

Computing Alpha and Omega Reliability Estimates

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This study has to do with calculating estimates of an instrument's reliability.

Coefficients alpha and omega are two reliability estimates used with tests and scales. Of the two, alpha is by far the most popular, a veteran with many decades of application behind it. McDonald (1999) reviewed the long-recognized shortcomings of alpha, suggesting "omega" as a fix for one of alpha's main limitations: the "tau-equivalent" assumption which is seldom met in practice.

The present paper builds on work by [Nelson \(2016\)](#). The majority of the datasets included in Table 1 below have been carried over from that work, with the addition of six new ones², and two additional statistics: standardized alpha in column 7, and omega hierarchical in column 11.

The new datasets serve in part to address an imbalance in the original paper – now there are more affective scales to counter the former predominance of cognitive instruments.

Nelson (2016) used two R packages ([MBESS](#) and [psych](#)), and the [CALIS](#) procedure in SAS University to calculate omega total values. These tools, powerful as they are, lean on software skills which might be seen by some as being in the somewhat advanced realm, tending to involve installation steps often substantially more demanding than those found in many of the usually straightforward installers for other apps.

The present paper has included the free [JASP](#) system as an alternative to MBESS. SAS is carried forward here even though the installation and application of the free University Edition is cumbersome and may well require IT assistance.

SPSS also receives mention in an appendix – it came to include support for computing omega in a system update released in the latter half of the year 2020.

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² Numbers 10, 11, 12, 14, 15, and 16 in Table 1.

Table 1

1	2	3	4	5	6	7	8	9	10	11
No.	Source	Type	Items	N	Alpha	Std. Alpha	Omega CALIS	Omega JASP	Omega total	Omega hier.
1	MathsQuiz	Test	15	999	0.80	0.78	0.80	0.81	0.80	0.69
2	UniAA	Test	30	127	0.74	0.74	0.75	0.74	0.76	0.41
3	UniBB	Test	34	132	0.82	0.81	0.82	0.82	0.83	0.49
4	Zmed	Test	100	2,470	0.96	0.96	0.95	0.96	0.96	0.76
5	HalfTime	Test	100	424	0.94	0.93	0.92	0.93	0.94	0.70
6	N Rivers	Test	50	689	0.92	0.92	0.92	0.92	0.92	0.74
7	LenguaBlg	Test	50	5,504	0.81	0.81	0.82	0.82	0.83	0.72
8	LenguaBlg	Test	47	5,504	0.83	0.83	0.84	0.83	0.84	0.72
9	Negocios	Test	60	500	0.86	0.86	0.85	0.86	0.87	0.57
10	FIMS	Test	14	6,371	0.69	0.70	0.70	0.70	0.73	0.53
11	FIMS AUS	Test	14	4,320	0.60	0.60	0.61	0.62	0.63	0.46
12	FIMS JPN	Test	14	2,051	0.73	0.73	0.74	0.74	0.75	0.45
13	DunnSES	Scale	7	201	0.94	0.94	0.94	0.94	0.96	0.92
14	BFIneuro	Scale	5	2,663	0.81	0.81	0.80	0.81	0.85	0.73
15	Blirt8	Scale	8	211	0.78	0.78	0.79	0.79	0.84	0.54
16	Hammer	Scale	29	758	0.93	0.93	0.93	0.94	0.94	0.75

Table 1 serves as a stage for a variety of questions.

Q1: what is standardized alpha (column 7)?

Both alpha and standardized alpha are reliability estimates with corresponding models.

Alpha is often also referred to as “Cronbach’s alpha”. It is based on what is referred to as the “tau-equivalent” model and, as such, has a basic underlying assumption of equal inter-item covariances.

Standardized alpha is not used nearly as often but is certainly supported in numerous apps/programs (three of them being the [psych](#) package in R, the reliability module in [JASP](#), and the Scale option in **SPSS**). Its underlying model adds another assumption: items are “parallel”, they meet the tau-equivalent assumption, and, in addition, it is assumed that in the population all items have the same variance.

According to Falk and Savailie (2010, p.445), “The decision of which version of alpha to use depends on whether researchers decide to standardize a test’s items before adding the items to form a composite score.” They elaborate on the importance of recognizing that alpha and standardized alpha are based on different models, tau-equivalent and parallel.

