Package ‘compute.es’

October 12, 2022

Type Package
Title Compute Effect Sizes
Version 0.2-5
Date 2020-04-01
Author AC Del Re
Maintainer AC Del Re <acdelre@gmail.com>
Description Several functions are available for calculating the most widely used effect sizes (ES), along with their variances, confidence intervals and p-values. The output includes ES's of d (mean difference), g (unbiased estimate of d), r (correlation coefficient), z' (Fisher's z), and OR (odds ratio and log odds ratio). In addition, NNT (number needed to treat), U3, CLES (Common Language Effect Size) and Cliff's Delta are computed. This package uses recommended formulas as described in The Handbook of Research Synthesis and Meta-Analysis (Cooper, Hedges, & Valentine, 2009).

Depends R (>= 2.10.1)
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R topics documented:

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Description

This package provides a comprehensive set of tools/functions to easily derive and/or convert statistics generated from one’s study (or from those reported in a published study) to all of the common effect size estimates, along with their variances, confidence intervals, and p-values. Several additional statistics are generated, including NNT (number needed to treat), U3 (Cohen’s U3 distribution overlap statistic), CLES (Common Language Effect Size) and Cliff’s Delta (success rate difference). The compute.es package’s functions will convert a variety of statistics, such as means and standard deviations, t-test or p-value and sample size, to estimates of:

1. Cohen’s $d$ (mean difference)
2. Hedges’ $g$ (unbiased estimate of $d$)
3. $r$ (correlation coefficient)
4. $z$’ (Fisher’s $z$)
5. log odds ratio
6. the variances, confidence intervals and p-values of the above estimates
7. Other statistics: NNT, U3, CLES, Cliff’s Delta

The functions in this package can compute the effect sizes from a single study or from multiple studies simultaneously. The compute.es package uses recommended conversion formulas as described in *The Handbook of Research Synthesis and Meta-Analysis* (Cooper, Hedges, & Valentine, 2009).

Details

```
Package:       compute.es
Type:          Package
Version:       0.2-4
Date:          2014-09-16
License:       GPL-2
```
LazyLoad: yes

Structure of Functions

The function names for this package are designed for quick processing, such that the first part of the function corresponds to the input method (statistical information reported in the study) and the remaining part corresponds to the output values, which are the effect size estimates ('es' at the end of each function). For example, the function des() has the input of a Cohen’s $d$ and will output various effect size ('es') estimates.

The other function inputs and names are as follows:

- ANCOVA F-test: a.fes()
- ANCOVA means: a.mes()
- ANCOVA means (pooled $sd$): a.mes2()
- ANCOVA p-value: a.pes()
- ANCOVA t-test: a.tes()
- Chi-squared ($1 df$): chies()
- Correlation: res()
- d-statistic: des()
- Failure group (binary): failes()
- F-test: fes()
- Log odds ratio: lores()
- Means: mes()
- Means (pooled $sd$): mes2()
- Proportions (binary): propes()
- p-value: pes()
- t-test: tes()

Author(s)

AC Del Re with contributions from Jeffrey C. Valentine
Maintainer: AC Del Re <acdelre@gmail.com>

References


See Also

For information and user-friendly R packages to conduct a meta-analysis see:

Menu-Driven Meta-Analysis (Graphical User Interface):

**RcmdrPlugin.MA package**: https://CRAN.R-project.org/package=RcmdrPlugin.MA

Meta-Analysis with Correlations:

**MAc package**: https://CRAN.R-project.org/package=MAc

Meta-Analysis with Mean Differences:

**MAd package**: https://CRAN.R-project.org/package=MAd

Examples

```r
## 1. Computations to Calculate Effect Sizes:

# For example, suppose the primary study reported a t-test value for differences between 2 groups. Then, running:

tes(t=1.74, n.1=30, n.2=31)

# Or, more simply:

tes(1.74, 30, 31)

# where the reported t-value = 1.74, treatment sample size = 30, and the control/comparison sample size = 31 will output effect sizes of d, g, r, z, OR, and log odds ratio.

# The variances, confidence intervals, p-values and other statistics will also be computed.

# Note: If only the total sample size is reported simply split the number in half for entry into the function.

# Now suppose one has a dataset (i.e., data.frame in R-speak) with several t-values to be converted into effect sizes:

# First, we will generate sample data:

dat <- data.frame(id=1:5,t=rnorm(5, 2, .5),
                  n.t=round(rnorm(5, 25),0),
                  n.c=round(rnorm(5, 25),0))

# Running the function as follows will generate a new data.frame with several effect size estimates

tes(t=t, n.1=n.t, n.2=n.c, level=95, dig=2, id=id, data=dat)
```
Description

Converts an ANCOVA $F$ to an effect size of $d$ (mean difference), $g$ (unbiased estimate of $d$), $r$ (correlation coefficient), $z'$ (Fisher's $z$), and log odds ratio. The variances, confidence intervals and p-values of these estimates are also computed, along with NNT (number needed to treat), U3 (Cohen's $U_3$) overlapping proportions of distributions), CLES (Common Language Effect Size) and Cliff’s Delta.

Usage

```r
a.fes(f, n.1, n.2, R, q, level=95, cer = 0.2, dig = 2, verbose = TRUE, id=NULL, data=NULL)
```

Arguments

- **f**: $F$ value from ANCOVA.
- **n.1**: Treatment group sample size.
- **n.2**: Comparison group sample size.
- **R**: Covariate outcome correlation or multiple correlation.
- **q**: number of covariates.
- **level**: Confidence level. Default is 95%.
- **cer**: Control group Event Rate (e.g., proportion of cases showing recovery). Default is 0.2 (=20% of cases showing recovery). **CER is used exclusively for NNT output. This argument can be ignored if input is not a mean difference effect size.** Note: NNT output (described below) will NOT be meaningful if based on anything other than input from mean difference effect sizes (i.e., input of Cohen's d, Hedges' $g$ will produce meaningful output, while correlation coefficient input will NOT produce meaningful NNT output).
- **dig**: Number of digits to display. Default is 2 digits.
- **verbose**: Print output from scalar values? If yes, then verbose=TRUE; otherwise, verbose=FALSE. Default is TRUE.
- **id**: Study identifier. Default is NULL, assuming a scalar is used as input. If input is a vector dataset (i.e., data.frame, with multiple values to be computed), enter the name of the study identifier here.
- **data**: name of data.frame. Default is NULL, assuming a scalar is used as input. If input is a vector dataset (i.e., data.frame, with multiple values to be computed), enter the name of the data.frame here.
Value

d Standardized mean difference ($d$).
var. $d$ Variance of $d$.
1. $d$ lower confidence limits for $d$.
u. $d$ upper confidence limits for $d$.
$U_3$. $d$ Cohen’s $U(3)$, for $d$.
c1. $d$ Common Language Effect Size for $d$.
cliffs. $d$ Cliff’s Delta for $d$.
p. $d$ p-value for $d$.
g Unbiased estimate of $d$.
var. $g$ Variance of $g$.
1. $g$ lower confidence limits for $g$.
u. $g$ upper confidence limits for $g$.
$U_3$. $g$ Cohen’s $U(3)$, for $g$.
c1. $g$ Common Language Effect Size for $g$.
p. $g$ p-value for $g$.
$r$ Correlation coefficient.
var. $r$ Variance of $r$.
1. $r$ lower confidence limits for $r$.
u. $r$ upper confidence limits for $r$.
p. $r$ p-value for $r$.
$z$ Fisher’s $z$ ($z’$).
var. $z$ Variance of $z’$.
1. $z$ lower confidence limits for $z’$.
u. $z$ upper confidence limits for $z’$.
p. $z$ p-value for $z’$.
OR Odds ratio.
1. $or$ lower confidence limits for $OR$.
u. $or$ upper confidence limits for $OR$.
p. $or$ p-value for $OR$.
$lor$ Log odds ratio.
1. $lor$ lower confidence limits for $lor$.
u. $lor$ upper confidence limits for $lor$.
p. $lor$ p-value for $lor$.
$N_\text{total}$ Total sample size.
NNT Number needed to treat.
Note

