



---

## Effect of Varying Sample Size in Estimation of Coefficients of Internal Consistency

**Corresponding Author:**

Dr. Shivalingappa B Javali,  
Senior Grade Lecturer, Department of Biostatistics, SDM College of Dental Sciences, 580009 - India

**Submitting Author:**

Dr. Shivalingappa B Javali,  
Senior Grade Lecturer, Department of Biostatistics, SDM College of Dental Sciences, 580009 - India

**Previous Article Reference:** [http://www.webmedcentral.com/article\\_view/1572](http://www.webmedcentral.com/article_view/1572)

**Article ID:** WMC001649

**Article Type:** Research articles

**Submitted on:** 28-Feb-2011, 10:55:03 AM GMT **Published on:** 28-Feb-2011, 06:50:43 PM GMT

**Article URL:** [http://www.webmedcentral.com/article\\_view/1649](http://www.webmedcentral.com/article_view/1649)

**Subject Categories:** BIOSTATISTICS

**Keywords:** Sample Size, Coefficients, Internal Consistency, Measurement Scale

**How to cite the article:** Javali S B, Gudaganavar N V, Raj S M. Effect of Varying Sample Size in Estimation of Coefficients of Internal Consistency . WebmedCentral BIOSTATISTICS 2011;2(2):WMC001649

**Source(s) of Funding:**

Not assisted by any financial support.

**Competing Interests:**

Resubmission of article with rcorrected according to reviewers comments. (No. is WMC001572)

# Effect of Varying Sample Size in Estimation of Coefficients of Internal Consistency

**Author(s):** Javali S B, Gudaganavar N V, Raj S M

## Abstract

Reliability refers to accuracy of a measurement instrument or scale. Reliability of test scores are estimated through measures of internal consistency has been characterized mathematically in many ways that appear, on the surface at least, to be very different to one another. The coefficient alpha is the most widely used measure of internal consistency for composite scores. In this article, the inferential statistics for three coefficients of internal consistency i.e. alpha coefficient with theta coefficient and omega coefficients are estimated. These indices of internal consistency reliability are extremely important in health research (medical and oral health). The estimation of alpha, theta and omega coefficients and analytical effects under different sample sizes are examined and described. But computations of these coefficients are easily put forwarded by statistical software programs like SPSS, STATA, SYSTAT, STATISTICA etc. The good quantity of internal consistency estimates is observed in the sample size of 50 and more. Therefore, the researcher claims that for calculation of coefficient of internal consistency for five points scale or any, the sample size should be at least 50 and more is enough. It is also concluded that with a prescription that every time a researcher reports any one of alpha coefficient, theta coefficient and omega coefficients.

## Introduction

Precision of measurement is one of the major issues, which is frequently quantified by the coefficients of reliability. The coefficient alpha, developed by Cronbach (1951), is the most commonly used index for estimating the internal consistency reliability of measurement instruments such as scales (Stevanovic D., 2011; Heston T., 2011), multiple item tests, questionnaires, or inventories (Raykov 1997) in all the fields of research such as psychology, education, statistics, sociology, medicine, counseling, nursing, political science, and economics (Cortina 1993). Measurement of concrete characteristics required a scale, which must be reliable and valid. But, it is an important problem in the case of measuring

conceptual characteristics. There is a great deal of interest in developing sensitive, reliable and valid measure for clinical populations and for aggregates such as organizations and families. It is an appropriate to begin the series with a discussion of internal consistency reliability of measurement, required some statistical procedures.

Internal consistency reliability estimates provide essential information regarding one aspect of soundness of the measurement of variables, items or attributes etc. Thus, the internal consistency reliability that is suitable in obtaining the reliability of the scale is important. In this article we used three coefficients were introduced and calculated under various sample sizes, in which coefficient of alpha in particular is important, but there are circumstances it is inappropriate and another estimates should be generated.

Further, the sample size is playing an important role on estimation of the internal consistency reliability level of the measurement scale. Thus, cronbach, theta and omega are as three measures of internal consistency are examined and an example of the calculation of each is provided.

## Methods

### Methodology

To know the efficiency of three coefficients of internal consistency, the data set has been used from dental environment stress scale with five points developed by Garbee (1980) to measure stress of dental professionals including graduates, interns and postgraduate from SDM College of Dental Sciences and Hospital, Dharwad, Karnataka, India. The example that follows is based on analysis of a 33 item scale administered to 316 dental health professionals, on convenient basis. The response rate was 98.74% (n=312). After receiving the scale from each professional, the response of each item is scored and entered in MS office-2003, then converted into SPSS 16.00 format. The three coefficients of internal consistency i.e. alpha coefficient, theta coefficient and omega coefficient were calculated under different sample sizes starting from n=33 (because of total number of items are 33) and so on. In order to obtain theta and omega coefficients, the eigen values were

calculated from a principle component analysis and communalities were estimated from a factor analysis. The mean item correlation and Split-half reliability coefficient were calculated to know the reliability of dental environment stress scale under different sample size. Further, the three coefficients for internal consistency were compared under different sample size.

