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UNDERSTANDING FACTOR ANALYSIS AS A METHOD FOR QUANTITATIVE RESEARCH

JULIUS S. ANTONIO, PH.D.
Laboratory Schools, Catanduanes State University,Virac, Philippines

ABSTRACT

Psychometrically sound instrument for applications in research, training and practice (Worthington & Whittaker, 2006) are produced through a proper and intensive process of scale development. This is realized through the application of factor analysis. Factor analysis is not just a simple statistical tool that you plug in all data and in an instant a result will come out. Yong and Pearce (2013) has explained how exploratory factor analysis. According to them "Factor analysis is mathematically complex and the criteria used to determine the number and significance of factors are vast."

KEYWORDS: Quantitative Research & Factor Analysis

INTRODUCTION

To fully understand factor analysis and have a deeper insight about this method, once must know its historical and philosophical basis, why it is used and its advantages and disadvantages. In this paper, I will show you the philosophical background of how factor analysis started; why use it, and the benefits and limitations of factor analysis as it is applied in research.

What is Factor Analysis?

Let us define first what factor analysis is. Several authors have defined factor analysis and give a common definition for this. Some of these authors are Child (2006), Harman (1976), Tabachnick and Fidell (2001), and Worthington and Whittaker (2006).

Summarizing the data in such a way that relationships and patterns can be easily interpreted and understood is the main purpose of factor analysis. Factor analysis is commonly used to regroup variables into limited set of groups or clusters based on their shared variance. From this, isolating constructs and concepts help a lot. With the use of mathematical procedures, factor analysis simplifies the interrelated measures in a given set of variables and discovers pattern from this (Child, 2006 as cited by Yong, & Pearce, 2013). Parsimony or the attempt to discover simplest method in interpreting observed data is the essential aim of factor analysis (Harman, 1976 as cited by Yong, & Pearce, 2013).

In their book, *Using Multivariate Analysis (4th ed)*, Tabachnick and Fidell (2001) described factor analysis as a method used in identifying or confirming a smaller number of latent or constructs from a large number of observed variables or items (Worthington & Whittaker, 2006).

Hair, Black, Babin, Anderson, & Tatham (2006) described factor analysis as "an interdependence technique, whose primary purpose is to define the underlying structure among the variables in the analysis."

Factor analysis is used in several fields and the most common of these are behavioural and social sciences. Scale construction or scale development is one of the most common applications of factor analysis. This is evident from the studies of Worthington, & Whittaker (2006); Hinkin, Tracey, & Enz (1997); and Morgado, Meireles, Neves, Amaral, & Feirrera (2017).

HISTORICAL AND PHILOSOPHICAL BASIS OF FACTOR ANALYSIS

The concept of common factor analysis was derived primarily from the deep philosophical heritage. It all started from the big concept of Greek atomist that what appears to be seen must be explained from something that is not directly perceived. Then the ideas of Descartes about analysis and synthesis came through, followed by the proposition of Francis bacon on the automatic algorithm for discovering knowledge, and from the idea of Karl Pearson and Udney Yule on the correlational exploratory statistics as an inducted method. From these rich perspectives of historical and philosophical beginnings, the concept of exploratory common factor analysis was mainly drawn. However, users of exploratory common factor analysis have drawn also their false expectations from these perspectives. They claimed that exploratory common factor analysis method could yield unique and unambiguous knowledge about the fundamental causes of a domain of variables without prior assumptions. And this idea is of inductivist fallacy. These expectations were rooted mainly on the indeterminacy of common factors. However, this indeterminacy of factors may not ruin the model of common factor analysis nor for exploratory common factor analysis, only if you will treat the method with less desire to produce a hypothesis. The idea, however of Kant, pointed out that our freedom to infinitely formulate hypotheses requires a skill to separate hypotheses that are constructed subjectively than those hypotheses that are objectively constructed and are formulated that will have bearing on the specific set of data stimulating the hypothesis. To process this, there is a need to test the hypothesis with additional set of data. Thus, confirmatory factor analysis followed the exploratory factor analysis (Mulaik, 1987).

