PROGRAM ABSTRACTS/ALGORITHMS

FACLOD: A program to estimate the statistical significance of factor loadings

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Factor analysts often define all loadings above .30 (some prefer .40) as statistically significant. This simple habit is paradoxical when one considers the elegant and complex models upon which factor analysis is based. The paradox, however, is explained by the fact that little is known about the distributional characteristics of factor loadings. Perhaps the most definitive work in this area was done by Cliff and Hamburger (1967), Cliff and Pennell (1967), and Pennell (1968, 1972). Pennell (1972) developed a computer program to estimate confidence intervals of factor loadings, which represented a culmination of the series of studies. Pennell's program, however, yielded rather liberal estimates and was expensive to run, requiring repeated factor analyses of subsets of the data matrix.

These difficulties led to the development of FACLOD, which employs the jackknife algorithm (Mosteller & Tukey, 1968) and is patterned after Spitzer's (1976) program. FACLOD, written in CDC FORTRAN for the MNF compiler, provides an estimate of the smallest significant factor loading ($\alpha = .05$) for an entire factor matrix.

To determine the relative value of FACLOD, the results of running both FACLOD and Pennell's (1972) program were compared for two sets of data: Holzinger and Swineford (1939) and Humphreys, Ilgen, McGrath, and Montanelli (1969). Pennell extracted four factors from the 24-variable Holzinger and Swineford data. Although he conservatively identified as significant only those loadings for which the 95% confidence interval did not include .10, Pennell found 41 of the total 96 loadings significant. Eight variables were found to load significantly on two factors, three on three factors, and one variable loaded significantly on all four factors. This is rather distressing in view of the fact that the loadings were rotated to the varimax criterion, which should minimize such multiple loadings. In contrast, FACLOD found 20 significant loadings, 1 for each of 20 variables. Four variables did not load significantly on any of the four factors. In addition, Pennell extracted three factors from 12 random variables and found 4 of the 36 loadings significant. FACLOD, however, found only 1 of the 36 loadings to be significant. FACLOD not only provided more conservative estimates, it required a total of only .892 sec of CPU time to run both problems on the University of Texas CDC 6600 system.

Input. FACLOD accepts as input any factor-loading matrix with as many as 100 variables (rows) and 50 factors (columns). The specific nature and sequence of problem definition and data cards are as follows.

Card 1—Three values are read under a 215, F5.3 format: the number of variables or rows (NV) of the input factor matrix, the number of factors or columns (NF), and the tabled t value for $NV * NF - 1$ df.

Card 2—A variable format of the factor matrix is read under a 20A4 format. The variable format must be written to allow the factor matrix to be read as a continuous vector of $NV * NF$ elements.

Data deck—Next come the data cards representing the factor-loading matrix of interest. The data cards may be prepared under any format as long as the data are read as a continuous vector. Problems may be stacked; a blank card following the last problem terminates the run.

Output. For each factor-loading matrix input to FACLOD, two sets of three values are printed. The first is obtained by jackknifing the standard deviation of the loadings; the second set is determined by jackknifing the common logarithm of the standard deviation of the loadings. The latter is generally preferred (see Mosteller & Tukey, 1968, pp. 140-141).

Availability. A listing of FACLOD is available free of charge from Randall Parker, Department of Special Education, University of Texas, Austin, Texas 78712.

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