Detailed information regarding output values of:

1. Cohen’s $d$, Hedges’ $g$ (unbiased estimate of $d$) and variance
2. Correlation coefficient ($r$), Fisher’s $z'$, and variance
3. Log odds and variance

is provided below (followed by general information about NNT, U3, Common Language Effect Size, and Cliff’s Delta):

**Cohen’s $d$, Hedges’ $g$ and Variance of $g$**

In this particular formula Cohen’s $d$ is calculated from the ANCOVA $F$ with independent groups

$$d = \sqrt{\frac{F(n_1 + n_2)}{n_1 n_2}} \sqrt{1 - R^2}$$

The variance of $d$ is derived from

$$v_d = \frac{(n_1 + n_2)(1 - R^2)}{n_1 n_2} + \frac{d^2}{2(n_1 + n_2)}$$

The effect size estimate $d$ has a small upward bias (overestimates the population parameter effect size) which can be removed using a correction formula to derive the unbiased estimate of Hedges’ $g$. The correction factor, $J$, is defined as

$$J = 1 - \frac{3}{4df - 1}$$

where $df$ = degrees of freedom, which is $n_1 + n_2 - 2$ for two independent groups. Then, to calculate $g$

$$g = Jd$$

and the variance of $g$

$$v_g = J^2 v_d$$

**Correlation Coefficient $r$, Fisher’s $z$, and Variances**

In this particular formula $r$ is calculated as follows

$$r = \frac{d}{\sqrt{d^2 + a}}$$

where $a$ corrects for inbalance in $n_1$ & $n_2$ and is defined as

$$a = \frac{(n_1 + n_2)^2}{n_1 n_2}$$
The variance of $r$ is then defined as

$$v_r = \frac{a^2 v_d}{(d^2 + a)^3}$$

Often researchers are interested in transforming $r$ to $z'$ (Fisher's $z$) because $r$ is not normally distributed, particularly at large values of $r$. Therefore, converting to $z'$ will help to normally distribute the estimate. Converting from $r$ to $z'$ is defined as

$$z = .5 \log\left(\frac{1 + r}{1 - r}\right)$$

and the variance of $z$

$$v_z = \frac{1}{n - 3}$$

where $n$ is the total sample size for groups 1 and 2.

**Log Odds Ratio & Variance of Log Odds:**

In this particular formula, log odds is calculated as follows

$$\log(o) = \frac{\pi d}{\sqrt{3}}$$

where $\pi = 3.1459$. The variance of log odds is defined as

$$v_{log(o)} = \frac{\pi^2 v_d}{3}$$

**General information about NNT, U3, Common Language Effect Size, and Cliff’s Delta:**

**Number needed to treat (NNT).** NNT is interpreted as the number of participants that would need to be treated in one group (e.g., intervention group) in order to have one additional positive outcome over that of the outcome of a randomly selected participant in the other group (e.g., control group). In the compute.es package, NNT is calculated directly from $d$ (Furukawa & Leucht, 2011), assuming relative normality of distribution and equal variances across groups, as follows:

$$NNT = \frac{1}{\Phi(d - \Psi(CER)) - CER}$$

**U3.** Cohen (1988) proposed a method for characterizing effect sizes by expressing them in terms of (normal) distribution overlap, called U3. This statistic describes the percentage of scores in one group that are exceeded by the mean score in another group. If the population means are equal then half of the scores in the treatment group exceed half the scores in the comparison group, and U3 = 50%. As the population mean difference increases, U3 approaches 100% (Valentine & Cooper, 2003).

**Common Language Effect Size (CLES).** CLES (McGraw & Wong, 1992) expresses the probability that a randomly selected score from one population will be greater than a randomly sampled score
from another population. CLES is computed as the percentage of the normal curve that falls between negative infinity and the effect size (Valentine & Cooper, 2003).

Cliff’s Delta/success rate difference. Cliff’s delta (or success rate difference; Furukawa & Leucht (2011)) is a robust alternative to Cohen’s d, when data are either non-normal or ordinal (with truncated/reduced variance). Cliff’s Delta is a non-parametric procedure that provides the probability that individual observations in one group are likely to be greater than the observations in another group. It is the probability that a randomly selected participant of one population has a better outcome than a randomly selected participant of the second population (minus the reverse probability). Cliff’s Delta of negative 1 or positive 1 indicates no overlap between the two groups, whereas a value of 0 indicates complete overlap and equal group distributions.

\[ \delta = 2 \Phi \left( \frac{d}{\sqrt{2}} \right) - 1 \]

Author(s)
AC Del Re

Much appreciation to Dr. Jeffrey C. Valentine for his contributions in implementing U3 and CLES procedures and related documentation.

Maintainer: AC Del Re <acdelre@gmail.com>

References


See Also
fes

Examples

# CALCULATE SEVERAL EFFECT SIZES BASED ON F-STATISTIC FROM ANCOVA:

a.fes(3, 30, 30, .4, 2)
Mean Values from ANCOVA F-statistic to Effect Size

Description

Converts an ANCOVA F-statistic to an effect size of \( d \) (mean difference), \( g \) (unbiased estimate of \( d \)), \( r \) (correlation coefficient), \( z' \) (Fisher’s \( z \)), and log odds ratio. The variances, confidence intervals and p-values of these estimates are also computed, along with NNT (number needed to treat), \( U_3 \) (Cohen’s \( U(3) \) overlapping proportions of distributions), CLES (Common Language Effect Size) and Cliff’s Delta.

Usage

\[
\text{a.mes}(\text{m.1.adj}, \text{m.2.adj}, \text{sd.adj}, \text{n.1}, \text{n.2}, \text{R}, \text{q},
\text{level} = 95, \text{cer} = 0.2, \text{dig} = 2, \text{verbose} = \text{TRUE}, \text{id}=\text{NULL}, \text{data}=\text{NULL})
\]

Arguments

- \text{m.1.adj} \quad \text{Adjusted mean of treatment group from ANCOVA.}
- \text{m.2.adj} \quad \text{Adjusted mean of comparison group from ANCOVA.}
- \text{sd.adj} \quad \text{Adjusted standard deviation.}
- \text{n.1} \quad \text{Treatment group sample size.}
- \text{n.2} \quad \text{Comparison group sample size.}
- \text{R} \quad \text{Covariate outcome correlation or multiple correlation.}
- \text{q} \quad \text{Number of covariates.}
- \text{level} \quad \text{Confidence level. Default is 95\%.}
- \text{cer} \quad \text{Control group Event Rate (e.g., proportion of cases showing recovery). Default is 0.2 (\approx 20\% of cases showing recovery). \text{CER is used exclusively for NNT output. This argument can be ignored if input is not a mean difference effect size. Note: NNT output (described below) will NOT be meaningful if based on anything other than input from mean difference effect sizes (i.e., input of Cohen’s d, Hedges’ g will produce meaningful output, while correlation coefficient input will NOT produce meaningful NNT output).}
- \text{dig} \quad \text{Number of digits to display. Default is 2 digits.}
- \text{verbose} \quad \text{Print output from scalar values? If yes, then verbose=TRUE; otherwise, verbose=FALSE. Default is TRUE.}
- \text{id} \quad \text{Study identifier. Default is NULL, assuming a scalar is used as input. If input is a vector dataset (i.e., \text{data.frame}, with multiple values to be computed), enter the name of the study identifier here.}
- \text{data} \quad \text{name of \text{data.frame}. Default is NULL, assuming a scalar is used as input. If input is a vector dataset (i.e., \text{data.frame}, with multiple values to be computed), enter the name of the \text{data.frame} here.}
Value