Cho (2018) suggests that standardized alpha is a misnomer as it has nothing to do with alpha, saying that “... there is no reason to include the word alpha in the name of the coefficient”. He found that the use of this statistic increased after SPSS included it many years ago³. Cho suggested that uninformed users may think standardized alpha to be superior to alpha just because “standardized” sounds better. To clarify matters, he

³ Original reference is the SPSS User’s Guide (Sprecht, 1975).

suggested that alpha be renamed to “tau-equivalent reliability”. In an earlier paper, Cho (2016) suggested renaming “standardized alpha” to “parallel reliability”.

Looking at Table 1, a comparison of columns 6 and 7 indicates only a few very minor differences between the two alphas for the instruments included in this study. That is to say, in this study little difference was found in the estimates of tau-equivalent reliability and parallel reliability (columns 6 and 7 respectively)⁴.

{Bandalos 2018 has a summary of model assumptions in her “Reliability and Validity” chapter (Chapter 10); Meyer 2010 has a similar discussion in his Chapter 3, “Assumptions”.}

Q2: what are the omega total values in Table 1’s columns 8, 9, and 10?

McDonald (1999) is generally cited as the originator of the omega statistic. Omega is a reliability coefficient which, unlike alpha, does not depend on items being tau-equivalent, a dependence difficult to meet in practice, resulting in alpha often being an underestimate of reliability. When items are not tau-equivalent (the usual case), omega will be a more accurate estimate of reliability than alpha, and will exceed alpha in value⁵.

Here, in this paper, the term “omega total” is used in order to distinguish it from “omega hierarchical” (discussed below). In the current literature this distinction is generally not made, with omega total often being simply referred to as just “omega” or as “McDonald’s omega”.

Column 8 in Table 1 has omega total values computed using the [CALIS](#) module in SAS (as in Nelson (2016) and Geldhof et al. (2013)). CALIS uses a structural equation model (**SEM**).

Column 9 omega total values were obtained using [JASP](#) version 0.14.1. JASP uses a confirmatory factor analysis model (**CFA**), postulating a single factor.

Column 10 draws on the use of the CRAN [psych](#) package, using exploratory factor analysis (**EFA**) and a Schmid-Leiman transformation (Schmidt & Leiman, 1957) to obtain omega statistics. {The S-L transformation is covered in Thompson 2004.}

Q3: why are the three omega total values different?

This question arises when comparing columns 8, 9, and 10 in Table 1.

The first two of these columns essentially employ a structural equation model. CALIS and JASP use single-factor models (SEM for CALIS; CFA for JASP) and, as such, differences in column 8 and 9 omega total values should be slight. And they are.

Column 10’s values are based on EFA and a bifactor model. In this case, omega total involves loadings on a general factor plus cross loadings on secondary factors. Differences are now noted in a few of the Table 1 rows – compare columns 8, 9, and 10 for each of the 16 datasets.

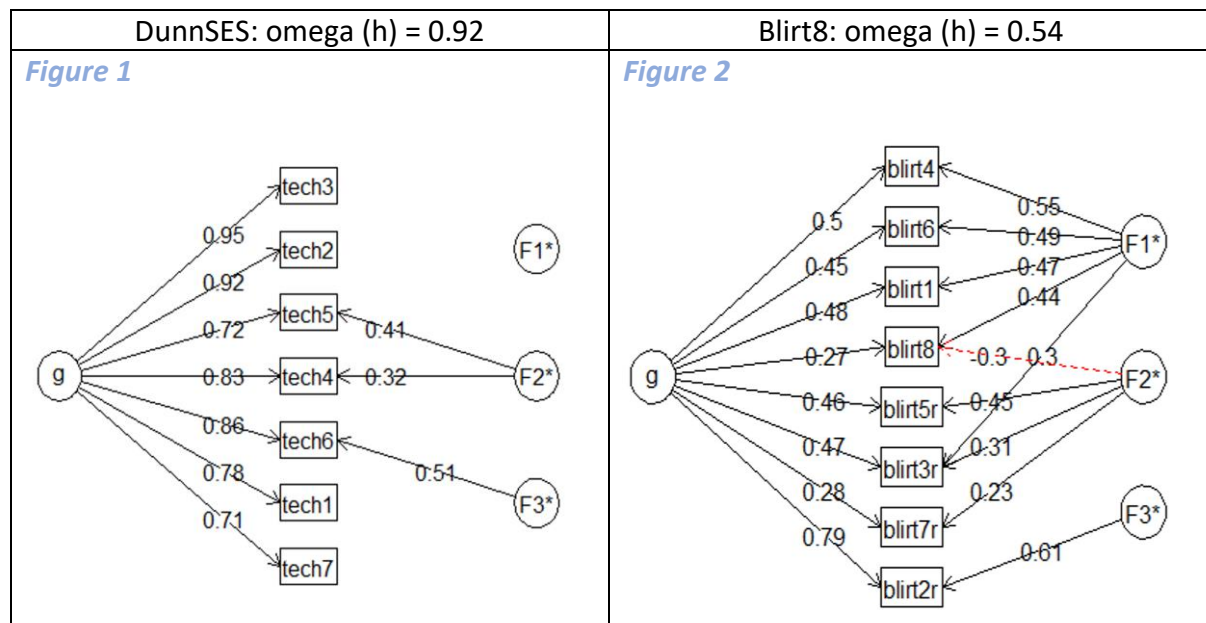
⁴ JASP 0.14.1 was used to get the values seen in columns 6 and 7.

