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The Integration of EFA and CFA: One Method of Evaluating the Construct Validity

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Abstract- The approach of evaluating the construct validity has little development in the past one hundred years. As the theory of EFA and CFA had been proposed and refined these years we can find that they are good methods to evaluating the construct validity. This paper give a concepts of construct validity firstly and then analyzed the shortcoming of existing methods of construct validity evaluating, then stated the traits of EFA and CFA, based on them we summarized that using EFA and CFA together is a good way to evaluating the construct validity.

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The Integration of EFA and CFA: One Method of Evaluating the Construct Validity

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Abstract- The approach of evaluating the construct validity has little development in the past one hundred years. As the theory of EFA and CFA had been proposed and refined these years we can find that they are good methods to evaluating the construct validity. This paper give a concepts of construct validity firstly and then analyzed the shortcoming of existing methods of construct validity evaluating, then stated the traits of EFA and CFA, based on them we summarized that using EFA and CFA together is a good way to evaluating the construct validity.

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I. Introduction

Validity is the most important and difficult problems in human behavior measurement. The classical definition of validity refers to the degree to which the measurement achieves the goal, which was proposed by some specialists of American Educational Research Association, AERA, in 1921 (Cronbach, 1969). In World War II the public was concerned about the validity of pilot selection, which led to many researches about it. Many concepts of validity arose in a short time after World War II, including criterion related validity, factor validity (Guilford, 1946), face validity (Mosier, 1947), logical validity, experience validity (Cronbach, 1949), internal validity (Gulliksen, 1950) and so on. In order to solve the problem of the validity concept being in massive confusion, and criterion related validity being emphasized too much, American Psychological Association, APA, sorted these concepts into four kinds of validity: content validity, predictive validity, concurrent validity and construct validity (APA, 1954). The traditional definition of construct validity refers to the degree to which a test measures what it claims, or purports, to measure (Cronbach & Meehl, 1955). Modern validity theory defines construct validity as the overarching concern of validity research, subsuming all other types of validity evidence (Messick, 1995; Schotte, Maes, Cluydts, De Doncker, & Cosyns, 1997).

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II. Development on Construct Validity Evaluation

There has been slowly development on validity evaluation in nearly the past one hundred years, especially of construct validity (Henry, Douglas & David, 2002). The method of construct validity evaluation was nearly always Campbell and Fisked's Multi-traits-Multi-methods, MTMM (Campbell & Fisked, 1959), and it was always used incorrectly, ignoring two important points: firstly MTMM is mainly to calculate convergent validity and discriminant validity rather than construct validity, secondly it demands the formation of a structural equation model, SEM, but very few researches did so. MTMM is impractical in fact because it is difficult to form a structure through different ways or to get different structures in one single way. When people cited MTMM they usually used the correlation matrix in Campbell's research but with little development.

It is necessary to make some efforts to develop methods of structure validity evaluation. One method is integrating factor analysis methods to evaluate the construct validity (Hu & Mo, 2007). This idea has been put forward earlier in 1946 by Guilford (Guilford, 1946). Later Eysenc strengthened this view in 1950 (Eysenck, 1950). Cronbach and Meehlpe regarded factor analysis as an effective method to computing the construct validity in 1955 (Cronbach & Meehl, 1955). Yet limited to the method of EFA, evaluating of construct validity was difficult then.

The traditional factor analysis is exploratory factor analysis (EFA), confirmatory factor analysis(CFA) was added till 1969 (Zhongfeng & Lei, 2002).

III. Problems About Traditional Factor Analysis—EFA

There are several problems concerned EFA, in the implementation process of EFA the researcher should make a series of important decisions.

a) Questions about research design

The most important issue with EFA research design is choosing variables. The public factors must be included in the measurement variables, and the variables must be closely associated with the research topic, otherwise it will lead to false public factors. Statisticians suggest that the measurement variables

had better be 3-5 times public factors. The second important issue with EFA design is about the sample. The researcher must decide the size of the sample and how to sample. Statisticians suggest that the size should be decided by the quantity of the variables. For example, Gorsuch suggested that the standard should be one item corresponding to five individuals, and the sample should include at least 100 individuals (Gorsuch, 1983). Researches have recently proposed that the size of sample isn't a function of the variable quantity because the public contribution ratio is bound to be increased if the public factors are overabundant. Thus even if the quality of a test is satisfied, the size of a sample should be over 200 individuals. According to the study of Comrey and Lee (Comrey &Lee, 1992), the outcome will be good enough if the size of the sample is over 500 individuals in factor analysis, and 1000 or more would be even better.