- **d**: Standardized mean difference ($d$).
- **var.** $d$: Variance of $d$.
- **l.** $d$: lower confidence limits for $d$.
- **u.** $d$: upper confidence limits for $d$.
- **U3.** $d$: Cohen’s $U(3)$, for $d$.
- **cl.** $d$: Common Language Effect Size for $d$.
- **cliffs.** $d$: Cliff’s Delta for $d$.
- **p.** $d$: p-value for $d$.
- **g**: Unbiased estimate of $d$.
- **var.** $g$: Variance of $g$.
- **l.** $g$: lower confidence limits for $g$.
- **u.** $g$: upper confidence limits for $g$.
- **U3.** $g$: Cohen’s $U(3)$, for $g$.
- **cl.** $g$: Common Language Effect Size for $g$.
- **p.** $g$: p-value for $g$.
- **r**: Correlation coefficient.
- **var.** $r$: Variance of $r$.
- **l.** $r$: lower confidence limits for $r$.
- **u.** $r$: upper confidence limits for $r$.
- **p.** $r$: p-value for $r$.
- **z**: Fisher’s $z$ ($z'$).
- **var.** $z$: Variance of $z'$.
- **l.** $z$: lower confidence limits for $z'$.
- **u.** $z$: upper confidence limits for $z'$.
- **p.** $z$: p-value for $z'$.
- **OR**: Odds ratio.
- **l.** OR: lower confidence limits for $OR$.
- **u.** OR: upper confidence limits for $OR$.
- **p.** OR: p-value for $OR$.
- **log OR**: Log odds ratio.
- **l.** log OR: lower confidence limits for log $OR$.
- **u.** log OR: upper confidence limits for log $OR$.
- **p.** log OR: p-value for log $OR$.
- **N.** total: Total sample size.
- **NNT**: Number needed to treat.
Note

Detailed information regarding output values of:

(1) Cohen’s $d$, Hedges’ $g$ (unbiased estimate of $d$) and variance

(2) Correlation coefficient ($r$), Fisher’s $z'$, and variance

(3) Log odds and variance

is provided below (followed by general information about NNT, U3, Common Language Effect Size, and Cliff’s Delta):

**Cohen’s $d$, Hedges’ $g$ and Variance of $g$:**

This function will initially calculate Cohen’s $d$ from the independent groups adjusted mean ANCOVA values. Then, all other effect size estimates are derived from $d$ and its variance. This parameter is calculated by

$$d = \frac{\bar{Y}_1^A - \bar{Y}_2^A}{S_{within}}$$

where $\bar{Y}_1^A$ and $\bar{Y}_2^A$ are the adjusted sample means in each group and $S_{within}$ is the 'readjusted' standard deviation defined as

$$S_{within} = \frac{S_A}{\sqrt{1 - R^2}}$$

where $S_A$= adjusted standard deviation and $R$= correlation between outcome and covariate (or its estimate if none is provided).

The variance of $d$ is derived from

$$v_d = \frac{(n_1 + n_2)(1 - R^2)}{n_1n_2} + \frac{d^2}{2(n_1 + n_2)}$$

The effect size estimate $d$ has a small upward bias (overestimates the population parameter effect size) which can be removed using a correction formula to derive the unbiased estimate of Hedges’ $g$. The correction factor, $J$, is defined as

$$J = 1 - \frac{3}{4df - 1}$$

where $df$ = degrees of freedom, which is $n_1 + n_2 - 2$ for two independent groups. Then, to calculate $g$

$$g = Jd$$

and the variance of $g$

$$v_g = J^2v_d$$

**Correlation Coefficient $r$, Fisher’s $z$, and Variances:**
In this particular formula $r$ is calculated as follows

$$r = \frac{d}{\sqrt{d^2 + a}}$$

where $a$ corrects for inbalance in $n_1$ & $n_2$ and is defined as

$$a = \frac{(n_1 + n_2)^2}{n_1 n_2}$$

The variance of $r$ is then defined as

$$v_r = \frac{a^2 v_d}{(d^2 + a)^3}$$

Often researchers are interested in transforming $r$ to $z'$ (Fisher’s $z$) because $r$ is not normally distributed, particularly at large values of $r$. Therefore, converting to $z'$ will help to normally distribute the estimate. Converting from $r$ to $z'$ is defined as

$$z = .5 \times \log\left(\frac{1 + r}{1 - r}\right)$$

and the variance of $z$

$$v_z = \frac{1}{n - 3}$$

where $n$ is the total sample size for groups 1 and 2.

**Log Odds Ratio & Variance of Log Odds:**

In this particular formula, log odds is calculated as follows

$$\log(o) = \frac{\pi d}{\sqrt{3}}$$

where $\pi = 3.1459$. The variance of log odds is defined as

$$v_{\log(o)} = \frac{\pi^2 v_d}{3}$$

**General information about NNT, U3, Common Language Effect Size, and Cliff’s Delta:**

**Number needed to treat (NNT).** NNT is interpreted as the number of participants that would need to be treated in one group (e.g., intervention group) in order to have one additional positive outcome over that of the outcome of a randomly selected participant in the other group (e.g., control group). In the `compute.es` package, NNT is calculated directly from $d$ (Furukawa & Leucht, 2011), assuming relative normality of distribution and equal variances across groups, as follows:

$$NNT = \frac{1}{\Phi(d - \Psi(CER)) - CER}$$
Cohen (1988) proposed a method for characterizing effect sizes by expressing them in terms of (normal) distribution overlap, called U3. This statistic describes the percentage of scores in one group that are exceeded by the mean score in another group. If the population means are equal then half of the scores in the treatment group exceed half the scores in the comparison group, and U3 = 50%. As the population mean difference increases, U3 approaches 100% (Valentine & Cooper, 2003).

Common Language Effect Size (CLES). CLES (McGraw & Wong, 1992) expresses the probability that a randomly selected score from one population will be greater than a randomly sampled score from another population. CLES is computed as the percentage of the normal curve that falls between negative infinity and the effect size (Valentine & Cooper, 2003).

Cliff’s Delta/success rate difference. Cliff’s delta (or success rate difference; Furukawa & Leucht (2011)) is a robust alternative to Cohen’s d, when data are either non-normal or ordinal (with truncated/reduced variance). Cliff’s Delta is a non-parametric procedure that provides the probability that individual observations in one group are likely to be greater than the observations in another group. It is the probability that a randomly selected participant of one population has a better outcome than a randomly selected participant of the second population (minus the reverse probability). Cliff’s Delta of negative 1 or positive 1 indicates no overlap between the two groups, whereas a value of 0 indicates complete overlap and equal group distributions.

\[ \delta = 2 \times \Phi \left( \frac{d}{\sqrt{2}} \right) - 1 \]

Author(s)

AC Del Re

Much appreciation to Dr. Jeffrey C. Valentine for his contributions in implementing U3 and CLES procedures and related documentation.

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References


See Also

mes, mes2, a.mes2
Examples

# CALCULATE SEVERAL EFFECT SIZES BASED ON MEAN VALUES FROM ANCOVA F-STATISTIC:

a.mes(10, 12, 1, 30, 30, .2, 2)

Description

Converts an ANCOVA F-statistic with a pooled standard deviation to an effect size of \( d \) (mean difference), \( g \) (unbiased estimate of \( d \)), \( r \) (correlation coefficient), \( z' \) (Fisher’s \( z \)), and log odds ratio. The variances, confidence intervals and p-values of these estimates are also computed, along with NNT (number needed to treat), U3 (Cohen’s \( U_3 \)) overlapping proportions of distributions), CLES (Common Language Effect Size) and Cliff’s Delta.