⁵ As pointed out below under Q6, omega will exceed alpha but often by only a slight amount.

Q4: what is omega hierarchical in Table 1 column 11?

The figure in column 11, “Omega hier.”, is derived from the same Schmid-Leiman bifactor solution used to find the omega total seen in column 10, but now only loadings on the general factor are employed in the calculation.

Two examples will help indicate the meaning of omega hierarchical. Figures 1 and 2 were produced by the [psych](#) program (omega (h) below is omega hierarchical):



DunnSES results are seen on the left in *Figure 1*. The general factor, “g”, has a strong influence on the measure’s seven items, with relatively high loadings: from 0.71 to 0.95. Such is not the case with Blirt8, *Figure 2*, where the influence from “g”, the general factor, is less, having loadings ranging from 0.27 to 0.79. The three second-order Blirt8 factors, F1, F2, and F3 have had much more impact than the second-order factors in DunnSES.

Revelle, the author of the *psych* package, shies away from using the term “unidimensional”, as does Cho (2016), but other authors (McDonald 1999, Thompson 2004, Meyer 2010, Bandalos 2018,) might look at *Figure 1* and possibly interpret it as at least suggesting unidimensionality – there’s a strong dominant general factor with little influence from the second-order factors. Some would say that the DunnSES result displayed in *Figure 1* is evidence of a “purer” measure when compared with the Blirt8 results seen in *Figure 2* – by and large, responses to the DunnSES items are attributable, or “linked”, to a single general factor. Revelle and Zinbarg (2009) suggest that omega(h) is “... an index of how much the test measures one common factor”.

Flora (2020) has a discussion of CFA/EFA, the bifactor model, and omega hierarchical, including mention of unidimensionality. His article also has examples and tutorials for using R packages to estimate omega. Goodboy & Martin (2020) also have extensive coverage of CFA and dimensionality, with tutorials and mention of related software.

Note that a measure can have good alpha and omega total reliability figures while having low omega hierarchical – the “Negocios” test (row 9 in Table 1) is an example – it’s not very “pure”, with omega hierarchical at 0.57, but its reliability is acceptable: both alpha and omega total are at 0.86. This serves to underline something known for decades, but not always acknowledged: alpha is not an index of a measure’s dimensionality. For that matter, neither is omega total.

Q5: should I report alpha, standardized alpha, or omega total in my report?

Omega total for sure. It is a more accurate estimate of reliability. It does not assume that items are tau-equivalent or parallel. In addition, omega total is an upper bound for alpha – alpha will always be less than omega total unless items are tau-equivalent, in which case alpha will equal omega total.

A suggestion might be to report alpha also. Omega is still relatively new. Readers of a technical report may be unfamiliar with omega and uncertain how to interpret it. We’ve had alpha for so long a reliability report may seem lacking if alpha is not included.

Standardized alpha is rarely encountered as its assumptions are difficult to meet.

Q6: if I don’t have an app for omega, and have to report only alpha, am I really bad off?

The answer might depend on what one is doing.

If engaged in a personal project of some sort, such as perhaps reviewing student responses to a cognitive test, or looking at returns from a class survey, then alpha will very likely be quite sufficient.

From a practical point of view, most often the difference between alpha and omega total may not amount to much. In this study, a comparison of alpha (column 6 in Table 1), and omega total, as computed by either CALIS or JASP (columns 8 and 9), shows nearly identical values for the 16 instruments involved in this study.

There are other studies that have noted the great similarity between alpha and omega total values. One of the more recent is Hayes & Coutts (2020) -- their study used 17 scales, comparing omega total and alpha, finding a maximum difference of just .01 (alpha 0.80, omega total 0.81, for a six-item scale of “social anxiety”). The Hayes & Coutts study made it clear that omega total had been calculated from a CFA model. (In the present study, Table 1’s columns 8 and 9 also used the CFA approach.)