#### Analysis of Internal Consistency Reliability

It is a property that measurement scale must have, is an indicator of consistency of measurement values obtained from the measurements repeated under the uniform circumstances (Ilker, et al. 2007; Gay, 1985; Carmines and Zeller, 1982; Arkin and Colton, 1970; O'connor, 1993; Carey 1988). It is an important concept when there is no gold standard. Using different ways, the reliability or internal consistency reliability of the scale can be examined by applying the scale once, twice or applying the parallel scales once. The internal consistency reliability can be examined, when scale is examined once. The coefficient of reliability takes the range 0 to 1.

#### Methods of measuring internal consistency

If the internal consistency reliability (Stevanovic D., 2011; Heston T., 2011) can be examined by applying the measurement scale once, the error of the estimated reliability will be smaller than the other estimation procedure of reliability, wrong management, incorrect methodology of scoring, unexceptional or temporary changes in personal performance affect the internal consistency (O'connor, 1993).

The split half method is another method denotes the homogeneity indices of the items in the scales. It pertains to the relationship between the responses of the items and the total scale score (Oncu, 1994). O'connor, 1993 claimed that an increase in homogeneity in the set of items increases the reliability estimates. The idea that the internal consistency methods depend upon is that every measurement tool is constructed to realize an objective (Karasar, 2000). The methods of internal consistency are widely and frequently preferred (Oncu, 1994). Although there are many estimates of reliability that can be used, but internal consistency is one of the most frequently generated estimates or scales or instruments composed of number of items or variables that will be formed into a linear composite.

#### Cronbach Alpha

Of the measures of internal consistency, the most frequently preferred is cronbach alpha (cronbach, 1951), can be used for three, four, or five point likert scale items. But Oncu (1994) claimed that, it is not limited to the true-false or correct-incorrect format of scale. It is equivalent of the average of all split-half

correlations that could be generated for the scale  $2N$  items long, where  $N$  equals the number of indicants (Novick and Lewis, 1967) and where each item is scored on more than two points (Nunnally, 1978). Alpha is easily interpreted and ranges from 0 to 1 gives low to very high internal consistency. At the lower extreme, the inter-item correlations are zero; and at the upper extreme, there is a perfect correlation among the items. Many researchers consider an alpha coefficient at least 0.070 or more to be adequate for the scale (Nunnally, 1978).

When interpreting alpha as a measure of internal consistency, every researcher should needed to understand several key factors. Initial and most basic thing is that there is an assumption that internal consistency is expected. Secondly, although the estimate is labeled internal consistency, that is not completely accurate. The nature of increase of alpha coefficient is depends on change in number of items while holding the average correlation among the items constant (Nannally, 1978). Finally, alpha is a best estimate of internal consistency given the assumption that the items are parallel. Otherwise it is a lower bound estimate of reliability. Parallel items are items that have identical true scores.

If the items are standardized, the alpha is estimated by using the items "correlation mean or variance-co variances" mean is (Carmines and Zeller 1983; Ozdamar 1999a). Alpha due to the correlation mean is and alpha coefficient due to the variance-co variance mean is . If the correlation between the items is negative alpha coefficient will be negative because this will spoil the scales additive property, it also causes a spoil in the reliability model and scale is no more additive (Ozdamar, 1999a).

#### Theta coefficient

Because alpha coefficient may not be an optimal estimator of internal consistency reliability, when the items are heterogeneous or when the number of items is small. The other two measures of scale should be interested (i.e. theta and omega). The theta is based on a principle components model analysis, in which components are in descending order due to the variances of each of constructions (Carmines and Zeller, 1982). Theta coefficient depends on the property like; the first component is the linear component with the maximum variance. The second component is the linear component with the second maximum variance. Components can be explained by percentage values to explain the variance of the original data set in order.

#### Omega coefficient

Heise and Bohrnstedt (1970) introduced the third estimate of internal consistency i.e. omega ( $W$ ). It is

based on the factor analysis model. Factor analysis is a computationally complex approach to examining the inter relationships among the items and subtests of items. In this type of modeling, in calculating the coefficient, before factoring '1' values on diagonal in the correlation matrix are replaced with the communality values.