Usage

a.mes2(m.1.adj, m.2.adj, s.pooled, n.1, n.2, R, q, level = 95, cer = 0.2, dig = 2, verbose = TRUE, id=NULL, data=NULL)

Arguments

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>m.1.adj</td>
<td>Adjusted mean of treatment group from ANCOVA.</td>
</tr>
<tr>
<td>m.2.adj</td>
<td>Adjusted mean of comparison group from ANCOVA.</td>
</tr>
<tr>
<td>s.pooled</td>
<td>Pooled standard deviation.</td>
</tr>
<tr>
<td>n.1</td>
<td>Treatment group sample size.</td>
</tr>
<tr>
<td>n.2</td>
<td>Comparison group sample size.</td>
</tr>
<tr>
<td>R</td>
<td>Covariate outcome correlation or multiple correlation.</td>
</tr>
<tr>
<td>q</td>
<td>Number of covariates</td>
</tr>
<tr>
<td>level</td>
<td>Confidence level. Default is 95%.</td>
</tr>
<tr>
<td>cer</td>
<td>Control group Event Rate (e.g., proportion of cases showing recovery). Default is 0.2 (=20% of cases showing recovery). <strong>CER is used exclusively for NNT output. This argument can be ignored if input is not a mean difference effect size.</strong> Note: NNT output (described below) will NOT be meaningful if based on anything other than input from mean difference effect sizes (i.e., input of Cohen’s ( d ), Hedges’ ( g ) will produce meaningful output, while correlation coefficient input will NOT produce meaningful NNT output).</td>
</tr>
<tr>
<td>dig</td>
<td>Number of digits to display. Default is 2 digits.</td>
</tr>
<tr>
<td>verbose</td>
<td>Print output from scalar values? If yes, then verbose=TRUE; otherwise, verbose=FALSE. Default is TRUE.</td>
</tr>
</tbody>
</table>
id  Study identifier. Default is NULL, assuming a scalar is used as input. If input is a vector dataset (i.e., data.frame, with multiple values to be computed), enter the name of the study identifier here.

data  name of data.frame. Default is NULL, assuming a scalar is used as input. If input is a vector dataset (i.e., data.frame, with multiple values to be computed), enter the name of the data.frame here.

Value

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>d</td>
<td>Standardized mean difference ($d$).</td>
</tr>
<tr>
<td>var.d</td>
<td>Variance of $d$.</td>
</tr>
<tr>
<td>l.d</td>
<td>lower confidence limits for $d$.</td>
</tr>
<tr>
<td>u.d</td>
<td>upper confidence limits for $d$.</td>
</tr>
<tr>
<td>U3.d</td>
<td>Cohen’s $U(3)$, for $d$.</td>
</tr>
<tr>
<td>cl.d</td>
<td>Common Language Effect Size for $d$.</td>
</tr>
<tr>
<td>cliffs.d</td>
<td>Cliff’s Delta for $d$.</td>
</tr>
<tr>
<td>p.d</td>
<td>p-value for $d$.</td>
</tr>
<tr>
<td>g</td>
<td>Unbiased estimate of $d$.</td>
</tr>
<tr>
<td>var.g</td>
<td>Variance of $g$.</td>
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<tr>
<td>l.g</td>
<td>lower confidence limits for $g$.</td>
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<td>p.g</td>
<td>p-value for $g$.</td>
</tr>
<tr>
<td>r</td>
<td>Correlation coefficient.</td>
</tr>
<tr>
<td>var.r</td>
<td>Variance of $r$.</td>
</tr>
<tr>
<td>l.r</td>
<td>lower confidence limits for $r$.</td>
</tr>
<tr>
<td>u.r</td>
<td>upper confidence limits for $r$.</td>
</tr>
<tr>
<td>p.r</td>
<td>p-value for $r$.</td>
</tr>
<tr>
<td>z</td>
<td>Fisher’s $z$ ($z'$).</td>
</tr>
<tr>
<td>var.z</td>
<td>Variance of $z'$.</td>
</tr>
<tr>
<td>l.z</td>
<td>lower confidence limits for $z'$.</td>
</tr>
<tr>
<td>u.z</td>
<td>upper confidence limits for $z'$.</td>
</tr>
<tr>
<td>p.z</td>
<td>p-value for $z'$.</td>
</tr>
<tr>
<td>OR</td>
<td>Odds ratio.</td>
</tr>
<tr>
<td>1.or</td>
<td>lower confidence limits for $OR$.</td>
</tr>
<tr>
<td>u.or</td>
<td>upper confidence limits for $OR$.</td>
</tr>
<tr>
<td>p.or</td>
<td>p-value for $OR$.</td>
</tr>
<tr>
<td>10R</td>
<td>Log odds ratio.</td>
</tr>
</tbody>
</table>
var.lor  Variance of log odds ratio.
l.or  lower confidence limits for lOR.
u.lor  upper confidence limits for lOR.
p.lor  p-value for lOR.
N.total  Total sample size.
NNT  Number needed to treat.

Note

Detailed information regarding output values of:
1) Cohen’s d, Hedges’ g (unbiased estimate of d) and variance
2) Correlation coefficient (r), Fisher’s z’, and variance
3) Log odds and variance

is provided below (followed by general information about NNT, U3, Common Language Effect Size, and Cliff’s Delta):

Cohen’s d, Hedges’ g and Variance of g:

This function will initially calculate Cohen’s d from the independent groups adjusted mean ANCOVA values. Then, all other effect size estimates are derived from d and its variance. This parameter is calculated by

\[ d = \frac{\bar{Y}_1^A - \bar{Y}_2^A}{S_{pooled}} \]

where \( \bar{Y}_1^A \) and \( \bar{Y}_2^A \) are the adjusted sample means in each group and \( S_{pooled} \) is the pooled standard deviation for both groups.

The variance of d is derived from

\[ v_d = \frac{(n_1 + n_2)(1 - R^2)}{n_1 n_2} + \frac{d^2}{2(n_1 + n_2)} \]

The effect size estimate d has a small upward bias (overestimates the population parameter effect size) which can be removed using a correction formula to derive the unbiased estimate of Hedges’ g. The correction factor, j, is defined as

\[ J = 1 - \frac{3}{4df - 1} \]

where df = degrees of freedom, which is \( n_1 + n_2 - 2 \) for two independent groups. Then, to calculate g

\[ g = Jd \]

and the variance of g

\[ v_g = J^2 v_d \]
**Correlation Coefficient r, Fisher’s z, and Variances:**

In this particular formula, $r$ is calculated as follows

$$r = \frac{d}{\sqrt{d^2 + a}}$$

where $a$ corrects for imbalance in $n_1$ & $n_2$ and is defined as

$$a = \frac{(n_1 + n_2)^2}{n_1 n_2}$$

The variance of $r$ is then defined as

$$v_r = \frac{a^2 v_d}{(d^2 + a)^3}$$

Often researchers are interested in transforming $r$ to $z'$ (Fisher’s $z$) because $r$ is not normally distributed, particularly at large values of $r$. Therefore, converting to $z'$ will help to normally distribute the estimate. Converting from $r$ to $z'$ is defined as

$$z = .5 \cdot \log\left(\frac{1 + r}{1 - r}\right)$$

and the variance of $z$

$$v_z = \frac{1}{n - 3}$$

where $n$ is the total sample size for groups 1 and 2.

**Log Odds Ratio & Variance of Log Odds:**

In this particular formula, log odds is calculated as follows

$$\log(a) = \frac{\pi d}{\sqrt{3}}$$

where $\pi = 3.1459$. The variance of log odds is defined as

$$v_{\log(a)} = \frac{\pi^2 v_d}{3}$$

**General information about NNT, U3, Common Language Effect Size, and Cliff’s Delta:**

*Number needed to treat (NNT).* NNT is interpreted as the number of participants that would need to be treated in one group (e.g., intervention group) in order to have one additional positive outcome over that of the outcome of a randomly selected participant in the other group (e.g., control group). In the compute.es package, NNT is calculated directly from $d$ (Furukawa & Leucht, 2011), assuming relative normality of distribution and equal variances across groups, as follows:

$$NNT = \frac{1}{\Phi(d - \Psi(CER)) - CER}$$
Cohen (1988) proposed a method for characterizing effect sizes by expressing them in terms of (normal) distribution overlap, called U3. This statistic describes the percentage of scores in one group that are exceeded by the mean score in another group. If the population means are equal then half of the scores in the treatment group exceed half the scores in the comparison group, and U3 = 50%. As the population mean difference increases, U3 approaches 100% (Valentine & Cooper, 2003).

