AN ARTIFACT OF THE ROTATION OF TOO FEW FACTORS: STUDY ORIENTATION VS. TRAIT ANXIETY

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ABSTRACT. A series of factor analyses was performed upon data obtained from 170 university students. It was found that the commonly accepted factor analysis "stop" criterion calling for cessation of factor extraction with the last factor attaining an eigenvalue of one resulted in an unrealisic factor structure. It was demonstrated that the extraction and rotation of two additional factors produced a more meaningful pattern of factors. It was suggested that the conservative investigator might make use of only those factors attaining eigenvalues equal to or greater than one, but that the initial extraction and rotation of a few additional factors may lead to an improved understanding of the relationships underlying the data.

RESUMEN. Se efectuó una serie de análisis factoriales con datos obtenidos de 170 estudiantes universitarios. Se encontró que el criterio comunmente aceptado de extracción de factores, con el último factor obteniendo un "eigenvalor" de uno, resultó en una estructura no realista de factores. Se demostró que la extracción y la rotación de dos factores adicionales produjeron un patrón factorial más significativo. Se sugirió que el investigador conservador pudiera hacer uso solamente de esos factores que obtienen "eigenvalores" iguales a, o mayores que, uno pero que la extracción y la rotación iniciales de unos cuantos factores adicionales puede llevar a un mejor entendimiento de las relaciones fundamentales de los datos.

One common criterion for termination of the factor extraction process in factor analysis is that each factor should have an eigenvalue of at least 1.0 (Kaiser, 1960; Veldman, 1967). Eigenvalues are simply the characteristic values or roots of the equations solved in the extraction of factors or in the solution of quadratic equations by means of matrix algebra. Harman suggests, ". . . the total communality for the *n* factors is the trace of the reduced correlation matrix . . . the factorization process should be stopped when the sum of the eigenvalues is equal to this value." (1967, p. 143). He goes on to say, however, that the extraction of this many factors is likely to provide the investigator with more factors than he can comfortably name or explain. In contrast to Kaiser's (1960) suggesion that the factorization process be terminated with the extraction of the last factor having an eigenvalue of at least 1.0 are the views of Cattell (1958), Dingman, *et al.* (1964), Guilford (1954), and Levonian and Comrey (1966). The contrasting view is that extraction and rotation of too few factors may obscure the true structure of the factor matrix latent in the data matrix. The most extreme view is that of Cattell who holds that it is permissible to extract as many factors as there are variables in the data matrix, and that a combination of visual and

computer rotations should be undertaken to obtain the final factor matrix. Digman, *et al.*, have suggested a more moderate approach and hold that both over- and under-rotation tend to obscure the obtained results.

In a recent study (Mote, 1970), the present writer found that using the 1.0 eigenvalue criterion resulted in the compression of the four well-established factors of the *Survey of Study Habits and Attitudes* (Brown & Holtzman, 1967) into a bipolar factor with Trait Anxiety (Spielberger, *et al.*, 1969) as the opposite pole. This result was obtained with the extraction and rotation of four factors: Study Orientation vs. Trait Anxiety; Student Grade Perception; Grade Point Average; and Academic Achievement Anxiety (Alper & Haber, 1960). Each of the *SSHA* subscales yielded high positive loadings on the first factor; Delay Avoidance, .73; Work Methods, .55; Teacher Approval, .81; and Education Acceptance, .96. The factor loading on the first factor for Trait Anxiety was −.66. The ensuing investigation was undertaken in the hope that the rotation of additional factors might yield a meaningful factor structure.

METHOD

Data were collected from 170 university students on the *Survey of Study Habits and Attitudes* (Brown & Holtzman, 1967), the *State-Trait Anxiety Inventory* (Spielberger, *et al.*, 1969), the *Achievement Anxiety Test* (Alpert & Haber, 1960) and an instrument designed to measure the students' attitudes toward grades (Mote, 1970). In addition, Grade-Point-Averages were obtained from official records.

The data were subjected to a series of seven factor analyses in which four, five, six, seven, eight, nine, and ten factors, respectively, were extracted and rotated. In each analysis only four factors achieved eigenvalues equal to or greater than 1.0.

RESULTS

The composition of the four factors with eigenvalues greater than 1.0 was essentially the same when four and five factors were rotated. When six factors were extracted and rotated, the first factor was simplified and yielded high loadings only on the tests making up the *SSHA* Study Attitudes score, a composite of Teacher Approval and Education Acceptance. The other two *SSHA* tests were found to load strongly on a new factor which included the bipolar Trait Anxiety as its other major contributor. The remaining factors were essentially unchanged. Subsequent analyses, with the extraction and rotation of more than six factors, led to a general trend toward unique factors for each variable.

DISCUSSION

It is suggested that factor analysis is no more than a tool, albeit a valuable one, for use by the investigator in the search for meaningfulness in his data. The rigorous adherence to an arbitrary eigenvalue criterion may occasionally impede the search. It would appear prudent to examine at least the results of the rotation of the next few factors in addition to those which satisfy the criterion. If a meaningful pattern appears one might then retain the factors which are reasonably close to the criterion value.

SUMMARY

Although the usual criterion for termination of factor extraction is the attainment of an eigenvalue equal to or greater than 1.0, it was shown that rotation of a few more factors leads at least occasionally to a more meaningful factor structure. It was suggested that, even though extra factors are rotated, only those should be retained which are reasonably close to satisfying the criterion.

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