## Results

The coefficients of internal consistency, mean item correlation and split-half reliability coefficients under different sample size were displayed in Table No. 1. As we observed that from the table the mean item correlation was highest when sample size is minimum ( $n=33$ ), when sample size increased by unity up to  $n=40$ , the mean item correlation is decreased from 0.3746 ( $n=34$ ) to 0.3428 ( $n=40$ ). Later, the inverse relationship was observed between sample size and mean item correlation after increasing the sample size from  $n=41$  to till  $n=130$ . However, the substantial amount of increase was observed in mean item correlation, when  $n>130$ .

Further, the split-half reliability coefficient was calculated for the dental environmental stress scale in varying sample size from  $n=33$ ,  $n=34$ ,  $n=35$ ,  $n=36$  ...  $n=250$ . The split-half reliability coefficient has maximum efficiency for sample size  $n=33$  and  $34$ , but the coefficient losing their efficiency under  $n=35$  to till  $n=40$ . If  $n>41$  the efficiency of split-half reliability coefficient further decreasing. However, if  $n >200$ , there is an improvement over its efficiency.

Reflecting on these variation in trends, note that the effect of sample size is the case of gaining improvement in mean item correlation and split-half reliability coefficient as one has to obtained more information. These estimates asymptote out in that a sample size i.e.  $n>51$  is not much more effective in estimation of mean item correlation and split-half reliability coefficient. Even  $n=33$ , if mean item correlation and split-half reliability coefficient are large and are improved by the time of  $n>200$ .

Similarly, as can be seen from the Table 1, the alpha coefficient of internal consistency is higher and consistent in efficiency, when  $n=33$  to till  $n=50$  and  $n>140$ . There was small amount of loss in efficiency of alpha coefficient was seen when  $n=51$  to till  $n=139$ . Similar findings were observed in efficiencies of theta and omega coefficient of internal consistency. The efficiency of theta coefficients, which are based one principal component analysis are acceptably similar to alpha coefficient efficiency, but negligible amount of

gain in efficiency of omega coefficient which is calculated from factor analysis as compared to both alpha and theta coefficients. Later, when taking  $n=140$  and above, the efficiencies of all three coefficients of internal consistency are improved. The trends of efficacies of three coefficients of internal consistency reliability are presented in the Figure No. 1.

## Discussion

In the present study concern, the equations and analytical illustrations presented in this article should have great applicability to the health researchers. The sample size is playing important role in calculation of efficiency of coefficients of internal consistency. The accuracy of coefficients of internal consistency changes according to the sample size. A highly positive correlation was observed between number of items and internal consistency reliability coefficients in the present study, these finding are agreed with Carmines and Zeller (1982); and Ercon I. et al. (2007). The alpha, theta and omega coefficient displayed analogous findings under different sample size used. The computation of alpha coefficient is based on correlation coefficient, with theta coefficient calculated based on principle components analysis. However, the omega coefficient is based on factor analysis. Even the theta coefficient is larger in small extent as compared to alpha and theta coefficients. All the three coefficients are uniformly performing well on their efficacies under smaller as well as larger sample size for the present study concern.

On the basis of results of the present study, the efficacies of coefficients of internal consistency reliability are consistent and comparable for  $n>50$ . For coefficient of internal consistency calculation for any scale with five points or four points, or three points, the sample size should be 50 enough. Ozdamar (1999a) claimed that for internal consistency reliability analysis applications the sample size should be  $>50$ , but Ercon I et al. (2007) claimed that the sample size is not important for reliability coefficient, but number of items is playing an important role in order to estimate the population parameter especially with omega coefficient.

## Conclusion(s)

On the basis of results of the present study, the efficacies of coefficients of internal consistency reliability are consistent and comparable for  $n>50$ . For coefficient of internal consistency calculation for any

scale with five points or four points, or three points, the sample size should be 50 enough.