A study by Savalie & Reise (2019) stated that “Researchers working with well-established unidimensional scales who continue reporting alpha are rarely more than trivially misrepresenting their measures’ reliability.”

In a simulation study comparing alpha and omega values under varied conditions, Zhang and Yuan (2016) concluded: “... for normally distributed data, there is no substantial difference between alpha and omega estimates regardless of whether the items are tau-equivalent or not”.

Geldhof et al. (2013) used CALIS to compute omega total, compared results to alpha, and found no compelling reason to advocate against the continued use of alpha.

Even McDonald (1999, Chapter 6), wrote that "... it is difficult to find ... empirical examples in which the estimate of alpha is very much lower than that of omega".

These literature citations are largely founded on the use of omega total values resulting from CFA or SEM. In the present study, omega total was also derived by applying an EFA bifactor model – the results for the 16 Table 1 datasets show at least one non-trivial difference between alpha (column 6) and EFA omega total (column 10): see row 15 where the Blirt8 scale has alpha at 0.78 and EFA omega total (column 10) at 0.84.

At the end of the day, and in spite of often highly similar alpha and omega total figures, one could be "bad off" reporting only alpha as editors, reviewers, and publishers increasingly come to expect omega total – it is a more accurate reliability coefficient. An alpha-only report might now be seen as reflective of inadequate and dated research, below par, not up to snuff⁶.

Q7: Should I look at omega hierarchical?

Doing so might be insightful. If there are a relatively small number of items, the path diagrams (*Figure 1* and *Figure 2* above) can be informative. They may be quite welcome in a report.

But above twenty items or so, the path diagrams become much too busy, overcrowded. Then a simple comparison of omega hierarchical and omega total will carry a message as to the saturation of the general factor.

⁶ A bonus of computing omega is that its value will (should) never be less than alpha.

Software used

[JASP](#) Version 0.14.1 was used to calculate the alpha and standardized alpha figures seen in columns 6 and 7 of Table 1, and the CFA-based omega total in column 9. JASP will accept files in these formats: .sav, .txt, .csv, and .ods. In this study, the [Omega1](#) macro in [Lertap5](#) was used to prepare csv files having item scores for each of the 16 datasets⁷.

JASP limitation: using version 0.14.1 to save large datasets required a great deal of time and resulted in very large JASP files. Getting JASP results for the two largest datasets, Zmed and HalfTime, each with 100 items, took more than an hour to process, and over 400 megabytes to save (each). The other datasets were much easier – UniBB, for example, took less than a minute and required 14 megabytes to save⁸.

Appendix B has more information about JASP.

The [CALIS procedure](#) in the University edition of [SAS](#) was used to produce the factor loadings needed to compute the omega total values seen in Table 1 column 9. The SAS script used may be downloaded [from here](#).

CALIS limitations: SAS University is somewhat cumbersome to set up. CALIS does not actually calculate omega total – the sum of factor loadings must be squared and then divided by the variance of the test or scale score. JASP is much easier to use.

Omega total in Table 1 column 10, and omega hierarchical in column 11, were obtained by using the CRAN [psych](#) package following a process described in Appendix C.

[AMOS](#) and [Mplus](#) are two other programs capable of producing omega total estimates. Bandalos (2018, Chapter 13) has an Mplus omega example, as does Goodboy and Martin (2020).

A version of **SPSS** released late in 2020 has support for omega users (see Appendix A).

Updated comments, 22 February 2021:

[Lertap5](#) was tested after it was updated to include an estimate of omega total (see Appendix D). Lertap5 limitation: requires a version of Microsoft Excel.

Data sources

Many of the datasets used in Table 1 may be [found here](#). The “Blirt8” dataset is included in [this zip file](#). Hammer data are [found here](#).

⁷ csv files have “comma-separated values” and are made by a number of apps (Microsoft Excel and Google Sheets to name just two). Lertap5 is not required.

⁸ JASP has been informed of this problem and is said to be working on a revised version.

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Zhang, Z., & Yuan K. (2016). Robust Coefficients Alpha and Omega and Confidence Intervals with Outlying Observations and Missing Data: Methods and Software, *Educational and Psychological Measurement*, Vol. 76(3) 387–411

The references found on this [Wikipedia page](#) are also useful (as at January 29, 2021).

Appendix A: SPSS

Version 27.0.1.0 of **SPSS** was released in the latter half of the year 2020. This was the first version to support the calculation of omega total⁹.