Common Language Effect Size (CLES). CLES (McGraw & Wong, 1992) expresses the probability that a randomly selected score from one population will be greater than a randomly sampled score from another population. CLES is computed as the percentage of the normal curve that falls between negative infinity and the effect size (Valentine & Cooper, 2003).

Cliff’s Delta/success rate difference. Cliff’s delta (or success rate difference; Furukawa & Leucht (2011)) is a robust alternative to Cohen’s d, when data are either non-normal or ordinal (with truncated/reduced variance). Cliff’s Delta is a non-parametric procedure that provides the probability that individual observations in one group are likely to be greater than the observations in another group. It is the probability that a randomly selected participant of one population has a better outcome than a randomly selected participant of the second population (minus the reverse probability). Cliff’s Delta of negative 1 or positive 1 indicates no overlap between the two groups, whereas a value of 0 indicates complete overlap and equal group distributions.

\[ \delta = 2 \times \Phi\left(\frac{d}{\sqrt{2}}\right) - 1 \]

Author(s)
AC Del Re

Much appreciation to Dr. Jeffrey C. Valentine for his contributions in implementing U3 and CLES procedures and related documentation.

Maintainer: AC Del Re <acdelre@gmail.com>

References


See Also
mes, a.mes2, a.mes
Examples

# CALCULATE SEVERAL EFFECT SIZES BASED ON MEAN VALUES FROM ANCOVA F-STAT (WITH POOLED SD):

a.mes2(10, 12, 1, 30, 30, .2, 2)

a.pes

One or Two-tailed p-value from ANCOVA to Effect Size

Description

Converts a one or two-tailed p-value from ANCOVA to an effect size of \( d \) (mean difference), \( g \) (unbiased estimate of \( d \)), \( r \) (correlation coefficient), \( z' \) (Fisher’s \( z \)), and log odds ratio. The variances, confidence intervals and p-values of these estimates are also computed, along with NNT (number needed to treat), U3 (Cohen’s \( U_3 \) overlapping proportions of distributions), CLES (Common Language Effect Size) and Cliff’s Delta.

Usage

a.pes(p, n.1, n.2, R, q, tail = "two", level = 95, cer = 0.2, dig = 2, verbose = TRUE, id=NULL, data=NULL)

Arguments

- \( p \): One- or two-tailed p-value.
- \( n.1 \): Treatment group sample size.
- \( n.2 \): Comparison group sample size.
- \( R \): Covariate outcome correlation or multiple correlation.
- \( q \): number of covariates.
- \( tail \): One or two-tailed p-value. The argument is scalar only—it can only take on a single value of ‘one’ or ‘two’. Default is two.
- \( level \): Confidence level. Default is 95%.
- \( cer \): Control group Event Rate (e.g., proportion of cases showing recovery). Default is 0.2 (=20% of cases showing recovery). **CER is used exclusively for NNT output. This argument can be ignored if input is not a mean difference effect size.** Note: NNT output (described below) will NOT be meaningful if based on anything other than input from mean difference effect sizes (i.e., input of Cohen’s d, Hedges’ g will produce meaningful output, while correlation coefficient input will NOT produce meaningful NNT output).
- \( dig \): Number of digits to display. Default is 2 digits.
- \( verbose \): Print output from scalar values? If yes, then verbose=TRUE; otherwise, verbose=FALSE. Default is TRUE.
- \( id \): Study identifier. Default is NULL, assuming a scalar is used as input. If input is a vector dataset (i.e., data.frame, with multiple values to be computed), enter the name of the study identifier here.
data  name of data.frame. Default is NULL, assuming a scalar is used as input. If input is a vector dataset (i.e., data.frame, with multiple values to be computed), enter the name of the data.frame here.

Value

d  Standardized mean difference (d).
var.d  Variance of d.
l.d  lower confidence limits for d.
u.d  upper confidence limits for d.
U3.d  Cohen’s U(3), for d.
cl.d  Common Language Effect Size for d.
cliffs.d  Cliff’s Delta for d.
p.d  p-value for d.
g  Unbiased estimate of d.
var.g  Variance of g.
l.g  lower confidence limits for g.
u.g  upper confidence limits for g.
U3.g  Cohen’s U(3), for g.
cl.g  Common Language Effect Size for g.
p.g  p-value for g.
r  Correlation coefficient.
var.r  Variance of r.
l.r  lower confidence limits for r.
u.r  upper confidence limits for r.
p.r  p-value for r.
z  Fisher’s z (z’).
var.z  Variance of z’.
l.z  lower confidence limits for z’.
u.z  upper confidence limits for z’.
p.z  p-value for z’.
OR  Odds ratio.
l.or  lower confidence limits for OR.
u.or  upper confidence limits for OR.
p.or  p-value for OR.
lOR  Log odds ratio.
var.lor  Variance of log odds ratio.
l.lor  lower confidence limits for lOR.
u.lor  upper confidence limits for lOR.
p.lor  p-value for lOR.
N.total  Total sample size.
NNT  Number needed to treat.
Note

Detailed information regarding output values of:

1. **Cohen’s d, Hedges’ g (unbiased estimate of d) and variance**
2. **Correlation coefficient (r), Fisher’s z’, and variance**
3. **Log odds and variance**

is provided below (followed by general information about NNT, U3, Common Language Effect Size, and Cliff’s Delta):

**Cohen’s d, Hedges’ g and Variance of g:**

This function will initially calculate Cohen’s d from a one or two-tailed p-value from ANCOVA. Then, all other effect size estimates are derived from d and its variance. This parameter estimate is calculated from a one-tailed p by

\[
d = t^{-1}(p) \sqrt{ \frac{n_1 + n_2}{n_1 n_2} } \sqrt{1 - R^2}
\]

where \( t^{-1} \) is the inverse of t-distribution with \( n - 1 \) degrees of freedom and \( p \) is the one-tailed p-value from ANCOVA. The two-tailed parameter estimate is calculated from

\[
d = t^{-1} \left( \frac{p}{2} \right) \sqrt{ \frac{n_1 + n_2}{n_1 n_2} } \sqrt{1 - R^2}
\]

\( p \) is the two-tailed p-value.

The variance of d from either a one or two-tailed p-value from ANCOVA is defined as

\[
v_d = \frac{(n_1 + n_2)(1 - R^2)}{n_1 n_2} + \frac{d^2}{2(n_1 + n_2)}
\]

The effect size estimate d has a small upward bias (overestimates the population parameter effect size) which can be removed using a correction formula to derive the unbiased estimate of Hedges’ g. The correction factor, \( J \), is defined as

\[
J = 1 - \frac{3}{4df - 1}
\]

where \( df = \) degrees of freedom, which is \( n_1 + n_2 - 2 \) for two independent groups. Then, to calculate g

\[
g = Jd
\]

and the variance of g

\[
v_g = J^2 v_d
\]

**Correlation Coefficient r, Fisher’s z, and Variances:**

In this particular formula r is calculated as follows
\[ r = \frac{d}{\sqrt{d^2 + a}} \]

where \( a \) corrects for inbalance in \( n_1 \) \& \( n_2 \) and is defined as

\[ a = \frac{(n_1 + n_2)^2}{n_1 n_2} \]

The variance of \( r \) is then defined as

\[ v_r = \frac{a^2 v_d}{(d^2 + a)^3} \]

Often researchers are interested in transforming \( r \) to \( z' \) (Fisher’s \( z \)) because \( r \) is not normally distributed, particularly at large values of \( r \). Therefore, converting to \( z' \) will help to normally distribute the estimate. Converting from \( r \) to \( z' \) is defined as

\[ z = .5^*\log\left(\frac{1 + r}{1 - r}\right) \]

and the variance of \( z \)

\[ v_z = \frac{1}{n - 3} \]

where \( n \) is the total sample size for groups 1 and 2.