Harman (1976) as cited by Yong, & Pearce (2013) mentioned in his book that "Factor analysis has its origins in the early 1900's with Charles Spearman's interest in human ability and his development of the Two-Factor Theory; this eventually lead to a burgeoning of work on the theories and mathematical principles of factor analysis."

As described by the above authors, the rich concept of factor analysis can be traced back from the ancient Greek to the modern society. There is no single person that developed the concept of factor analysis, but rather collective ideas have sprung to the development of the factor analysis.

Types of Factor Analysis

There are two types of factor analysis, Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA). In the initial development of your instrument, you want to identify the number of factors that describe your variables, EFA is applied. Through EFA, you can determine what items belong to set of clusters and which items do not. On the other hand, CFA tries to confirm your hypothesis on the factors you have identified. Through CFA, you can confirm whether the items you have identified really belong to the same cluster or not.

A. Exploratory Factor Analysis

The construct validity during the initial development of an instrument is being assessed by the EFA. Once the initial set of items was developed, researchers use EFA to determine the underlying dimensionality of the item set. From this, they can group several items to meaningful subsets that measure different constructs. The main reason for using factor analysis is that it relates specific items to a factor according to the examinees responses. As a result, researchers can identify items that do not measure a given construct or factor and items that simultaneously measure the given factors. With this, they can determine items that are poorly developed and later on be discarded (Worthington & Whittaker, 2006).

B. Confirmatory Factor Analysis

Although an exploratory factor analysis is very useful in assessing the degree to which a set of items assesses a particular construct or set of scales, there still weaknesses in this method, one of which is the inability to quantify the goodness-of-fit of the resulting factor structure (Long, 1983 as cited by Hinkin, Tracey, & Enz, 1997). In addition to this, Gerbing & Anderson (1988) pointed that, exploratory factor analysis is very useful preliminary technique in scale construction, but you still need to use CFA to evaluate and refine the items that belong to a set of clusters. This is similar to the words of Hinkin, Tracey & Enz (1997) that it is a necessary for scale development to subject your instrument for further analysis, CFA, whether the instrument has already undergone an exploratory factor analysis.

BENEFITS USING FACTOR ANALYSIS

One of the most conceivable benefits using factor analysis is its basic objective of grouping highly intercorrelated variables into well-defined constructs or factors. In many situations these factors can give wide information about the interrelationship of different variables (Hair, Black, Babin, Anderson, & Tatham, 2006). With the use of factor analysis, researchers can objectively regroup the items into clusters that measure the same constructs. It could have been difficult to regroup items by merely identifying the statement that lead to similar constructs. This simple identification of items can be very tedious on the part of the researcher. Moreover, the objective way of regrouping the items into constructs cannot be achieved for there is no evidence on how researchers came up with such reason of grouping the factors. The items identified by the researcher by his/her decision out of examining the statements could not really be intercorrelated to the other items. With this, factor analysis is of great help in identifying what items measures the same constructs, what items are to be grouped together and what items are intercorrelated with other items.

To use a factor analysis, one does not need to be expert in this statistical tool. With the varied resources found on the internet, one can easily learn how to use factor analysis. As long as you have with you your software SPSS, performing factor analysis will not be expensive. Steps on how to perform factor analysis are readily available on the internet. Books on how to perform factor analysis by Andy Field and (Hair, Black, Babin, Anderson, & Tatham, 2006) are already available. One has to only faithfully follow the steps on how to perform factor analysis. Videos are also available on YouTube. With the vast information found on the internet, one must not be problematic on how to perform factor analysis on his own. A constant practice is just needed to skilfully master factor analysis. Besides, you will not use factor analysis if you do not have any background on it.

Moreover, results given by factor analysis are accurate. The outputs you get from factor analysis rely solely on the information you have input in the software. Users must be careful on inputting data on the software for whatever you input

on it, that what are you are going to get. Remember, what you input to a computer is what you get from it. So be aware and careful to input your data.

LIMITATIONS OF USING FACTOR ANALYSIS

On the contrary to the benefits of using factor analysis, there are also limitations in the use of this method. Hair, Black, Babin, Anderson & Tatham (2006) has enumerated three major limitations of using factor analysis: (1) because many techniques for performing exploratory factor analyses are available, controversy exist over which technique is the best; (2) the subjective aspects of factor analysis (i.e. deciding how many factors to extract, which technique to use to rotate the factor axes, which factor loadings are significant) are all subject to many differences and opinions; (3) the problem of reliability is real.

