A PET-based program for stepwise orthogonal hand rotation

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Computer programs to perform orthogonal rotation using standard techniques such as varimax, quartimax, and so on, have been available at large installations for a considerable period of time (see, e.g., Kaiser, 1959). Such routines have long since been incorporated within the more popular batch packages, for instance, in SPSS. The extension of such facilities in an interactive format to the laboratory machine (as in Wilson & Frederickson, 1980) is a welcome development for those interested in this medium of operation. In principle, however, the routines operated in this way offer only minor advantages for researchers wishing to "dig around" their data to obtain a deeper understanding of their associated factor structure.

In fact, the availability and low cost of modern microcomputers make them ideal instruments for going beyond standard package output. In terms of factor rotation, the microcomputer is one means by which we can help to reestablish the "lost art" of hand rotation.

Comrey (1973) has provided an extremely clear argument for the importance of hand rotation in obtaining a proper understanding of a given factor structure. This, of course, is not to deny the importance of analytic rotation techniques such as varimax, but merely to point out that the massive availability of programs for such techniques and the presumed difficulty of hand rotation are factors in the demise of a most subtle and revealing procedure. The varimax criterion is one important means by which we can determine an "elegant" solution, but to explore fully the range of possible solutions in a given situation, a technique for hand rotation is essential.

The present program was developed to provide a means by which orthogonal hand rotations could be performed conveniently in the laboratory by use of a PET microcomputer. For the convenience of the user in making comparisons, a varimax routine has also been incorporated into the program.

Description. The program was written for use on an 8K PET with attached printer. The matrices employed are dimensioned interactively by the user, and the unrotated matrix is input at the keyboard. The user also inputs the analysis required (hand or varimax rotation) and indicates whether a "raw" or "normalized" procedure is to be employed (see Comrey, 1973; Harmon, 1976). Crudely speaking, the latter procedure treats all the variables as of equal importance, independent of

the size of their communalities. The former procedure can be instructive in cases in which a proportion of the variables have low communalities and in which it would thus be unreasonable to treat them all on an equal footing. Generally speaking, the normalization procedure is the default option on most packaged versions of the varimax routine.

A print is run on the input matrix before the analysis is performed, to allow the user to check that the input values are correct. Both procedures operate on a cycle-by-cycle basis, in which each cycle consists of a logical consideration of each possible pairing of the various factors. In the case of a three-factor solution, for instance, this would involve considering Factor 1 with Factor 2, 1 with 3, and 2 with 3 on each cycle. In the case of the varimax routine, this procedure goes back to Kaiser's (1959) paper and has been described by other writers since (e.g., Comrey, 1973; Harmon, 1976). For both routines, the varimax criterion is calculated after each cycle. In the hand rotation program, the rotation procedure is terminated by the user interactively; the varimax program terminates when successive values of the criterion differ by no more than .0001.

On each pairing in the varimax routine, the angle of rotation is computed automatically. Using the hand rotation option, the investigator may instead stipulate either an angle of rotation or a variable to which a specified axis is to be rotated to give a zero loading. Again, for each factor pairing on both procedures, a screen plot is presented for the unrotated and then for the rotated factor structure. Similarly, the associated matrices of unrotated and rotated factor loadings are presented. On completion of the routine, a complete matrix of rotated factor loadings is output to the printer. A shortcut is allowed if the user wishes to eliminate intermediate plots and prints on the varimax procedure.

Limitations. Because of the array handling limitations associated with old ROM PETs, the number of variables (V) and factors (F) should be such that $V \times F \leq 256$. The program resides in 3,579 bytes of memory and, when tested with a problem involving five factors and 10 variables, required just over 1K of additional store. The program as it stands requires a printer to be attached to PET, but relatively simple editing allows it to be used independently.

Translation of the program to make it operative on other machines is perfectly possible but would require some work on the screen plot routines, as these are based on POKE statements directed at screen locations.

Availability. A program listing can be obtained without charge by writing to the author at the School of Psychology, Manchester Polytechnic, John Dalton Building, Chester Street, Manchester M1 5GD, England.

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