An introduction to this version is [here](#). To be noted is that SPSS does not support CFA¹⁰ (confirmatory factor analysis). Instead, SPSS omega relies on a “closed-form” solution, likely to be as described in Hancock & An (2020), and in Hayes & Coutts (2020)¹¹.

SPSS was used to obtain estimates of alpha, standardized alpha, and omega total for each of the 16 datasets in Table 1. Table 2 below has results. Most of the JASP and SPSS omega values agree.

When asked to compute standardized alpha, SPSS gave a warning, reporting that “the determinant of the covariance matrix is zero (or approx.)” for all 16 datasets. However, it nonetheless reported figures and as seen in Table 2, they were close to those reported in column 7 of Table 1.

Table 2

1	2	3	4	5	6a	6b	7	7b	9	9b
No.	Source	Type	Items	N	Alpha	SPSS Alpha	Std. Alpha	SPSS Std. Alpha	Omega JASP	SPSS Omega
1	MathsQuiz	Test	15	999	0.80	0.80	0.78	0.80	0.81	0.81
2	UniAA	Test	30	127	0.74	0.74	0.74	0.74	0.74	0.71
3	UniBB	Test	34	132	0.82	0.82	0.81	0.82	0.82	0.80
4	Zmed	Test	100	2,470	0.96	0.96	0.96	0.96	0.96	0.96
5	HalfTime	Test	100	424	0.94	0.94	0.93	0.94	0.93	0.93
6	N Rivers	Test	50	689	0.92	0.92	0.92	0.92	0.92	0.92
7	LenguaBlg	Test	50	5,504	0.81	0.81	0.81	0.81	0.82	0.88
8	LenguaBlg	Test	47	5,504	0.83	0.83	0.83	0.83	0.83	0.83
9	Negocios	Test	60	500	0.86	0.86	0.86	0.86	0.86	0.85
10	FIMS	Test	14	6,371	0.69	0.69	0.70	0.69	0.70	0.69
11	FIMS AUS	Test	14	4,320	0.60	0.60	0.60	0.60	0.62	NA
12	FIMS JPN	Test	14	2,051	0.73	0.73	0.73	0.73	0.74	0.74
13	DunnSES	Scale	7	201	0.94	0.94	0.94	0.94	0.94	0.94
14	BFlneuro	Scale	5	2,663	0.81	0.81	0.82	0.81	0.81	0.81
15	Blirt8	Scale	8	211	0.78	0.78	0.78	0.78	0.79	0.78
16	Hammer	Scale	29	758	0.93	0.93	0.93	0.93	0.94	0.93

When computing omega, SPSS again reported problems with dataset covariance matrices; it gave warnings for all but one of the tests (the exception was the FIMS test in row 10). For the FIMS AUS dataset (row 11), SPSS found that “Omega could not be estimated due to negative or zero item covariances”. SPSS found no problems with the four scales (rows 13 – 16).

Note: a few (3) SPSS alpha values exceeded omega values (unexpected). JASP had one similar case.

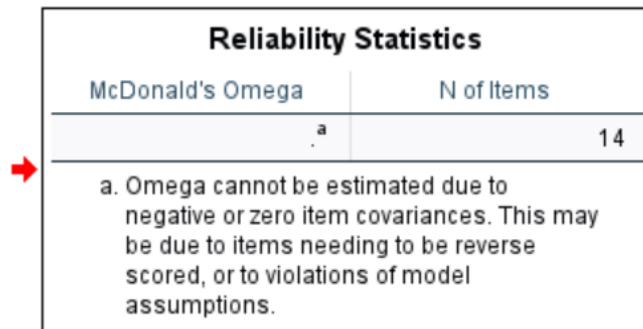
⁹ [IBM SPSS](#) Version 27.0.1.0. Omega statistic discussed [here](#). Parallel reliability discussed [here](#).

¹⁰ According to Hayes & Coutts (2020), “SPSS has no built in procedures for confirmatory factor analysis.”

¹¹ Both papers suggest CFA is preferred; the closed-form method is a possible option when CFA is not available.

Updated SPSS comments, 4 February 2021

The previous page makes mention of problems SPSS encountered when processing data from the FIM AUS dataset. The error message from SPSS was informative:



The image shows a screenshot of the SPSS 'Reliability Statistics' dialog box. The 'McDonald's Omega' field contains a period '.' and the 'N of Items' field contains the number '14'. A red arrow points to a text box below the dialog box containing the following error message: 'a. Omega cannot be estimated due to negative or zero item covariances. This may be due to items needing to be reverse scored, or to violations of model assumptions.'

