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Research Article

ASSESSING TOOL RELIABILITY: A SHINY R APPLICATION FOR MCDONALD'S OMEGA AND CRONBACH'S ALPHA

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Abstract

Reliability analysis is a widely used method to assess the consistency and internal reliability of psychometric instruments, particularly in medical and social science research. Cronbach's Alpha and McDonald's Omega are two commonly estimated reliability coefficients that evaluate the internal consistency of a scale. This article introduces an interactive and user-friendly application, created using the Shiny R framework to automate the process of computing these reliability measures. This tool allows researchers and practitioners to upload datasets, select relevant items, and instantly generate reliability statistics, making the analysis process more efficient and accessible. The tool can be accessed here: *https://stat-kmk.shinyapps.io/mcdonald/*

Keywords: Reliability analysis, Cronbach's Alpha, McDonald's Omega, internal consistency, psychometric assessment, Shiny R, statistical software

INTRODUCTION

Reliability is a critical aspect of psychometric and survey-based research, ensuring that measurement instruments consistently produce stable and reproducible results[1]. It is especially important in fields such as psychology, education, and medical research, where assessments and questionnaires are frequently used to measure latent traits such as intelligence, attitudes, and health-related quality of life. A reliable instrument ensures that results remain consistent across different testing conditions and populations, thus enhancing the credibility and applicability of research findings. One of the most common methods for assessing reliability is internal consistency analysis, which evaluates how well individual items within a scale correlate with one another. This is particularly relevant for Likert-scale surveys, where respondents indicate their level of agreement with a series of statements. High internal consistency suggests that all items measure the same underlying construct, whereas low consistency may indicate problems with item wording, scale design, or construct validity. Two widely used reliability coefficients, Cronbach's Alpha and McDonald's Omega, provide insights into the internal consistency of a scale. While Cronbach's Alpha is the more conventional measure, it assumes tau-equivalence, meaning that all items contribute equally to the underlying construct. McDonald's Omega, on the other hand, accounts for varying factor loadings, providing a more accurate reliability estimate in many cases. While both focus on consistency rather than distribution, extreme non-normality can impact them. However, McDonald's Omega is generally more robust to violation of normality assumptions. This article presents an interactive and user-friendly application developed with the Shiny R framework to automate the computation of reliability measures.

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METHODOLOGY

To facilitate reliability analysis, we developed an R Shiny-based interactive application that enables users to compute Cronbach's Alpha and McDonald's Omega with ease. We have outlined the fundamental concepts of these methods below.

Cronbach's Alpha

Cronbach's Alpha (α) is a statistical measure used to assess the internal consistency and reliability of a psychometric scale or test[2]. It calculates the average inter-item correlation, providing a value between 0 and 1 that indicates how closely related a set of items are. Values closer to 1 suggest better reliability, with scores typically interpreted as follows: 0.90-1.00 represents excellent reliability, 0.80-0.89 is good, 0.70-0.79 is acceptable, 0.60-0.69 is questionable, and below 0.50 is considered unacceptable. However, Cronbach's Alpha has limitations, such as assuming items are equally weighted and being sensitive to the number of items in the scale.

It is computed using the formula

$$\alpha = \frac{k}{k-1}\left(1 - \frac{\sum_{i=1}^{k}\sigma_i^2}{\sigma_{total}^2}\right)$$

Where,
k is the number of items
σ_i^2 is the variance of the individual item
σ_{total}^2 is the variance of the total test score

McDonald's Omega

McDonald's Omega (ω) is an alternative reliability measure that addresses some of Cronbach's Alpha's limitations by using

factor analysis to estimate reliability[3,4]. Unlike Cronbach's Alpha, Omega considers the factor loadings of individual items and can handle scales with non-uniform item contributions. This makes it particularly useful for multi-dimensional scales or those with items that have different factor loadings. McDonald's Omega provides a more robust assessment of scale reliability, especially when the underlying assumption of tau-equivalence (equal item variances) is violated. Researchers often recommend reporting both Cronbach's Alpha and McDonald's Omega to provide a comprehensive view of a scale's reliability and to ensure the measurement tool is psychometrically sound.

It is computed based on a factor analysis model, typically expressed as:

$$\omega = \frac{\left(\sum_{i=1}^{k} \lambda_i\right)^2}{\left(\sum_{i=1}^{k} \lambda_i\right)^2 + \sum_{i=1}^{k} \psi_i}$$

Where,
λ_i represents the factor loadings of each item
ψ_i is the residual variance of each item

Implementation in Shiny App

The Shiny application[5] processes uploaded data using the psych package in R, ensuring robust statistical computation. In this app, while calculating McDonald's statistic, negatively correlated items are dropped, whereas Cronbach's alpha is based on all included items. The application dynamically updates reliability coefficients based on user selections and presents results in an interactive format (Fig-1). The output panel of this Shiny App provides a detailed summary of the reliability analysis for an assessment tool. It includes both Cronbach's Alpha and McDonald's Omega reliability estimates, offering insights into the internal consistency of the items. Additionally, the item-level statistics help evaluate the contribution of each item to overall reliability, indicating how removing an item would impact the scale's consistency. This information is essential for identifying weak items and refining the tool to enhance its reliability and validity. The structured output allows researchers and practitioners to make data-driven decisions about the assessment tool's effectiveness.

Users can:

- Upload an Excel file with the dataset.
- Select relevant variables for reliability analysis and compute reliability with a single click.
- Automatically generate Cronbach's Alpha and McDonald's Omega.
- Assess the impact of removing individual items on reliability scores.

The tool can be accessed here: *https://stat-kmk.shinyapps.io/mcdonald/*

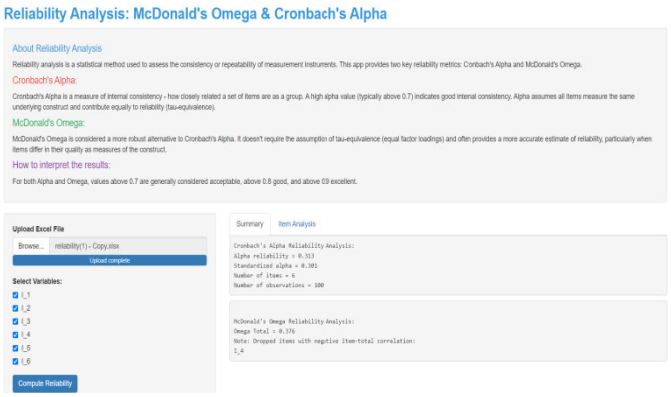

Fig. 1. Shiny app interface for reliability analysis

Conclusion

Reliability analysis plays a crucial role in evaluating the internal consistency of psychometric instruments. This Shiny application simplifies this process by providing an interactive, user-friendly platform for researchers and practitioners. By automating the calculation of Cronbach's Alpha and McDonald's Omega, this tool enhances efficiency, reduces errors, and ensures reproducible results in reliability assessment.

Declaration of Competing Interest

The authors declare that there is no conflict of interest.

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