

## Version History

### Matlab Toolbox 'Measures of Effect Size'

Harald Hentschke, Maik C. Stüttgen

#### Version 1.6 (April 2018)

##### general

- corrected version info (sorry for the confusion in the previous round of updates) and updated author affiliations in all m-files
- from now on, omitting version number in file name of documentation pdf

##### mes

- **Overhaul of standardized mean differences**, based on i) a discussion of appropriate bias correction for paired data (see issue raised by Rainer Dusing, <https://github.com/hhentschke/measures-of-effect-size-toolbox/issues/1>), ii) the following (re-) appraisal of old and new literature, and ii) simulations (<https://github.com/hhentschke/simulate-standardized-mean-differences>). Also see Table 1 below for a summary.
  - in the previous versions of mes, approximate analytical CI (also termed 'traditional' CI) of Hedges's g were computed from the bias-corrected point estimate. Following recommendations in the literature and results from own simulations we now refrain from doing that and instead use the uncorrected point estimate because - counterintuitively - this results in better coverage
  - in textbook formulas for traditional CI of Hedges's g, critical z values are used. However, in accord with a recommendation by Nakagawa & Cuthill (Biol. Rev. 82:591-605, 2007; p. 599), previous versions of mes computed them with critical t values. Yet, as simulations showed that CI coverage is better with critical z values, we now use these, in line with textbook wisdom
  - exact analytical CI of Hedges's g had been bias-corrected in the previous versions in the erroneous belief that this would improve coverage; they are not anymore
  - changes to standardized mean differences for dependent data:
    - i) Glass's  $\Delta$  may now be computed for dependent data as well
    - ii) bias correction has changed for Hedges's g and has been implemented for Glass's  $\Delta$
    - iii) improved formulas for confidence intervals have been implemented for Hedges's g and Glass's  $\Delta$  (as described in Bonett 2008 & 2015, see documentation)
    - iv) in the context of these changes, we provide an overview of the various standardized mean differences that have been discussed in the literature, including the confusing nomenclature, in the documentation (see introductory note to Hedges's g)
  - function fast\_corr.m by Elliot Layden is used to compute correlations between input

variables x and y (much faster in the computation of some variants of Hedges's g and its confidence intervals (CI) for dependent data)

- an indexing bug in the code for effect size 'requiv' led to an error if inputs x and y had more than one column and exact confidence intervals were requested - this is fixed
- a warning is now issued if both exact and bootstrapped confidence intervals are requested as the latter take precedence over the former
- minor improvements of code (readability) in some places as suggested by Matlab's Code Analyzer Report and correction of some typos
- renamed some variables to better accomodate new code

	Hedges's g	Glass's delta
<b>independent data</b>	<ul style="list-style-type: none"> <li>• point estimate: unchanged</li> <li>• CI, exact analytical: removed bias correction</li> <li>• CI, approximate analytical: removed bias correction, replaced <math>t_{crit}</math> by <math>z_{crit}</math></li> </ul>	<ul style="list-style-type: none"> <li>• point estimate: introduced bias correction</li> <li>• CI, approximate analytical: replaced <math>t_{crit}</math> by <math>z_{crit}</math></li> </ul>
<b>dependent data</b>	<ul style="list-style-type: none"> <li>• point estimate: implemented new bias correction (Bonett 2009 &amp; 2015)</li> <li>• CI, approximate analytical: implemented improved formula (Bonett 2015)</li> <li>• CI, exact (using noncentral t-distribution): newly implemented</li> </ul>	point estimate, approximate analytical CI and bias correction newly implemented

**Table 1: summary of changes to standardized mean differences**

### Version 1.5 (July 2017)

NOTE: this is the last version of the toolbox uploaded on SourceForge (<https://sourceforge.net/projects/mestoolbox/>). All further versions will be developed on GitHub (<https://github.com/hhentschke/measures-of-effect-size-toolbox>) and will be uploaded automatically on the Matlab Central File Exchange (<http://de.mathworks.com/matlabcentral/fileexchange/32398-measures-of-effect-size-toolbox>).

- mes1way, mes2way: renamed variable 'table' to 'summaryTable' (to avoid name intersection with the homonymous data type introduced in Matlab R2013b)
- correction of typos

### **Version 1.4 (January 2015)**

- mes2way: it is now possible to run mixed within/between analyses with unequal sample sizes along the between-subjects factor. According changes were made to the documentation and help. Also, in the table of results mes2way now puts out summed squares, degrees of freedom etc. of the total error, too (which had simply been forgotten)
- correction of some typos in documentation (missing subscript 'p' in formula for partial omega squared for oneway designs)

### **Version 1.3 (April 2013)**

- the documentation contained errors: the numerators in the formulas for Hedges' g, Glass's delta and mdbysd were given as  $m_2 - m_1$  (or  $m_{\text{exp}} - m_{\text{control}}$ ) whereas in the code (mes.m) they are computed as  $m_1 - m_2$ , which is the correct and intended way (thanks to Philippe Terrier for the hint).
- exact confidence intervals for g1 are implemented
- setting up a twoway analysis, particularly with contrasts and if each factor has many levels, is not easy. In order to facilitate this and to give the user some visual orientation an option to plot the data was implemented in mes2way.m: if input variable 'doDataPlot' is set to true, function mesdplot.m will be called from within mes2way.m and generate a figure with a subplot layout reflecting the layout of the analysis. Furthermore, repeated measures data will be marked by color, as will be contrast weights (via the subplot background color). For specifics see the help for mes2way.m, msdplot.m and/or the documentation.
- the documentation is corrected and extended in the points listed above.