The [FIMS AUS dataset](#) is from a short cognitive test of mathematics.

Cognitive items are not candidates for reverse scoring. When, as above, SPSS mentions a possible need for items to be “reverse scored”, it is assuming that affective items are in use, such as those found in scales. That’s not the case here.

What has happened is that one of the 14 test items had negative correlations with some of the other items. Table 3 below has been copied from a [Lertap5](#) spreadsheet; SPSS and JASP will readily make similar reports.

Table 3

Lertap5 IStats matrix, created: 31-Oct-20.

Record No.	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14
Q12	-0.01	-0.05	-0.04	0.00	0.02	0.01	0.08	-0.02	0.00	-0.02	0.01	1.00	0.05	-0.07
Q13	0.00	0.04	0.03	0.05	0.11	-0.01	0.03	0.01	0.08	0.02	0.18	0.05	1.00	0.04
Q14	0.15	0.23	0.24	0.23	0.08	0.19	0.05	0.09	0.10	0.19	0.16	-0.07	0.04	1.00
average	0.10	0.14	0.11	0.15	0.08	0.13	0.07	0.05	0.07	0.12	0.14	0.00	0.05	0.13
SMC	0.10	0.18	0.11	0.17	0.06	0.16	0.04	0.03	0.04	0.12	0.14	0.02	0.04	0.14

We can see that Q12 had negative correlations with Q1, Q2, Q3, Q8, Q10, and Q14.

An item meant to form part of a test or scale should not correlate negatively with other items. When negative correlations are found, coefficient alpha’s value will be affected – it’ll be lower than what it otherwise would be. Many times, an app will tell us what alpha would be if an item were deleted from the test or scale. In this example, alpha with all 14 items included was 0.602 – omitting Q12 boosted alpha up to 0.626

The closed-form method SPSS uses to calculate omega chokes when it encounters negative item correlations (or covariances). These incidents will not arise when standard data analysis procedures are followed: an initial look at item correlations/covariances should be made to make sure that negative inter-item correlations or covariances are not present.

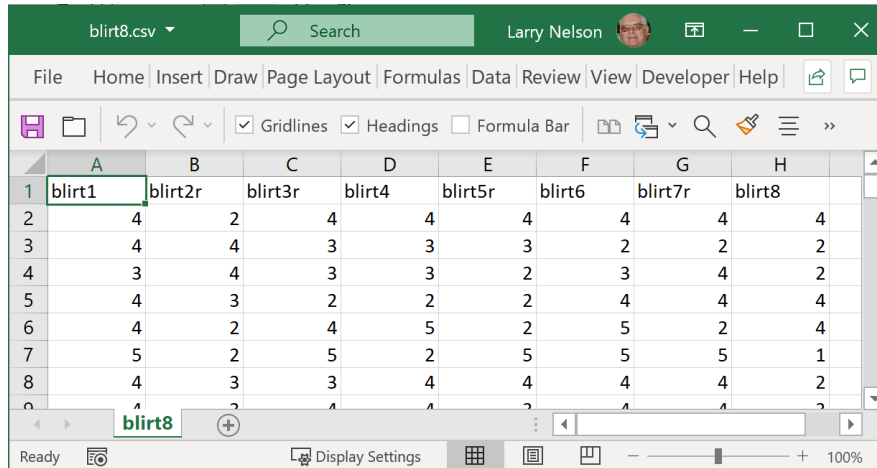
Appendix C mentions the use of an RStudio RMD script for calculating omega estimates using the closed-form method. It also found a fatal error -- no estimate could be made.

JASP processed the FIMS AUS dataset without problem but did note that Q12 “correlated negatively with the scale”.

Appendix B: JASP

JASP is a project based at the University of Amsterdam. The website [is here](#).

The JASP work undertaken for this paper involved the use of csv data files¹². A number of apps will open such files. The screen snapshot in Figure 3 displays the “blirt8.csv” file when opened in Microsoft Excel.



The screenshot shows a Microsoft Excel window titled 'blirt8.csv'. The window has a ribbon with tabs for File, Home, Insert, Draw, Page Layout, Formulas, Data, Review, View, Developer, and Help. The Home tab is active, showing options for Gridlines, Headings, and Formula Bar. The spreadsheet contains the following data:

	A	B	C	D	E	F	G	H
1	blirt1	blirt2r	blirt3r	blirt4	blirt5r	blirt6	blirt7r	blirt8
2	4	2	4	4	4	4	4	4
3	4	4	3	3	3	2	2	2
4	3	4	3	3	2	3	4	2
5	4	3	2	2	2	4	4	4
6	4	2	4	5	2	5	2	4
7	5	2	5	2	5	5	5	1
8	4	3	3	4	4	4	4	2

Figure 3

The snapshot shows the first eight rows of the csv file. The first row contains “headers” corresponding to the names of the eight items used in the BLIRT8 dataset.