**Log Odds Ratio & Variance of Log Odds:**

In this particular formula, log odds is calculated as follows

\[ \log(\phi) = \frac{\pi d}{\sqrt{3}} \]

where \( \pi = 3.1459 \). The variance of log odds is defined as

\[ v_{\log(\phi)} = \frac{\pi^2 v_d}{3} \]

**General information about NNT, U3, Common Language Effect Size, and Cliff’s Delta:**

*Number needed to treat (NNT).* NNT is interpreted as the number of participants that would need to be treated in one group (e.g., intervention group) in order to have one additional positive outcome over that of the outcome of a randomly selected participant in the other group (e.g., control group). In the compute.es package, NNT is calculated directly from \( d \) (Furukawa & Leucht, 2011), assuming relative normality of distribution and equal variances across groups, as follows:

\[ NNT = \frac{1}{\Phi(d - \Psi(CER)) - CER} \]
U3. Cohen (1988) proposed a method for characterizing effect sizes by expressing them in terms of (normal) distribution overlap, called U3. This statistic describes the percentage of scores in one group that are exceeded by the mean score in another group. If the population means are equal then half of the scores in the treatment group exceed half the scores in the comparison group, and U3 = 50%. As the population mean difference increases, U3 approaches 100% (Valentine & Cooper, 2003).

Common Language Effect Size (CLES). CLES (McGraw & Wong, 1992) expresses the probability that a randomly selected score from one population will be greater than a randomly sampled score from another population. CLES is computed as the percentage of the normal curve that falls between negative infinity and the effect size (Valentine & Cooper, 2003).

Cliff’s Delta/success rate difference. Cliff’s delta (or success rate difference; Furukawa & Leucht, 2011) is a robust alternative to Cohen’s d, when data are either non-normal or ordinal (with truncated/reduced variance). Cliff’s Delta is a non-parametric procedure that provides the probability that individual observations in one group are likely to be greater than the observations in another group. It is the probability that a randomly selected participant of one population has a better outcome than a randomly selected participant of the second population (minus the reverse probability). Cliff’s Delta of negative 1 or positive 1 indicates no overlap between the two groups, whereas a value of 0 indicates complete overlap and equal group distributions.

\[ \delta = 2 \times \Phi\left( \frac{d}{\sqrt{2}} \right) - 1 \]

Author(s)

AC Del Re

Much appreciation to Dr. Jeffrey C. Valentine for his contributions in implementing U3 and CLES procedures and related documentation.

Maintainer: AC Del Re <acdelre@gmail.com>

References


See Also

pes
Examples

# CALCULATE SEVERAL EFFECT SIZES BASED ON P-VALUE FROM ANCOVA STATISTIC:

a.pes(.3, 30, 30, .2, 3)

--

a.tes  
*t-test Value from ANCOVA to Effect Size*

Description

Converts a t-test value from ANCOVA to an effect size of $d$ (mean difference), $g$ (unbiased estimate of $d$), $r$ (correlation coefficient), $z'$ (Fisher’s $z$), and log odds ratio. The variances, confidence intervals and p-values of these estimates are also computed, along with NNT (number needed to treat), U3 (Cohen’s $U_3$) overlapping proportions of distributions), CLES (Common Language Effect Size) and Cliff’s Delta.

Usage

a.tes(t, n.1, n.2, R, q,  
  level = 95, cer = 0.2, dig = 2, verbose = TRUE, id=NULL, data=NULL)

Arguments

t    t-test value reported in primary study.

n.1  Treatment group sample size.

n.2  Comparison group sample size.

R    Covariate outcome correlation or multiple correlation.

q    number of covariates.

level  Confidence level. Default is 95%.

cer  Control group Event Rate (e.g., proportion of cases showing recovery). Default is 0.2 (=20% of cases showing recovery). **CER is used exclusively for NNT output. This argument can be ignored if input is not a mean difference effect size.** Note: NNT output (described below) will NOT be meaningful if based on anything other than input from mean difference effect sizes (i.e., input of Cohen’s $d$, Hedges’ $g$ will produce meaningful output, while correlation coefficient input will NOT produce meaningful NNT output).

dig  Number of digits to display. Default is 2 digits.

verbose  Print output from scalar values? If yes, then verbose=TRUE; otherwise, verbose=FALSE. Default is TRUE.

id  Study identifier. Default is NULL, assuming a scalar is used as input. If input is a vector dataset (i.e., data.frame, with multiple values to be computed), enter the name of the study identifier here.

data  name of data.frame. Default is NULL, assuming a scalar is used as input. If input is a vector dataset (i.e., data.frame, with multiple values to be computed), enter the name of the data.frame here.
<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>d</td>
<td>Standardized mean difference ($d$).</td>
</tr>
<tr>
<td>var. $d$</td>
<td>Variance of $d$.</td>
</tr>
<tr>
<td>l. $d$</td>
<td>lower confidence limits for $d$.</td>
</tr>
<tr>
<td>u. $d$</td>
<td>upper confidence limits for $d$.</td>
</tr>
<tr>
<td>U3. $d$</td>
<td>Cohen’s $U(3)$, for $d$.</td>
</tr>
<tr>
<td>cl. $d$</td>
<td>Common Language Effect Size for $d$.</td>
</tr>
<tr>
<td>cliffs. $d$</td>
<td>Cliff’s Delta for $d$.</td>
</tr>
<tr>
<td>p. $d$</td>
<td>p-value for $d$.</td>
</tr>
<tr>
<td>g</td>
<td>Unbiased estimate of $d$.</td>
</tr>
<tr>
<td>var. $g$</td>
<td>Variance of $g$.</td>
</tr>
<tr>
<td>l. $g$</td>
<td>lower confidence limits for $g$.</td>
</tr>
<tr>
<td>u. $g$</td>
<td>upper confidence limits for $g$.</td>
</tr>
<tr>
<td>U3. $g$</td>
<td>Cohen’s $U(3)$, for $g$.</td>
</tr>
<tr>
<td>cl. $g$</td>
<td>Common Language Effect Size for $g$.</td>
</tr>
<tr>
<td>p. $g$</td>
<td>p-value for $g$.</td>
</tr>
<tr>
<td>r</td>
<td>Correlation coefficient.</td>
</tr>
<tr>
<td>var. $r$</td>
<td>Variance of $r$.</td>
</tr>
<tr>
<td>l. $r$</td>
<td>lower confidence limits for $r$.</td>
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<tr>
<td>u. $r$</td>
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<tr>
<td>p. $r$</td>
<td>p-value for $r$.</td>
</tr>
<tr>
<td>z</td>
<td>Fisher’s $z$ ($z'$).</td>
</tr>
<tr>
<td>var. $z$</td>
<td>Variance of $z'$.</td>
</tr>
<tr>
<td>l. $z$</td>
<td>lower confidence limits for $z'$.</td>
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<tr>
<td>u. $z$</td>
<td>upper confidence limits for $z'$.</td>
</tr>
<tr>
<td>p. $z$</td>
<td>p-value for $z'$.</td>
</tr>
<tr>
<td>OR</td>
<td>Odds ratio.</td>
</tr>
<tr>
<td>l. $OR$</td>
<td>lower confidence limits for $OR$.</td>
</tr>
<tr>
<td>u. $OR$</td>
<td>upper confidence limits for $OR$.</td>
</tr>
<tr>
<td>p. $OR$</td>
<td>p-value for $OR$.</td>
</tr>
<tr>
<td>10R</td>
<td>Log odds ratio.</td>
</tr>
<tr>
<td>var. $1OR$</td>
<td>Variance of log odds ratio.</td>
</tr>
<tr>
<td>l. $1OR$</td>
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<tr>
<td>u. $1OR$</td>
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<tr>
<td>p. $1OR$</td>
<td>p-value for $1OR$.</td>
</tr>
<tr>
<td>N. total</td>
<td>Total sample size.</td>
</tr>
<tr>
<td>NNT</td>
<td>Number needed to treat.</td>
</tr>
</tbody>
</table>
Note