### **Version 1.2 (March 2012)**

We have deliberately taken a small step back, namely from standardized to unstandardized mean differences: it is now possible to obtain as an output the mean difference between two samples (mes.m) and the oneway and twoway equivalents, contrasts (mes1way.m and mes2way.m). Mean differences are of course trivial to compute, but confidence intervals may pose a challenge, particularly those of contrasts in oneway and twoway analyses. We included these unstandardized mean differences because statistics expressed in the original units of measurement (e.g. millivolts) may confer a better 'feeling' for the relevance of differences between groups, depending on the data at hand. Even unstandardized mean differences including confidence intervals provide more information than p values from t-tests. Similar arguments apply to contrasts and confidence intervals. So, the details:

#### **mes.m**

- new output fields md and mdCi (mean difference and corresponding confidence intervals)
- the code computing t statistics has been streamlined: instead of resorting to the Matlab-provided functions ttest.m and ttest2.m the code now computes all relevant terms from

scratch. This is more economical than the previous version because many terms computed in this section are building blocks not only for the t statistic but also for e.g. Hedges' g. Please note that values of the terms affected by this change (t, p, mdbysd, requiv, Hedges' g, and confidence intervals thereof) may differ between versions 1.1. and 1.2. in the very remote digits (by ca.  $10^{-15}$  for typical test examples) due to different arithmetics and, consequently, rounding errors, in both versions.

- field stats.t.sd (the estimate of the population standard deviation) is gone as this term is probably of little use for most users
- minor edits of comments

#### **mes1way.m**

- new output fields psi and psiCi (contrast and corresponding confidence interval)
- correction of a silly bug in the computation of confidence intervals of contrast-related MES for dependent data with option 'tDenom' set to 'msw' (the code would crash with bootstrapped data because of an indexing error)
- minor edits of comments

#### **mes2way.m**

- new output fields psi and psiCi (contrast and corresponding confidence interval)
- minor edits of comments

#### **mestab.m**

- minor edits of comments

#### **documentation**

- enlarged section on confidence intervals
- included mean difference and contrasts
- minor edits

### **Version 1.1 (October 2011)**

#### **mes.m**

- U3 and U3\_1 behaved incorrectly with discretized data (e.g. histogram data). Consider an extreme example: `mes(zeros(10,1), zeros(10,1), 'U3')`. The two groups are identical, so the result should be 0.5, the zero effect value, but the old version yielded U3=1. This is now corrected, by counting the number of values in the 'lower' group which are exactly at the median of the 'higher' group with a factor of 0.5.

#### **mes1way.m**

- for *dependent* data, there was an inconsistency in the computation of F and p values of *contrasts*: F values were computed as the ratio of  $SS_{\psi}$  and  $MS_{\text{between} \times \text{subject}}$ . While not

wrong, this was at odds with the confidence intervals of  $g_\psi$ , computed from the standard deviation of the contrast's difference score,  $S_{D\psi}$ . In other words, while the confidence intervals depended only on the groups participating in the contrast,  $F$  and  $p$  depended on all groups in the data set. Consequently, this could lead to the confusing situation of  $p$  and confidence intervals of  $g_\psi$  signalling contradictory messages, depending on the data. This is fixed; the user now has a choice (via new input parameter 'tDenom') between the two methods of computing  $F$ ,  $p$  and confidence intervals of  $g_\psi$ , and the output of `mes1way` on the command line includes a note if the (probably) less common method is chosen. In the documentation, introductory notes to `mes1way` were added which explain the two methods in detail.

- if contrast weights containing more than one entry of zero are specified, a warning is issued because if this choice of weights reflects the user's wish to exclude groups from analysis it had better be done by eliminating the corresponding data prior to input to `mes1way`.

#### **mes2way.m**

- minor edits of H1 and help text
- main contrasts and MES depending on it were not computed correctly: they were too large by a factor of [number of levels in the non-analyzed factor]. This is fixed.
- when fed oneway data sets `mes2way` originally interpreted a (properly shaped) array of contrast weights as an instruction to compute an interaction contrast, although a main contrast would have been more appropriate. This is now fixed.

#### **mestab.m**

- minor edits of H1 and help text

#### **documentation**

- addition of introductory notes to `mes1way`
- included table of input arguments
- minor edits

**Version 1.0, first release (July 2011)**