Each column contains item scores for a person. The first person had a response scored as a “4” on the first item, “blirt1”. If the eight item scores were summed to get a person’s total score, in this case the first person would have a total score of 30.

There are a number of ways to create a csv file similar to this example. The file must have item scores, as exemplified above for Blirt8. The “[omega1](#)” special macro in Lertap5 will create csv files with item scores when users have cognitive items needing to be scored before making the csv file. Many users may have item scores already at hand in an Excel workbook, or Google Sheets, in which case saving a copy as a csv file will be straightforward.

The screen snapshot in Figure 4 below shows JASP version 0.14.1 with the first eight blirt8.csv rows displayed.

Figure 5 captures the JASP interface after initiating a “Single-Test Reliability Analysis”, and Figure 6 displays the resultant output.

¹² The same csv files were also used with SPSS.

blirt8 (D:\Omega work\Blirt8\Hayes-Coutts\omega)

Descriptives T-Tests ANOVA Mixed Models Regression Frequencies Factor Reliability

	blirt1	blirt2r	blirt3r	blirt4	blirt5r	blirt6	blirt7r	blirt8
1	4	2	4	4	4	4	4	4
2	4	4	3	3	3	2	2	2
3	3	4	3	3	2	3	4	2
4	4	3	2	2	2	4	4	4
5	4	2	4	5	2	5	2	4
6	5	2	5	2	5	5	5	1
7	4	3	3	4	4	4	4	2
8	4	3	4	4	3	4	4	3

Figure 4

blirt8* (D:\Omega work\Blirt8\Hayes-Coutts\omega)

Descriptives T-Tests ANOVA Mixed Models Regression Frequencies Factor Reliability SEM R

Single-Test Reliability Analysis

Variables

blirt1
blirt2r
blirt3r
blirt4
blirt5r
blirt6
blirt7r
blirt8

Single-Test Reliability

Scale Statistics

- Confidence Interval 95.0 %
- McDonald's ω
- Cronbach's α
- Guttman's λ_2
- Guttman's λ_6
- Greatest lower bound
- Average interitem correlation

Individual Item Statistics

- McDonald's ω (if item dropped)
- Cronbach's α (if item dropped)
- Guttman's λ_2 (if item dropped)
- Guttman's λ_6 (if item dropped)
- Greatest lower bound (if item dropped)
- Item-rest correlation
- Mean

Results

Single-Test Reliability Analysis

Frequentist Scale Reliability Statistics

Estimate	McDonald's ω	Cronbach's α
.	.	.

Figure 5

Once the eight items are moved from the left-hand panel (Figure 5) over to the “Variables” panel, action will begin automatically. Results are as seen in Figure 6.

Results

Single-Test Reliability Analysis

Frequentist Scale Reliability Statistics

Estimate	McDonald's ω	Cronbach's α
Point estimate	0.785	0.780
95% CI lower bound	0.741	0.731
95% CI upper bound	0.829	0.821

Figure 6

Appendix C: CRAN psych module

CRAN, the Comprehensive R Archive Network, is a repository of application packages and tools contributed by numerous authors, created using the R scripting language. An introduction may be found at [this webpage](#). Discussions of the advantages and disadvantages of R and CRAN are numerous, as an internet search will reveal (try “pros and cons of R”).

Readers who are not familiar with CRAN and R packages may be best advised to muster a considerable amount of patience before “taking the plunge”. There’s a great deal to like, a large number of free packages. Many of them are very powerful data analysis tools. However, the learning curve can be rather steep, and at times the documentation may be seen as rather abrupt, less than friendly for beginners.

The following resources cover the steps used in this paper to get the omega reliability estimates seen in columns 10 and 11 of Table 1, and the path diagrams displayed in *Figure 1* and *Figure 2*.

- (1) Use [this document](#) for instructions on the installation of R and RStudio.
- (2) Then, confer with [this document](#) for instructions on the installation and use of two R packages, “psych”, and “TAM”, and note: “TAM” is not required for calculating omega statistics – its installation may be skipped.