Now, deciding on what components of factor analysis is what left to the researcher. Remember, in using factor analysis following the steps in not only needed to get the result. There are several techniques to choose from (i.e. principal axis component). The researcher will now decide on what technique is appropriate to be used for his data. Different references suggest different techniques. The researcher is now left with a difficult task on what technique to choose.

Although factor analysis objectively identify what items are intercorrelated with other factors, deciding on how many factors to extract is left subjectively on the researcher. Again, different references suggest different things; the decision on this matter relies on the researcher alone, especially when references are conflicting.

Further, deciding on what level of reliability factor is said to be reliable is also left on the part of the authors. There are references that suggest a 0.70 reliability factor is accepted. Others say 0.80 and 0.60. There are also authors who suggest that a 0.90 reliability factor is no longer reliable instrument for the whole instrument may measure a single construct only. With these conflicting ideas, the researcher is left to choose what references and authors is he going to cite and to believe in.

Moreover, (1) usefulness of factor analysis depends on the researchers' ability to develop a complete and accurate set of product attributes. If important attributes are missed the value of the procedure is reduced accordingly. (2) If the observed variables are completely unrelated, factor analysis is unable to produce a meaningful pattern (though the eigenvalues will highlight this: suggesting that each variable should be given a factor in its own right). (3) If sets of observed variables are highly similar to each other but distinct from other items, Factor analysis will assign a factor them, even though this factor will essentially capture true variance of a single item (Sternberg, 1990).

Tabachnick & Fidell (2007) as cited by Yong & Pearce (2013) presented three limitations of the use of factor analysis. (1) According to them the researchers are left with the problem on how to name the factors they have identified on the exploratory factor analysis. Names of the factors must reflect the construct being measured by the instrument and it should be in cognizant with the research problem. (2) Another limitation is the difficulty of interpreting the variables found in the factor analysis. Using factor analysis is not an easy task as well as gathering data for factor analysis. (3) Tabachnick and Fidell (2007) emphasized that researchers need to conduct a study using a large sample at a specific period of time. Whortington & Whittaker (2006) suggested the following in guideline in using factor analysis: (a) Sample sizes of at least

300 are generally sufficient in most cases, (b) sample sizes of 150 to 200 are likely to be adequate with data sets containing communalities higher than .50 or with 10:1 items per factor with factor loadings at approximately |.4|, (c) smaller samples sizes may be adequate if all communalities are .60 or greater or with at least 4:1 items per factor and factor loadings greater than |.6|, and (d) samples sizes less than 100 or with fewer than 3:1 participant-to-item ratios are generally inadequate.

Conducting a study to a large sample is a tedious one. Remember, the number of instrument to be produced is directly proportional on the number of sample. Because the sample is very large the number of instrument to be produced is very large also. This may cause you a lot of expenses plus the number of research assistants that will distribute and collect the instruments to the sample. Even though you explain the value of the research to the assistants, you cannot insist on them to faithfully insist to do their job faithfully. In addition to this, the percentage of retrieval from a very large population may not always be a hundred per cent. Be willing to expend a lot of money on a lesser return of investment. If you will alone distribute and collect the instruments, you can have a greater chance of retrieval percentage of the instruments, however it will be tedious on your part and it will take a long time to collect all from the sample.

CONCLUSIONS

In summary, there are benefits and limitations of the use of factor analysis. One does not need to be a mastery of the method but a background on factor analysis is needed to ensure that you will succeed on the use of factor analysis. Objectivity and accuracy of the output is the number one benefit of the use of factor analysis while expensive in the production of a large number of instruments is the number one disadvantage of using factor analysis.

The philosophical background of the development of factor analysis first came from the ancient Greek until the modern time. There is no single person that developed the idea of factor analysis, but rather collective ideas of different philosopher and mathematicians has led to the development of factor analysis. Although, Charles Spearman's development of two-factor theory has a great contribution on the development of theories and mathematical principles of factor analysis.

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