A Comment on the Use of Factor Analysis

In a number of articles published in this Journal authors have used a variety of multivariate statistical techniques for data analysis. In general, the use of these procedures has been appropriate; that is, a major multivariate model assumption has not been violated.

However, the article by Rogers, Weinstein, and Figone, entitled "The Interest Check List: An Empirical Assessment," published in November-December 1978 (1), requires a number of statistical clarifications with respect to the authors' use of factor analysis. The issues of concern are the ratio of number of subjects to number of variables, the omission of communalities and eigenvalues from the factor analysis presentation, and the overall conclusions based upon their data analysis.

Regarding the ratio of subjects to variables, the authors analyzed a modified version of the Neuropsychiatric Interest Check List (NPI) with 80 variables involving 143 subjects in their sample, yielding a subject-to-variable ratio of 1.788-to-1. The size of this ratio is quite small relative to the standard of 5 subjects to each variable suggested by Gorsuch (2) and Nunnally (3). When a small subject sample is selected relative to the number of variables, questions relating to sampling error become important. The investigators may be capitalizing on chance in the outcome of their analysis. That is, they may obtain more "significant" factors than their a priori hypothesis had predicted. It is difficult to interpret the results from studies using a subject-to-variable ratio of 1.788-to-1 with a high degree of statistical confidence.

Another concern involves the presentation of the factor analysis data in Table 1 of the article. Five a priori categories of variables are displayed: Activities of Daily Living, Manual Skills, Cultural/Educational, Physical Sports, and Social Recreation with each item's factor loadings. However, communalities and eigenvalues are not presented. The communalities ($h^2$) are the sum of squared loadings in any given row of the factor-loading matrix, and represent the proportion of variance in an item that is accounted for by the $k$ factors. In this case, a communality could be computed for each of the 80 variables and would represent the proportion of variance explained in each item by the 5 factors. An eigenvalue is the sum of squared loadings in each column of the factor-loading matrix, and represents the amount of total variance that can be accounted for by a given factor. In the article, 5 eigenvalues could be computed, one for each of the factors in Table 1 of that article. In a principal components analysis, if any given eigenvalue is divided by the total number of items, in this case 80, the result would represent the proportion of the total variance accounted for by that factor.

I calculated the communalities for each of the 80 items and 5 eigenvalues, one for each of the factors. These were computed from the values in the factor-loading matrix presented in Table 1. The proportion of total variance accounted for by the 5 factors is 38.52 percent; obviously, the proportion of variance not accounted for is equal to 1 minus 38.52 percent, or 61.48 percent. Therefore, it is quite unrealistic to accept the conclusions stated by Rogers et al. that the "factor structure identified for adolescent interests in this study offers several suggestions for instrument usage and development." (p 630) The results obtained from the factor analysis and the subsequent conclusions drawn about them, predicated on data obtained from the sample of 143 individuals, are questionable. Even with the addition of the communalities and eigenvalues as statistics to aid in the interpretation, one cannot make meaningful statements in regard to the NPI data.

Future investigators contemplating the use of factor analysis or any multivariate technique in their research should consider achieving this five subject-to-one variable ratio. In addition, communalities and eigenvalues should be reported in the presentation of factor-analyzed data. While these considerations are in no way "hard and fast rules," they do...
represent characteristics that, when included, aid the reader in formulating an opinion of the research.


REFERENCES

Reply to Mr. Rock

Mr. Rock takes issue with the quality of the data presentation and the adequacy of the data. Concerning the first criticism, the presentation of communalities and eigenvalues is a matter of journalistic style. This may be illustrated by a perusal of recent issues of periodicals in education (Mr. Rock’s field). Neither eigenvalues nor communalities are provided in articles by Arkin and Maruyama (1) and Marsh, Overall, and Kesler (2) in the Journal of Educational Psychology published by the American Psychological Association. Haladyna and Thomas (3) give eigenvalues but not communalities in their report in the Journal of Educational Measurement published by the National Council on Measurement in Education. In the Journal of Educational Research, Graver and Richard (4) provide communalities but not eigenvalues. Reporting in Educational and Psychological Measurement, Veldman and Sheffield (5), and Crowther and Preece (6) give neither communalities nor eigenvalues; Middleton and Mason (7) give communalities only; and Motowidlo (8), eigenvalues only. As Mr. Rock has demonstrated, both communalities and eigenvalues may be calculated from the data provided in the article.

Concerning the adequacy of the data and, hence, of the conclusions, the results show that there is little correspondence between the data collected on the adolescents and the five categories defined by Matsutsuyu. The possible reasons for this are twofold: 1. that the sample size is too small; 2. that the five-category model is wrong. The results are suggestive, not definitive. They were presented as such, as is indicated by guarded statements such as: “Summarizing interests according to these categories would appear to be conceptually and empirically meaningful”; “Until such time as a revision is available it would appear best to view each of these items as separate dimensions”; and “The pattern of high item loadings for the Activities of Daily Living and Manual Skills categories suggests a differentiation based on traditional sex roles.” The five-to-one subjects-to-variable ratio quoted by Rock is a desirable standard. However, in research involving human subjects the ideal is not always achievable. When the five-to-one standard was applied to the above selection of articles, four articles (1, 3, 4, 5) met the standard and three (6, 7, 8) did not. It was achieved for one analysis performed by Marsh, Overall, and Kesler (2), but not for the other.

REFERENCES

Joan C. Rogers, Ph.D., Jennifer M. Weinstein, Joanne J. Figone, M.A. Stanley P. Azen, Ph.D.