PROGRAM ABSTRACTS/ALGORITHMS

A computer program to cross-correlate several types of factors across separately factor-analyzed variable domains

JOHN D. MORRIS

Georgia Southern College, Statesboro, Georgia 30458

Darlington, Weinberg, and Walberg (1973) have cited many research examples in which it is necessary to examine relationships between two multidimensional domains of variables measured on each of several subjects. If the number of pairwise relationships between the two variable domains becomes so numerous as to confuse rather than clarify, one may wish to relate scores of the "trait" level from domains of reduced rank. Some evidence indicates that a separate factor analysis of the two domains and cross-correlation of resultant factor scores, as well as the canonical correlations and redundancies (Stewart & Love, 1968) between factor score sets, may yield more meaningful information than the more popular canonical correlation analysis of the data-level variables (Morris & Guertin, 1975).

The purpose of this paper is to update a previously described program which calculates least-squares factor score cross-correlations, canonical correlations, and associated redundancy statistics across two previously factor-analyzed variable domains (Morris & Guertin, 1976). The new version allows the user to choose among any of the prominent "complete" factor score estimation methods (least squares, short method, Bartlett's minimizing unique factors, and ideal variables), as described by Harman (1970), or from any of several typically used "incomplete" estimation methods (weighted by structure loading, weighted by loading squared, unit weight of +1 or -1 if the absolute value of the loading is larger than an input threshold, and similar unit weighting but with the restriction that a variable may load on only one factor).

Computational Procedure. All calculations operate directly on the intercorrelation matrix of the data-level variables from both domains, obviating the necessity of calculating factor scores. Nunnally (1967, p. 150) has described the simple methods by which one may calculate the correlations between linear composites totally as a function of the intercorrelations and weights of the component variables. Since any of the mentioned types of factor score estimates are linear composites, this method is used. This approach allows the inter- and cross-correlation of the factor scores to be calculated by using only the factor structures and an intercorrelation matrix containing the variables from both domains. The intercorrelation matrix may also contain variables not

included in the factor analysis, since the user specifies the variables that are to be associated with each domain. This capability is in line with a similar ability to select subsamples of variables for factor analysis from an input intercorrelation matrix in such a popular program package as *Statistical Package for the Social Sciences* (Nie, Hull, Jenkins, Steinbrenner, & Bent, 1975). Reanalysis of data from the literature is also a possibility if the appropriate correlation matrix is available; however, if the user wishes, the subjects' raw score vectors can be read in and the intercorrelation matrix would be created internally.

The user provides the number of variables and factors in each domain and the types of factor score estimates desired for each domain, as well as the number of subjects on a control card. If the intercorrelation matrix is to be read in rather than raw score vectors, the number of subjects is entered as negative or zero. The zero option is chosen if the number of subjects is unknown. In this case no inferential tests of the significance of the canonical correlations are attempted; however, the factor score inter- and cross-correlations as well as the canonical correlations and redundancies between factor score sets are output, since they only depend on the factor structures and combined intercorrelation matrix.

If the number of subjects is entered as nonzero, Bartlett's (1954) test of sphericity (independence) is applied individually to the factor score intercorrelation matrices. This procedure can help the researcher to decide whether the factor score estimates are to be thought of as independent, since, even with a complete estimation method, common factor scores from an orthogonal solution are typically intercorrelated (Harman, 1970, p. 347). If only a test of the sphericity of the intercorrelation of factor scores for one factor structure is desired, the number of variables and factors in the second domain are merely left blank. The matrix input for the second domain is not entered. This option allows the researcher to examine the intercorrelation matrix of the estimated factor scores and associated test of sphericity in deciding how closely related the factor score estimates are, even though the factor structure may be orthogonal. Such seemingly important information does not seem to be available in common statistical packages even though the only input necessary is the intercorrelation matrix and factor structure of the variables that were factor analyzed. This information is available in any factor analysis program.

This program can be used also in examining one-domain variables under two rotational schemes or in using different factor score estimation methods. In either case the purpose is to ascertain the amount of

agreement between methods. The variable intercorrelation matrix from only one domain is needed, since both domains contain the same variables.

Input. Depending on the combination of parameters entered, the combined intercorrelation matrix, or raw score vectors, and the factor structure(s), or pattern(s), are read under a variable format specified by the user. To insure that an input intercorrelation matrix can contain variables extraneous to this analysis, the user also enters a vector of variable indices which assigns the proper variables to the proper factor.

Output. Program output includes, contingent upon data entered, the inter- and cross-correlations of the factor scores, canonical correlations between factor score sets, the correlation of the factor scores with the canonical variates (canonical structure), tests of the significance of the canonical roots, redundancies, and test(s) of sphericity.

Computer and Language. This FORTRAN IV program is in use on a CDC CYBER 74, in both batch and interactive modes, and on an IBM 370/165.

Availability. The program, with complete documentation and sample input and output illustrating the options described, is available at no cost on request from the

author at the Department of School Services, Box 8143, Georgia Southern College, Statesboro, Georgia 30458.

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