## References

1. Cronbach, (1951). Coefficient alpha and the Internal Structure of tests. *Psychometrika*--VOL. 16, NO. 3, pp.297-334.
2. Stevanovic D (2011). Coefficients of internal consistency reliability [Review of the article "Effect of varying sample size in estimation of reliability coefficients of internal consistency" J S]. *WebmedCentral* 2011; 2(2):WMCRW00504.
3. Heston T. (2011). Structure [Review of the article "Effect Of Varying Sample Size In Estimation Of Reliability Coefficients Of Internal Consistency" by J S]. *WebmedCentral* 2011;2(2):WMCRW00511
4. Raykov, T. (1997). Scale reliability, Cronbach's coefficient alpha, and violations of essential tau-equivalence with fixed congeneric components. *Multivariate Behavioral Research*, 32, 329-353.
5. Cortina, J. M. (1993). What is coefficient alpha? An examination of theory and applications. *Journal of Applied Psychology*, 78 (1), 98-104.
6. Ercan Ilker et al. (2007). Examining Cronbach Alpha, Theta, Omega, Reliability Coefficients According to the Sample Size, Vol. 6, No. 1, 2-354
7. Gay, L. R. (1985). Educational evaluation and measurement. London: A Bell & Howell.
8. Carmines, E. G., & Zeller, R. A. (1982). Reliability and validity assessment. Beverly Hills: Sage Publications.
9. Arkin, H., & Colton, P. R. (1970). Statistical methods. New York: Barnes & Noble Books.
10. O'Connor, R. (1993). Issues in the measurement of health-related quality of life, working paper 30. Melbourne: NHMRC National Centre for Health Program Evaluation ISBN: 1-875677-26-7.
11. Carey, L. M. (1988). Measuring and evaluating school learning. London: Allyn and Bacon.
12. Oncu, H. (1994). Egitimde olcme vedegerlendirme (Measurement and evaluation in education). Ankara: Matser Basim.
13. Karasar, N. (2000). Bilimsel arastirma yontemleri (Research methods in science). Ankara: Nobel Yayin Dagitim.
14. Novick, M. R., & Lewis, M. R. (1967). Coefficient alpha and the reliability of composite measurements. *Psychometrika*, 32, 1-13.
15. Nunnally, J. C. (1978). Psychometric theory (2nd ed.). New York: McGraw-Hill
16. Carmines, Edward G., and Richard A. Zeller (1979). Reliability and Validity Assessment. Newbury Park, CA: Sage Publications
17. Carmines, E. G., & Zeller, R. A. (1982). Reliability and validity assessment. Beverly Hills: Sage Publications.
18. Thorndike, R. M., Cunningham, G. K., Thorndike, R. L., & Hagen, E. P., (1991). Measurement and evaluation in psychology and education (5th ed.). New York: Macmillian Publishing Co.
19. Rosenthal, and Rubin (1996). Comparing Correlated but Non-overlapping Correlation Coefficients, , *Psychological Methods*, 1, 178-183
20. Mendoza, J. L., Stafford, K. L., & Stauffer, J.M. (2000). Large-sample confidence intervals for validity and reliability coefficients. *Psychological Methods*, 5, 356-369.
21. Van Zyl, J.M., Neudecker, H. and Nel, D.G. (2000). On the distribution of the maximum likelihood estimator of Cronbach's alpha, *Psychometrika* 65(3), 271-280.
22. Ozdamar, K. (1999a). Paket programlarla istatistiksel veri analizi-1 (Statistical data analysis by custom softwares-1). Eskisehir: Kaan Kitabevi.
23. Heise, D. R., & Bohrnstedt, G. W. (1970). Validity, invalidity, and reliability. *Sociological Methodology*, 2, 104-129.