The document covers two “test drives”. The first uses RStudio and an RMD script, “Omega-From-IScores.Rmd”. A Microsoft Word document with sample output produced by this script may be downloaded from [this link](#)¹³.

The second test drive uses the R programming environment and the “Omega-IScoresProg.R” script. Output is seen in the document itself.

Updated comments, 6 February 2021

- There can at times be limitations when using the psych package. For example, when processing data collected using the 21-item [Beck Depression Inventory](#) with a sample of Australian students, the following error messages appeared:

```
Warning in fa.stats(r = r, f = f, phi = phi, n.obs = n.obs, np.obs = np.obs, :The estimated weights for the factor scores are probably incorrect.Try a different factor score estimation method.

Warning in fac(r = r, nfactors = nfactors, n.obs = n.obs, rotate = rotate:An ultra-Heywood case was detected. Examine the results carefully

Warning in cov2cor(t(w) %*% r %*% w): diag(.) had 0 or NA entries; non-finite result is doubtful
```

¹³ A look at the output is recommended.

- An RMD script for calculating omega using the closed-form approach employed in SPSS is now available [here](#). It works in the same manner found in the “Omega-From-IScores.Rmd” script mentioned above.

An example of the output produced by the script [is here](#). Note (a): the script assumes that the psych package has been installed, as mentioned in (2) above. Note (b): the closed-form method is not the preferred method for calculating omega. It’s a resource perhaps useful when the methods based on CFA or EFA are not at hand.

Appendix D: Lertap5
(updated 22 February 2021)

Lertap5 is a veteran item, test, and survey analysis system now packaged as an Excel “app”:
[Lertap5.xlsm](#).

Some of its support for omega has been mentioned in main the text above. For example, the
“[Omega1 macro](#)” in Lertap5 is designed for use with the R psych package mentioned in Appendix C.

Hancock & An (2020) present a closed-form method for estimating omega total, and extensively document both its strengths and weaknesses. The method is used in SPSS to derive an estimate of omega total (see Appendix A in this document).

Hancock & An’s Appendix A has related R code – it has been used in the “RMD script for calculating omega” mentioned towards the end of Appendix C in this document.

Hayes & Coutts (2020) developed and made freely-available omega macros for use with SAS and SPSS. They also discussed the closed-form method presented by Hancock & An (2020), referring to it as the “HA algorithm”. Table 1 their article has a comparison of omega total estimates using CFA, EFA, and HA.

The closed-form method has now been installed in Lertap5 and tested with the 16 datasets used in this paper. Results concur with the SPSS omega estimates seen in the last column of Table 2 in Appendix A¹⁴ of this document.

Figure 7 displays Lertap5’s closed-form results using the Blirt8 dataset¹⁵

Closed-form lambda estimates:	
blirt1	0.652
blirt2r	0.676
blirt3r	0.582
blirt4	0.709
blirt5r	0.548
blirt6	0.634
blirt7r	0.379
blirt8	0.343
Sum of lambda estimates:	4.52
Score variance:	26.28
omega estimate:	0.779

Figure 7

Lertap5.xlsm has been programmed using VBA, Visual Basic for Applications. VBA code lines used to calculate the lambda estimate for a given item are shown below:

¹⁴ Agreement is to be expected as the closed-form method is a non-iterative procedure requiring only an inter-item covariance matrix.

¹⁵ Compare with Table 1 in Hayes & Coutts (2020). In Figure 7 above, “lambdas” are estimated factor loadings.

```

For ColNo1 = 1 To nits
  If ColNo1 <> rownumber Then
  If ColNo1 <> nits Then
    For ColNo2 = ColNo1 + 1 To nits
      If ColNo2 <> rownumber Then
        If ColNo2 <> nits + 1 Then
          Let lambdaNumerator = lambdaNumerator + (Cov(rownumber, ColNo1) * Cov(rownumber, ColNo2))
          Let lambdaDenominator = lambdaDenominator + Cov(ColNo1, ColNo2)
        End If
      End If
    Next ColNo2
  End If
  End If
Next ColNo1

```

In the VBA code above, “nits” is the number of items; “rownumber” is the sequential number of an item; it will range from 1 to nits as controlled by a For/Next sequence not shown above.

Cov(nits,nits) holds covariance values. The lambda estimate for an item will be numerator divided by denominator (*of course*).

To be mentioned is that CFA or EFA are preferred over the closed-form approach. See Hayes & Coutts (2020) and also Hancock & An (2020) for discussions on the limitations of the closed-form method. Lertap5 will present appropriate warnings when some of the limitations are encountered (they are often related to negative covariance figures).

Examples:

