Chapter 15: Factor Analysis and Reliability Analysis

I. Overview

a. Factor and reliability analyses are methods of data reduction

b. Researchers often measure or observe several variables and then want to group highly correlated variables together into a smaller number of factors, or constructs.
    i. This is what data reduction means: To reduce many measured variables into a smaller number of constructs.

c. The observed, or measured, variables that are grouped together are called indicators of the underlying, or latent, construct.
    i. For example, the latent construct of self-esteem may be indicated by several observed variables, including how one feels about one's appearance, one's intelligence, one's ability to get along with others, and one's athletic ability.

d. Factor analysis reveals which observed variables are strongly correlated with each other and therefore should perhaps be grouped together.

e. Reliability analysis provides a measure of how well a group of observed variables go together.

II. Principal Components Factor Analysis

a. A set of observed variables, such as survey items, are included in an analysis.
    i. All of the variables should be measured using interval scales.

b. Principal Components Analysis (PCA) arranges the variables into separate factors based on how strongly correlated variables are with each other.

c. These factors are then *rotated* to create maximum similarity among the strongly correlated variables within each factor and maximum distance between each of the factors.
    i. Orthogonal factor rotation is designed to create maximum distinctness among the factors and works well when the researcher does not expect the factors to correlate strongly with each other.
    ii. Oblique factor rotation assumes that factors will be correlated with each other and produces factors that allow overlap, or similarity, among them.

d. *Eigenvalues* and percentage of variance explained are used by the researcher to determine how many factors from the PCA should be retained.
    i. This decision is also influenced by the researcher's interpretations of the factors.

e. The items with the strongest *factor loadings* for a given factor tend to define that factor and reveal what the underlying construct is for that factor.
    i. Factor loadings are an indication of how strongly individual items are associated with each factor.

f. Items that do not load strongly on any factor indicate that these items are not good indicators of any of the underlying constructs represented by the factors created in the PCA.

g. Items that have strong factor loadings on more than one factor are said to *cross load* with multiple factors.
    i. These items are also considered to be weak indicators of the underlying constructs because they do not distinguish well between constructs.

III. Exploratory Factor Analysis (EFA)

a. In this method of factor analysis, a number of measured variables are put into the analysis and are separated into separate factors based on statistical measures.
    i. The researcher does not define which items belong on which factors before performing the factor analysis.
    ii. It is a method of *exploring* the data to find out which measured items correlate, or load, with each other.

b. This is a data- and statistics-driven model of data reduction more than a theory-based method of grouping measured variables together.
    i. It is important for the researcher to closely examine the factors that emerge from an EFA to see if they make sense conceptually and theoretically.

IV. Confirmatory Factor Analysis

a. The researcher decides ahead of time how to organize the observed variables (i.e., measured items) into factors.

b. The purpose of the confirmatory factor analysis (CFA) is to determine whether a hypothesized factor structure (i.e., organizing of items into factors) is supported by the data.
    i. In research terms, the purpose of the CFA is to determine whether the factor structure hypothesized by the researcher “fits” the data well.

c. A variety of *fit statistics* are used to determine how well a hypothesized factor structure fits the data.

d. Confirmatory factor analysis is often used as part of a larger set of statistical techniques known as *structural equation modeling.*

V. Reliability Analysis

a. The purpose of a reliability analysis is to determine how well a set of items, i.e., observed variables, go together into a single *scale*.
    i. This analysis also reveals how strongly each item in the scale is associated with the overall scale. This is called *item-total correlations.*
    ii. In survey research, building scales out of several individual measured items is important for at least two reasons:
        1. Using multiple items to measure a single latent construct allows researchers to build scales that are broader than any single items could measure

        a. E.g., Satisfaction with work involves several aspects (pay, respect, interesting work, likeability of co-workers, etc.) that cannot be assessed with a single item.
    2. Using multiple items to measure a single latent construct helps researchers have some confidence that participants are understanding the items as the researcher intended.

- *b.* The statistic that results from a commonly used reliability analysis is the *Cronbach's alpha coefficient.*
    - i. This coefficient has a maximum value of 1.0.
    - ii. Generally speaking, when a collection of items (i.e., a scale) has a Cronbach's alpha of .70 or larger, the scale is considered to be reliable.

- c. This type of reliability analysis refers to the *internal consistency* of a set of variables.
    - i. This differs from test-retest reliability.

VI. Summary

- a. Both factor analysis and reliability analysis are statistical techniques used to reduce a larger set of measured items (i.e., observed variables) into a smaller set of latent constructs.

- b. Researchers typically use factor analysis first to organize the items into constructs and then use reliability analysis to determine how well each construct holds together.

- c. There are many different kinds of factor analysis.
    - i. Exploratory Factor Analysis allows researchers to see which items should be grouped together based on statistical similarity.
    - ii. Confirmatory Factor Analysis allows researchers to test pre-existing factor models to see how well the model fits the data.