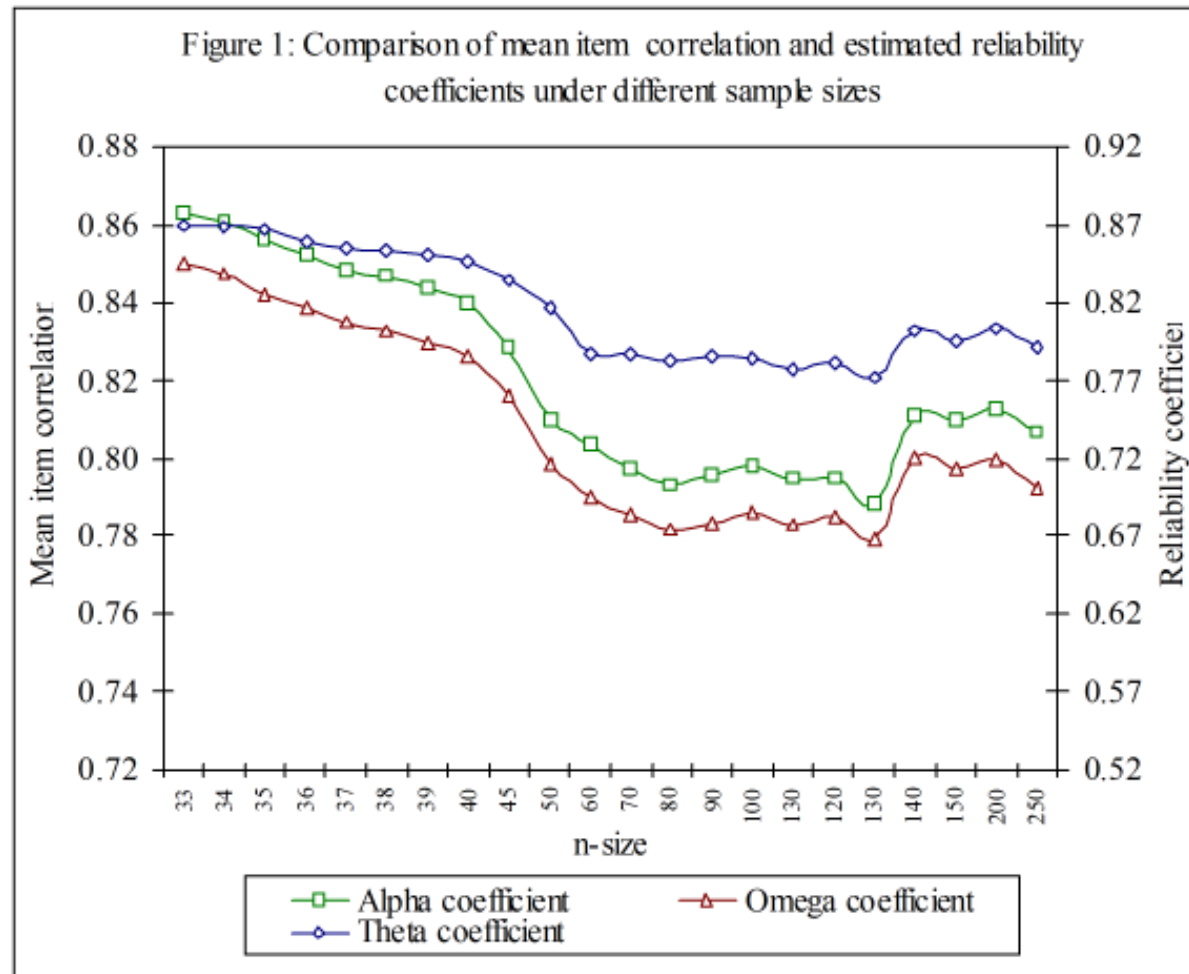
## Illustrations

### Illustration 1

#### Figure

Table 1: Estimated reliability coefficient in varying samples sizes

Samples size (n)	Mean item correlation	Split-half reliability	Alpha coefficient ( $\alpha$ )	Theta coefficient ( $\tau$ )	Omega coefficient ( $\Omega$ )
33	0.3780	0.8408	0.8631	0.8703	0.8500
34	0.3746	0.8445	0.8609	0.8684	0.8475
35	0.3657	0.8304	0.8559	0.8668	0.8419
36	0.3605	0.8269	0.8526	0.8591	0.8386
37	0.3547	0.8288	0.8487	0.8552	0.8348
38	0.3521	0.8310	0.8471	0.8531	0.8329
39	0.3479	0.8297	0.8436	0.8505	0.8297
40	0.3428	0.8242	0.8398	0.8469	0.8261
45	0.3276	0.8177	0.8283	0.8346	0.8160
50	0.3087	0.7777	0.8099	0.8169	0.7988
60	0.3023	0.7818	0.8035	0.7877	0.7899
70	0.2980	0.7486	0.7976	0.7877	0.7857
80	0.2940	0.7458	0.7930	0.7836	0.7818
90	0.2981	0.7574	0.7959	0.7860	0.7836
100	0.2998	0.7648	0.7983	0.7844	0.7862



## Disclaimer

This article has been downloaded from WebmedCentral. With our unique author driven post publication peer review, contents posted on this web portal do not undergo any prepublication peer or editorial review. It is completely the responsibility of the authors to ensure not only scientific and ethical standards of the manuscript but also its grammatical accuracy. Authors must ensure that they obtain all the necessary permissions before submitting any information that requires obtaining a consent or approval from a third party. Authors should also ensure not to submit any information which they do not have the copyright of or of which they have transferred the copyrights to a third party.

Contents on WebmedCentral are purely for biomedical researchers and scientists. They are not meant to cater to the needs of an individual patient. The web portal or any content(s) therein is neither designed to support, nor replace, the relationship that exists between a patient/site visitor and his/her physician. Your use of the WebmedCentral site and its contents is entirely at your own risk. We do not take any responsibility for any harm that you may suffer or inflict on a third person by following the contents of this website.