Title of Resource	Selecting the Optimal Rotation in Exploratory Factor Analysis
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Brief Description:	When factors are first extracted through Exploratory Factor Analysis, the location of the factors is arbitrary. Therefore, researchers rotate the factors to make them more meaningful and interpretable. SPSS and other programs provide several methods of rotating factors. This free Excel sheet helps students pick the best rotation based upon number of complex items (this should be low), hyperplanar count (this should be high), and extent of correlation among the factors (other things being equal, this should be low).
Keywords:	Exploratory Factor Analysis, Principle Components Analysis, Rotation
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Additional Information:	Barchard, K. A. (2016, Oct 24). *Selecting the Optimal Rotation Version 15.* Excel file for assessing the quality of a factor pattern matrix, to assist in selecting the optimal rotation in Exploratory Factor Analysis or Principle Components Analysis. Available at https://osf.io/t45da/ or from kim.barchard@unlv.edu

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Instructors:

When factors are first extracted through Exploratory Factor Analysis or Principle Components Analysis, the location of the factors is arbitrary. Therefore, researchers rotate the factors to make them more meaningful and interpretable. SPSS and other programs provide several analytic methods of rotating factors. However, these programs do not assist users in selecting between those analytic methods.

This Excel file has been designed to examine three criteria for selecting the optimal rotation.
   (1) The number of complex variables. Variables are complex if they have salient (large) pattern matrix coefficients on more than one factor. We want there to be very few complex variables, because they make it difficult to distinguish what the factors are measuring.
   (2) Number of hyperplanar coefficients. Pattern matrix coefficients are considered hyperplanar if they are so small that they indicate that there is no relationship between the variable and the factor. We want the hyperplanar count to be high, because this means that each factor is measuring only some specific content.
   (3) Degree of correlation between the factors. If we are using an oblique rotation, it is possible for two factors to be highly correlated. This is called factor collapse. When this happens, we cannot tell the difference between our factors. Other things being equal, we want lower correlations between our factors. There is no standard method of judging the size of the correlations among the factors. Therefore, this Excel file summarizes the correlations in two ways: the maximum absolute correlation between factors and the average absolute correlation among factors.

Students can download the Excel file directly from the Open Science Framework website at
https://osf.io/t45da/
Selecting the Optimal Rotation version 15 was published on Oct 24, 2016. More recent versions of this Excel file may be available on that site.

To use this file, students should copy and paste the pattern matrix from SPSS (or another program) into one of the worksheets in this file. For each oblique rotation, they should also copy the matrix of factor inter-correlations into the same worksheet. Excel will then calculate the four numbers listed above. Students will do this over and over for different rotations.

To decide which of these rotations is best, students will copy the results of the four criteria for each rotation to the "summary" worksheet. They will compare the rotations to each other, to determine which has the fewest complex variables, highest hyperplanar count, and lowest correlations among the factors. Often there will be several bad rotations that can be rejected immediately. For example, they may have much higher complexity, much lower hyperplanar counts, or much higher correlations than other rotations. To choose between the remaining rotations, students may need to decide which of these three criteria is the most important for their particular research question. Students can also examine the rotated pattern matrices to see how interpretations of the factors change.

Detailed instructions on how to use the Excel file are given on the "Instructions" worksheet.

This Excel file has been designed for up to 30 variables and up to 6 factors. If students have fewer variables or rows than that, the instructions explain that students will need to delete columns or rows from one of the sheets. If students have more variables or factors than that, the instructions explain that students will need to add more columns or rows to one of the sheets.

I strongly encourage my students to work in groups of 2-3 when they are conducting exploratory factor analyses and using this Excel sheet to pick the optimal rotation. This allows them to follow the detailed instructions correctly and work through difficult parts of the assignment together. Groups larger than 3 would make it difficult for the students to work on a single computer and contribute equally.

Additional Resources

The following textbooks offer good explanations of factor rotation.

Harmon, H. H. (1976). *Modern factor analysis (3rd ed. revised).* Chicago, IL: The University of Chicago Press.

Meyers, L. S., Gamst, G., & Guarino, A. J. (2006). *Applied multivariate research: Design and interpretation.* Thousand Oaks, CA: Sage.

Warner, R. M. (2008). *Applied statistics: From bivariate through multivariate techniques.* Thousand Oaks, CA: Sage.