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1 Introduction to Rotation

- After extracting the initial components, computer software will create an unrotated factor pattern matrix. The rows of this matrix represent the variables being analyzed, and the columns represent the retained components.
- The entries in the matrix are ***factor loadings***. A factor loading is a general term for a coefficient that appears in a factor pattern matrix or a factor structure matrix.
- In an analysis that results in oblique (correlated) components, the definition for a factor loading is different depending on whether it is in a factor pattern matrix or in a factor structure matrix.
- However, the situation is simpler in an analysis that results in orthogonal components: In an orthogonal analysis, factor loadings are equivalent to conventional bivariate correlations between the observed variables and the components.

1.1 What Is Rotation?

- Rotation is the performing arithmetic to obtain a new set of factor loadings (similar to regression weights) from a given set.
- Rotation is any of several methods in factor analysis by which the researcher attempts to relate the calculated factors to theoretical entities. This is done differently depending upon whether the factors are believed to be correlated (oblique) or uncorrelated (orthogonal).
- In factor analysis and principal-components analysis, rotation of the factor axes (dimensions) identified in the initial extraction of factors, in order to obtain simple and interpretable factors.

1.2 What is a Rotation

- Ideally, you would like to review the correlations between the variables and the components and use this information to interpret the components; that is, to determine what construct seems to be measured by component 1, what construct seems to be measured by component 2, and so forth.
- Unfortunately, when more than one component has been retained in an analysis, the interpretation of an unrotated factor pattern is usually quite difficult. To make interpretation easier, you will normally perform an operation called a rotation.
- A rotation is a linear transformation that is performed on the factor solution for the purpose of making the solution easier to interpret.

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2.1 Introduction to Rotation

Factor patterns and factor loadings.

After extracting the initial components, computer softwars will create an unrotated factor pattern matrix. The rows of this matrix represent the variables being analyzed, and the columns represent the retained components (these components would commonly be referred to as FACTOR1, FACTOR2 and so forth in the output).

The entries in the matrix are ***factor loadings***. A factor loading is a general term for a coefficient that appears in a factor pattern matrix or a factor structure matrix. In an analysis that results in oblique (correlated) components, the definition for a factor loading is different depending on whether it is in a factor pattern matrix or in a factor structure matrix.

However, the situation is simpler in an analysis that results in orthogonal components (as in the present case): In an orthogonal analysis, factor loadings are equivalent to conventional bivariate correlations between the observed variables and the components.

2.2 Varimax Rotation

A varimax rotation is an orthogonal rotation, meaning that it results in uncorrelated components. Compared to some other types of rotations, a varimax rotation tends to maximize the variance of a column of the factor pattern matrix (as opposed to a row of the matrix). This rotation is probably the most commonly used orthogonal rotation in the social sciences.

2.3 VARIMAX rotation in Principal Component Analysis

- Varimax, which was developed by Kaiser (1958), is indubitably the most popular rotation method by far. For varimax a simple solution means that each factor has a small number of large loadings and a large number of zero (or small) loadings.
- This simplifies the interpretation because, after a varimax rotation, each original variable tends to be associated with one (or a small number) of factors, and each factor represents only a small number of variables. In addition, the factors can often be interpreted from the opposition of few variables with positive loadings to few variables with negative loadings.
- A VARIMAX rotation is a change of coordinates used in principal component analysis (PCA) that maximizes the sum of the variances of the squared loadings. Thus, all the coefficients (squared correlation with factors) will be either large or near zero, with few intermediate values.
- The goal is to associate each variable to at most one factor. The interpretation of the results of the PCA will be simplified. Then each variable will be associated to one and one only factor, they are split (as much as possible) into disjoint sets.

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2.6 Interpreting the Rotated Solution

Interpreting a rotated solution means determining just what is measured by each of the retained components. Briefly, this involves identifying the variables that demonstrate high loadings for a given component, and determining what these variables have in common. Usually, a brief name is assigned to each retained component that describes its content. The first decision to be made at this stage is to decide how large a factor loading must be to be considered "large."

Guidelines are provided in statistical literature for testing the statistical significance of factor loadings. Given that this is an introductory treatment of principal component analysis, however, simply consider a loading to be large if its absolute value exceeds 0.40.