Detailed information regarding output values of:

(1) Cohen’s d, Hedges’ g (unbiased estimate of d) and variance
(2) Correlation coefficient (r), Fisher’s z’, and variance
(3) Log odds and variance

is provided below (followed by general information about NNT, U3, Common Language Effect Size, and Cliff’s Delta):

Cohen’s d, Hedges’ g and Variance of g:

In this particular formula Cohen’s d is calculated from the ANCOVA t with independent groups

\[ d = t \sqrt{\frac{n_1 + n_2}{n_1 n_2}} \sqrt{1 - R^2} \]

where R is the correlation between the outcome and covariate.

The variance of d is derived from

\[ v_d = \frac{(n_1 + n_2)(1 - R^2)}{n_1 n_2} + \frac{d^2}{2(n_1 + n_2)} \]

The effect size estimate d has a small upward bias (overestimates the population parameter effect size) which can be removed using a correction formula to derive the unbiased estimate of Hedges’ g. The correction factor, J, is defined as

\[ J = 1 - \frac{3}{4df - 1} \]

where df = degrees of freedom, which is \( n_1 + n_2 - 2 \) for two independent groups. Then, to calculate g

\[ g = Jd \]

and the variance of g

\[ v_g = J^2 v_d \]

Correlation Coefficient r, Fisher’s z, and Variances:

In this particular formula r is calculated as follows

\[ r = \frac{d}{\sqrt{d^2 + a}} \]

where a corrects for inbalance in \( n_1 \) & \( n_2 \) and is defined as

\[ a = \frac{(n_1 + n_2)^2}{n_1 n_2} \]
The variance of $r$ is then defined as

$$v_r = \frac{a^2 v_d}{(d^2 + a)^3}$$

Often researchers are interested in transforming $r$ to $z'$ (Fisher’s $z$) because $r$ is not normally distributed, particularly at large values of $r$. Therefore, converting to $z'$ will help to normally distribute the estimate. Converting from $r$ to $z'$ is defined as

$$z = .5 \times \log \left( \frac{1 + r}{1 - r} \right)$$

and the variance of $z$

$$v_z = \frac{1}{n - 3}$$

where $n$ is the total sample size for groups 1 and 2.

**Log Odds Ratio & Variance of Log Odds:**

In this particular formula, log odds is calculated as follows

$$\log(o) = \frac{\pi d}{\sqrt{3}}$$

where $\pi = 3.1459$. The variance of log odds is defined as

$$v_{\log(o)} = \frac{\pi^2 v_d}{3}$$

**General information about NNT, U3, Common Language Effect Size, and Cliff’s Delta:**

**Number needed to treat (NNT).** NNT is interpreted as the number of participants that would need to be treated in one group (e.g., intervention group) in order to have one additional positive outcome over that of the outcome of a randomly selected participant in the other group (e.g., control group). In the compute.es package, NNT is calculated directly from $d$ (Furukawa & Leucht, 2011), assuming relative normality of distribution and equal variances across groups, as follows:

$$NNT = \frac{1}{\Phi(d - \Psi(CER)) - CER}$$

**U3.** Cohen (1988) proposed a method for characterizing effect sizes by expressing them in terms of (normal) distribution overlap, called U3. This statistic describes the percentage of scores in one group that are exceeded by the mean score in another group. If the population means are equal then half of the scores in the treatment group exceed half the scores in the comparison group, and U3 $= 50\%$. As the population mean difference increases, U3 approaches 100% (Valentine & Cooper, 2003).

**Common Language Effect Size (CLES).** CLES (McGraw & Wong, 1992) expresses the probability that a randomly selected score from one population will be greater than a randomly sampled score
from another population. CLES is computed as the percentage of the normal curve that falls between negative infinity and the effect size (Valentine & Cooper, 2003).

**Cliff’s Delta/success rate difference.** Cliff’s delta (or success rate difference; Furukawa & Leucht (2011)) is a robust alternative to Cohen’s d, when data are either non-normal or ordinal (with truncated/reduced variance). Cliff’s Delta is a non-parametric procedure that provides the probability that individual observations in one group are likely to be greater than the observations in another group. It is the probability that a randomly selected participant of one population has a better outcome than a randomly selected participant of the second population (minus the reverse probability). Cliff’s Delta of negative 1 or positive 1 indicates no overlap between the two groups, whereas a value of 0 indicates complete overlap and equal group distributions.

\[
\delta = 2 \times \Phi\left(\frac{d}{\sqrt{2}}\right) - 1
\]

**Author(s)**

AC Del Re

Much appreciation to Dr. Jeffrey C. Valentine for his contributions in implementing U3 and CLES procedures and related documentation.

Maintainer: AC Del Re <acdelre@gmail.com>

**References**


**See Also**

tes

**Examples**

# CALCULATE SEVERAL EFFECT SIZES BASED ON T STATISTIC (FROM ANCOVA):

```r
a.tes(3, 30, 30, .3, 2)
```
**chi.sq**  
*Chi-Squared Statistic to Effect Size*

**Description**

Converting Chi-squared ($\chi^2$) statistic with 1 degree of freedom to an effect size of $d$ (mean difference), $g$ (unbiased estimate of $d$), $r$ (correlation coefficient), $z'$ (Fisher’s $z'$), and log odds ratio. The variances, confidence intervals and p-values of these estimates are also computed, along with NNT (number needed to treat), U3 (Cohen’s $U_3$) overlapping proportions of distributions), CLES (Common Language Effect Size) and Cliff’s Delta.

**Usage**

```r
chies(chi.sq, n, level = 95, cer = 0.2, dig = 2, verbose = TRUE, id=NULL, data=NULL)
```

**Arguments**

- `chi.sq`: Chi squared statistic from primary study.
- `n`: Sample size in primary study.
- `level`: Confidence level. Default is 95%.
- `cer`: Control group Event Rate (e.g., proportion of cases showing recovery). Default is 0.2 (=20% of cases showing recovery). **CER is used exclusively for NNT output. This argument can be ignored if input is not a mean difference effect size.** Note: NNT output (described below) will NOT be meaningful if based on anything other than input from mean difference effect sizes (i.e., input of Cohen’s d, Hedges’ g will produce meaningful output, while correlation coefficient input will NOT produce meaningful NNT output).
- `dig`: Number of digits to display. Default is 2 digits.
- `verbose`: Print output from scalar values? If yes, then verbose=TRUE; otherwise, verbose=FALSE. Default is TRUE.
- `id`: Study identifier. Default is NULL, assuming a scalar is used as input. If input is a vector dataset (i.e., data.frame, with multiple values to be computed), enter the name of the study identifier here.
- `data`: Name of data.frame. Default is NULL, assuming a scalar is used as input. If input is a vector dataset (i.e., data.frame, with multiple values to be computed), enter the name of the data.frame here.

**Details**

The chi-squared statistic ($\chi^2$) is defined as

$$\chi^2 = \sum \frac{(o - e)^2}{e}$$

where $o$ is the observed value and $e$ is the expected value. **NOTE: This function requires the $\chi^2$ value to have been derived with 1 degree of freedom (indicating 2 independent groups are used in the calculation).**
Value

\( d \)  
Standardized mean difference (\( d \)).

