) which are to be compared or contrasted. When the knowledge implied in the setting up of such groups is not available, we face problems which non-factorial methods are not designed to handle, and statisticians whose hostility to factor analysis blinds them to the nature of the problem which this technique sets out to solve do a disservice to science by pretending that orthodox procedures can give answers to questions they were not designed to deal with.

Fundamentally, it may be said that factor analysis attempts to reduce the multiplicity of observed uniformities of nature to a much smaller number of hypothetical causes or factors. As Professor Holzinger and Mr. Harman<sup>5</sup> put it: 'Factor analysis is a branch of statistical theory concerned with the resolution of a set of descriptive variables in terms of a small number of categories or factors. This resolution is accomplished by the analysis of the intercorrelations of the variables. A satisfactory solution will yield factors which convey all the essential information of the original set of variables. The chief aim is thus to obtain scientific parsimony or economy of description.'

These factors are of course abstract and may justly be called 'statistical artefacts'; they are artefacts in the same way that any scientific concept (electron, aether, energy) is an artefact. Such factors may or may not have a physiological basis; the demonstration, for instance, that the factor of 'neuroticism' or 'emotional instability' is very largely inherited, and inherited as a whole, links this product of factor analysis with important facts and theories in other sciences, and thus establishes it more securely.<sup>3</sup> But in order to prove the usefulness of a factor such a demonstration is not necessary and may be impossible; we are unlikely to discover physiological factors that relate to patterns of interests or attitudes. Nevertheless such patterns can be shown to exist, and we must find some method of 'parsimonious description' which will allow us to handle these data scientifically.

In a sense, what factor analysis may be said to attempt is the dimensional analysis of its particular field of study; it seeks to isolate, identify, and measure objectively the main dimensions along which the units of study may be located. It is often objected that this procedure implies a certain subjectivity of choice; the results achieved by one analyst may differ from those achieved by another analysing the same table of intercorrelations.

In actual fact results reported by competent workers are usually remarkably congruent; thus, in the intellectual field, very much the same factors have been isolated by Professor Thurstone,<sup>8</sup> Professor Holzinger,<sup>4</sup> and Sir Cyril Burt,<sup>1</sup> using quite different methods of analysis. In any case a certain amount of subjectivity is a feature of all dimensional analysis and is not in any way exclusively connected with factor analysis. We may quote in support the physicist Dr. Bridgman, who maintains that 'there is nothing absolute about dimensions . . . they may be anything consistent with a set of definitions which agree with the experimental facts.' If the choice of dimensions is up to a point arbitrary in physics, it seems unreasonable to expect factor analysis or any other statistical procedure to give us psychological dimensions which are not equally arbitrary. All possible systems of dimensions to describe a given set of facts must be convertible into each other, as they must all agree with the experimental facts; if two systems of dimensions disagree an empirical test becomes possible to decide which of the two leads to deductions verifiable by experiment. A clear example of such experimental clarification is presented by Thurstone's disproof of Spearman's contention regarding the sufficiency of one single factor to account for the intercorrelations of cognitive tests. This example may serve as proof—if such be needed—that factor analysis can be used in the two ways suggested at the beginning of this paper. Spearman's factorial studies suggested to him the 'single factor theory' (factor analysis suggesting a hypothesis), and Thurstone showed conclusively that this hypothesis was not tenable (factor analysis disproving a hypothesis). This disproof led to new hypotheses (factor analysis suggesting a hypothesis) which to date have in the main survived experimental tests (factor analysis supporting a hypothesis).

Two examples may show the way in which the field of research may be clarified by means of factor analysis. The first example will be taken from the field of physiology. Dr. Wenger<sup>9</sup> put forward the hypothesis that in some people the sympathetic branch of the autonomic nervous system was dominant, in others the parasympathetic branch, and that in the majority a balance existed between these two. Hypotheses similar to these have been held by many physiologists before him. By taking a number of measures of physiological reactions known to be determined, some by sympathetic and others by parasympathetic innervation, and by correlating these for groups of children, adolescents, and adults, he showed that the factor loadings which emerged from the analysis of the correlations agreed precisely on the tests specified by his hypothesis.

The other example is taken from my own work<sup>2</sup> in the field of social attitudes. For a long time two apparently contradictory hypotheses have been held by many sociologists and social psychologists regarding the structure of social attitudes. On the one hand, Communists and Fascists were considered to lie to the left and right respectively on a continuum towards the centre of which lie the Socialists, Liberals, and

Conservatives in that order. This would put Communists and Fascists at opposite poles. On the other hand, it is often held that Communists and Fascists are very similar in many ways and that there may be little to choose between them. A factor analysis of the correlations between a number of social attitudes revealed two main factors; one of radicalism-conservatism; the other tentatively labelled 'tough-mindedness *versus* tender-mindedness.' It was shown, by giving factor scores to members of the Fascist, Communist, Socialist, Liberal, and Conservative parties, that these parties could not be represented in terms of a single continuum (running shall we say from left to right ?), but that while the Communists and Fascists were respectively very radical and very conservative, they were also extremely tough-minded; Socialists and Conservatives were respectively radical and conservative in their outlook and neither very tough- nor very tender-minded. Liberals were neutral with respect to the radical-conservative dichotomy but tended to be remarkably tender-minded. Thus the factor analysis reconciles the two original hypotheses (Communists and Fascists are at opposite poles with respect to the radicalism factor but are very similar with respect to the tough-mindedness factor) and gives a much better description of the field of social attitudes organisation than was previously available.

These, then, are the uses of factor analysis; what are the abuses to which it has given rise ? In the main these would seem to follow from a failure to make the distinction suggested between the two main functions of factor analysis. Many writers conduct a factorial study the results of which suggest a hypothesis and then proceed as if the hypothesis was thereby proved. This, of course, is completely inadmissible, and much of the criticism which factor analysis has provoked is due to this elementary error. It would not seem reasonable, however, to condemn a scientific method because some of its junior practitioners have misunderstood the logic underlying it. Another abuse which has given rise to criticism is the occasional tendency of some writers to treat the results of factorial studies as being in some mysterious sense absolute and fundamental; this lack of philosophical sophistication fortunately does not characterise any of the well-known factor analysts in their more carefully considered pronouncements, and while quotations can be torn out of their context to give a contrary appearance there can be no doubt that the relative nature of factorial constructs is appreciated by all of them. A third abuse is due to the absence of suitable and usable criteria of significance in factor analysis; in their absence data are often over-interpreted, and chance fluctuations are made the basis of far-reaching conclusions. This is a very real fault, and every effort should be made to find methods for the estimation of errors; it is here that the help of statisticians would be most appreciated. Duplication of experiments provides a reasonable safeguard against fallacies attributable to this difficulty, but again many analysts fail to guard against criticisms on this score.

In summary, it may be said that factor analysis is a complex and difficult method which should be used with great caution, and with a full knowledge of its underlying logic; those who use it as a sausage machine which will grind out absolute truth regardless of the data which are fed into it or of the underlying imperfection of their research design, fully merit the criticisms often levelled against factor analysis as a method. But these criticisms do not apply to those who appreciate fully the many pitfalls which beset any statistical evaluation of complex data, and who have chosen factor analysis after careful consideration as the only method at present available to solve certain urgent problems fundamental to their science.

## REFERENCES

- <sup>1</sup> BURT, Sir C. (1940). *The Factors of the Mind*. University of London Press, London.
- <sup>2</sup> EYSENCK, H. J. (1951). 'Primary Social Attitudes as related to Social Class and Political Party,' *Brit. J. Sociol.*, **2**, 198-209.
- <sup>3</sup> EYSENCK, H. J., and PRELL, D. B. (1951). 'The Inheritance of Neuroticism: an Experimental Study,' *J. Ment. Sci.*, **97**, 441-65.
- <sup>4</sup> HOLZINGER, K. J. (1934-6). *Preliminary Reports on the Spearman-Holzinger Unitary Trait Study*, Nos. 1-9. Chicago University Press, Chicago.
- <sup>5</sup> HOLZINGER, K. J., and HARMAN, H. H. (1941). *Factor Analysis: a Synthesis of Factorial Methods*. Chicago University Press, Chicago.
- <sup>6</sup> KELLEY, T. L. (1947). *Fundamentals of Statistics*. Harvard University Press, Cambridge.
- <sup>7</sup> KENDALL, M. G. (1950). 'Factor Analysis,' *J. R. Statist. Soc.*, **B**, **12**, 60-73.
- <sup>8</sup> THURSTONE, L. L. (1938). *Primary Mental Abilities*. Chicago University Press, Chicago.
- <sup>9</sup> WENGER, M. A. (1948). *States of Autonomic Balance in Army Air Forces Personnel*. University of California Press, Berkeley and Los Angeles.