What the researchers should think further is the specification of the samples. The scope may be limited if the consistence of the sample is too high, which will affect the correlation among variables. Therefore, different individuals should be chosen to maximize the variance of the measurement.

b) To decide whether or not EFA is suitable

EFA aims at finding out a few public factors to represent and explain more measurement variables. Only when the researchers expect to testify the latent variables will they use EFA. When they make these decisions, the key point is to distinguish the difference between latent structure and date classification. Data classification uses combination of fewer data to replace more measurement variables to maintain the original information, but construction of correlation model is unnecessary. The distinction between latent structure and date classification is important because approaches to the two goals are different. For a simple structure, EFA is suitable. For classifying the data, Principal Components Analysis (PCA) is more suitable (Fabrigar, Wegener, MacCallum & Strahan, 1999; Suhr, 2009). Some researchers mistakenly think PCA is a type of EFA (Bentler & Kano, 1990).

c) To Choose suitable program fitting the models

The most widely used programs fitting the models are Maximum Likelihood Estimation (MLE), and Principal Components (PC). The main advantage of MLE is that it allows the wider range of model fitting index than other methods while its main limitation is the demand of multi-norm distribution.

d) To Determine the quantity of public factors

In EFA the researcher must determine the quantity of factors in the model. It is generally thought that more errors will occur if too few public factors being extracted than too many being extracted (Thurstone, 1947; Rummel, 1970; Cattell, 1978).

The most famous standard of deciding the quantity of factors comes from Kaiser's computing the eigenvalues (Kaiser, 1960). This method is simply and objective, but it has several obviously problems: firstly it usually be used incorrectly; secondly this standard sometimes seems to be inflexible; finally it might lead to too many or too few factors. In addition this method will easily be effected by sample size.

Another famous method of deciding the factors quantity is "scree test" (Cattell, 1966). But this method is too subjective. The most shortcoming of it is the concept of break point hasn't a clear definition; secondly if the scree plot is vague or it hasn't a clear break point, it is quite difficult to point out it. Moreover, this method has not a quality standard (Kaiser, 1970).

The third method of deciding the factor quantities is "parallel analysis" (Horn, 1965).There is another method of this problem by testing the regenerated matrix. Some researchers proposed that the quantity of factors is reasonable if the contribution ratio of all the factors is 75%-80% of the sum variance. Some others think the number of factors should be n/5 to n/3 (n means the number of items). Today new methods are keeping on appearing (Ruscio & Roche 2012).

e) Questions about factor rotation

The models in EFA are not sole if there are more than one factors in a research, and the researcher must choose one unique solution among the numerous equal models (Fabrigar & Wegener, 1999). In EFA, the most popular theory about model selection is "simple structure theory" proposed by Thurstone (Thurstone, 1947). He pointed out five terms meeting to simple structure rule. In order to achieve "the simple structure", it is necessary to rotate the factors (Gorsuch, 1983). There are orthogonal rotation method and oblique rotation method in rotation theories. Orthogonal rotation is based on the theory that the factors are independent of each other, while the oblique rotation doesn't have this hypothesis as its basis. Some researchers think orthogonal rotation is simple and the concept of it is clear (Nunnally, 1978), but that is not the truth. Firstly in the mental structure construction (e.g. mental abilities, personality traits, attitudes), with the basis of the theory or their experience, people usually think that the factors are related to each other. Secondly because the orthogonal rotation requires the factors to be oriented at 90, they may get a worse simple structure if the factors are related to each other. Finally oblique rotation can provide more information than orthogonal rotation. An estimation of the correlations among the factors can be got through oblique rotation, which is helpful for interpretation of the public factors.

f) Problems about factor naming

Factor naming is beyond the scope of EFA, and becoming a specific question in research area, while the statisticians are powerless.

Many researchers explain the factors by inferring the mental process according to the measure variables high loaded on some specific factors. Because mental phenomena in FA are invisible, the researchers' subjective inference always be arbitrary, and different researchers have different opinions on the same test, which will lead to arbitrary explain on the factors.

However, there still are psychologists who keep putting forward methods to solve such problems, one of which is called "active identification" (Mo, 1989). "Active identification" analyses factors based on reality activities. With public factors obtained, researchers will divide the items into several sub-tests based on the factors which have maximum loading. Then sub-test will be carried out on individual students, after which researches give the complete process qualitative analysis to interpret the mental process and explain the mental essence of the factors depending on the outcomes. This way of factors identification is more objective and scientific than traditional ones.

EFA is the stage of exploring the relevance among the common factors and measurement variables, thus there is not index in EFA to show which model is better, which is main restriction of construction validity evaluation.

CFA is different from EFA in the way that CFA aims at testing the effectiveness of the model by using the data (Suhr, 2006). If the initial hypothetic models are rejected, we should make further efforts to find out and explore the true structure of the topic by modifying and testing the model based on the data. In confirmed models, there may be some public factors which are not interrelated with each other, and observed variables only affected by some of the public factors; some observed variables may proved to be related to some particular factors, while some others proved not related to the same group of particular factors (Thompson, 2004).

IV. One Method to Evaluate the Validity of Construct

In 1969 Sweden statistician Jöreskog proposed the theory of Confirmatory Factor Analysis (CFA) and it's method (Jöreskog, 1969), from then on factor analysis went into a new generation. Since 1946 statisticians think factor analysis is a good method to evaluate the validity of construct, this became practical when CFA has been proposed.

a) Characteristics of CFA

The basic idea of CFA is: the researcher will form a model in it the factors pertinent with each other, which comes from inference and hypothesis based on previous theories and knowledge. Many variables in social and behavior study can not be observed directly, or they are only the researcher's theoretical ideas, thus many factors in the model are potential factors. In order to make these potential factors to be displayed effectively and reliably, we should choose various variables to measure each potential factor. We can get a set of data of the observed variables to form a co-variance matrix, which is the base of CFA. In CFA, the researchers should judge the value of the public factors depend on the previous experience and some related information, at the same time they also should evaluate some parameters according to the situation in the model. Once the model has been defined the researcher can estimate the parameters based on the co-variance matrix and test the fitness of the model with the data. If the fitness of the model is not appropriate and cannot be accepted, the researcher need to modify the definition of the model.

CFA is different from EFA that the former aims at testing the effective of the model by using the data. If the initial hypothesis model are refused we should make further effort to make sure the true structure of the problem, by modifying and testing the model depended on the data. In confirmation models there may be some public factors are not interrelated with others, and the observed variables only be effected by some of the public factors, or some observed variables have relationship with some particular factors while some others has not relationship with these particular factors (Thompson, 2004).

b) Integration of EFA and CFA

CFA and EFA in fact are two stages of a whole process and can not be separated sharply. If the researcher can use these two method together the research will reach a deeper degree. Anderson suggested that during the procedure of proposing a theory should better to establish a model by EFA and verify the model or modify the model by CFA (Anderson & Gerbing, 1990). For example we can use EFA in one sample to find out the structure of factors, then use CFA to test or adjust the structure in another sample. The procedure are called cross-validation. Actually EFA and CFA not only have difference but also have relationships so they are two sides of one thing. EFA and CFA are all based on public factors model and looking forward to find the potential variables to establish the models about the measuring variables. EFA provides concepts of the hypothesis and calculating tools, these are important basis and guarantee for the establishment theory in CFA. It is incomplete if anyone of EFA or CFA is lacked in factor analysis.

In terms of the differences between EFA and CFA, we will find that EFA is a data-driven method, in which there is no distinct public factor numbers and few limitation in public factors or potential variables

beforehand. EFA provides the program to forming models according to the data, defining the number of factors and factor loads in the models. On the contrary, in CFA researchers have to provide some hypothetical models had been defined factors numbers or load could be different with each other. EFA acts the role of providing important basis in proposing hypothesis and CFA proves or disproves the hypothesis. Usually we should combine EFA and CFA in a research. EFA is the base of CFA by providing a hypothetical model. If the size of the sample is big enough we can split the sample into two parts randomly, one part to be analyzed by EFA and the other by CFA. The outcome of CFA can finger out which model of EFA is more suitable.

In short, EFA and CFA, as research methods, are two integral parts of factor analysis, which is a practical method to evaluate construct validity. The integration of EFA and CFA is very important for human behavior researches.

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