\( \text{var.} d \)  
Variance of \( d \).

\( l. d \)  
lower confidence limits for \( d \).

\( u. d \)  
upper confidence limits for \( d \).

\( U3. d \)  
Cohen’s \( U(3) \), for \( d \).

\( \text{cl.} d \)  
Common Language Effect Size for \( d \).

\( \text{cliffs.} d \)  
Cliff’s Delta for \( d \).

\( p. d \)  
p-value for \( d \).

\( g \)  
Unbiased estimate of \( d \).

\( \text{var.} g \)  
Variance of \( g \).

\( l. g \)  
lower confidence limits for \( g \).

\( u. g \)  
upper confidence limits for \( g \).

\( U3. g \)  
Cohen’s \( U(3) \), for \( g \).

\( \text{cl.} g \)  
Common Language Effect Size for \( g \).

\( p. g \)  
p-value for \( g \).

\( r \)  
Correlation coefficient.

\( \text{var.} r \)  
Variance of \( r \).

\( l. r \)  
lower confidence limits for \( r \).

\( u. r \)  
upper confidence limits for \( r \).

\( p. r \)  
p-value for \( r \).

\( z \)  
Fisher’s \( z (z') \).

\( \text{var.} z \)  
Variance of \( z' \).

\( l. z \)  
lower confidence limits for \( z' \).

\( u. z \)  
upper confidence limits for \( z' \).

\( p. z \)  
p-value for \( z' \).

\( \text{OR} \)  
Odds ratio.

\( l. \text{or} \)  
lower confidence limits for \( OR \).

\( u. \text{or} \)  
upper confidence limits for \( OR \).

\( p. \text{or} \)  
p-value for \( OR \).

\( \text{log} \)  
Log odds ratio.

\( \text{var.} \text{log} \)  
Variance of log odds ratio.

\( l. \text{log} \)  
lower confidence limits for \( \text{log} \).

\( u. \text{log} \)  
upper confidence limits for \( \text{log} \).

\( p. \text{log} \)  
p-value for \( \text{log} \).

\( N. \text{total} \)  
Total sample size.

\( \text{NNT} \)  
Number needed to treat.
Note

Detailed information regarding output values of:
(1) Cohen’s d, Hedges’ g (unbiased estimate of d) and variance
(2) Correlation coefficient (r), Fisher’s z’, and variance
(3) Log odds and variance

is provided below (followed by general information about NNT, U3, Common Language Effect Size, and Cliff’s Delta):

Cohen’s d, Hedges’ g and Variance of g:
In this particular formula Cohen’s d is calculated after r is computed and then derived from it

\[ d = \frac{2r}{\sqrt{1 - r^2}} \]

The variance of d is derived from

\[ v_d = \frac{4v}{(1 - r^2)^3} \]

The effect size estimate d has a small upward bias (overestimates the population parameter effect size) which can be removed using a correction formula to derive the unbiased estimate of Hedges’ g. The correction factor, j, is defined as

\[ J = 1 - \frac{3}{4df - 1} \]

where df = degrees of freedom, which is equal to 1 since the \( \chi^2 \) degree of freedom = 1. Then, to calculate g

\[ g = Jd \]

and the variance of g

\[ v_g = J^2v_d \]

Correlation Coefficient r, Fisher’s z, and Variances:
In this particular formula r is calculated as follows

\[ r = \sqrt{\frac{\chi^2}{n}} \]

where \( \chi^2 \) is the chi-squared value with 1 degree of freedom and n is the total sample size.

The variance of r is then defined as

\[ v_r = \frac{(1 - r^2)^2}{n - 1} \]
Often researchers are interested in transforming \( r \) to \( z' \) (Fisher’s \( z \)) because \( r \) is not normally distributed, particularly at large values of \( r \). Therefore, converting to \( z' \) will help to normally distribute the estimate. Converting from \( r \) to \( z' \) is defined as

\[
z = .5 \log \left( \frac{1 + r}{1 - r} \right)
\]

and the variance of \( z \)

\[
\nu_z = \frac{1}{n - 3}
\]

where \( n \) is the total sample size for groups 1 and 2.

**Log Odds Ratio & Variance of Log Odds:**

In this particular formula, log odds is calculated as follows

\[
\log(o) = \frac{\pi d}{\sqrt{3}}
\]

where \( \pi = 3.1459 \). The variance of log odds is defined as

\[
\nu_{\log(o)} = \pi^2 \nu_d \frac{3}{4}
\]

**General information about NNT, U3, Common Language Effect Size, and Cliff’s Delta:**

*Number needed to treat (NNT).* NNT is interpreted as the number of participants that would need to be treated in one group (e.g., intervention group) in order to have one additional positive outcome over that of the outcome of a randomly selected participant in the other group (e.g., control group). In the `compute.es` package, NNT is calculated directly from \( d \) (Furukawa & Leucht, 2011), assuming relative normality of distribution and equal variances across groups, as follows:

\[
NNT = \frac{1}{\Phi(d - \Psi(CER)) - CER}
\]

*U3.* Cohen (1988) proposed a method for characterizing effect sizes by expressing them in terms of (normal) distribution overlap, called U3. This statistic describes the percentage of scores in one group that are exceeded by the mean score in another group. If the population means are equal then half of the scores in the treatment group exceed half the scores in the comparison group, and U3 = 50%. As the population mean difference increases, U3 approaches 100% (Valentine & Cooper, 2003).

*Common Language Effect Size (CLES).* CLES (McGraw & Wong, 1992) expresses the probability that a randomly selected score from one population will be greater than a randomly sampled score from another population. CLES is computed as the percentage of the normal curve that falls between negative infinity and the effect size (Valentine & Cooper, 2003).

*Cliff’s Delta/success rate difference.* Cliff’s delta (or success rate difference; Furukawa & Leucht (2011)) is a robust alternative to Cohen’s \( d \), when data are either non-normal or ordinal (with truncated/reduced variance). Cliff’s Delta is a non-parametric procedure that provides the probability...
that individual observations in one group are likely to be greater than the observations in another group. It is the probability that a randomly selected participant of one population has a better outcome than a randomly selected participant of the second population (minus the reverse probability). Cliff’s Delta of negative 1 or positive 1 indicates no overlap between the two groups, whereas a value of 0 indicates complete overlap and equal group distributions.

\[
\delta = 2 \Phi \left( \frac{d}{\sqrt{2}} \right) - 1
\]

**Author(s)**

AC Del Re

Much appreciation to Dr. Jeffrey C. Valentine for his contributions in implementing \textit{U3} and \textit{CLES} procedures and related documentation.

Maintainer: AC Del Re <acdelre@gmail.com>

**References**


**Examples**

```r
# CALCULATE SEVERAL EFFECT SIZES BASED ON CHI^2 STATISTIC:

chies(4, 30)
```

<table>
<thead>
<tr>
<th>des</th>
<th>Mean Difference (d) to Effect size</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Description**

Converts \(d\) (mean difference) to an effect size of \(g\) (unbiased estimate of \(d\)), \(r\) (correlation coefficient), \(z'\) (Fisher’s \(z\)), and log odds ratio. The variances, confidence intervals and \(p\)-values of these estimates are also computed, along with NNT (number needed to treat), \(U3\) (Cohen’s \(U(3)\) overlapping proportions of distributions), CLES (Common Language Effect Size) and Cliff’s Delta.
Usage

```r
des(d, n.1, n.2, level = 95, cer = 0.2, dig = 2, verbose = TRUE, id=NULL, data=NULL)
```

Arguments

d  Mean difference statistic ($d$).

n.1  Sample size of group one.

n.2  Sample size of group one.

level  Confidence level. Default is 95%.

cer  Control group Event Rate (e.g., proportion of cases showing recovery). Default is 0.2 (=20% of cases showing recovery). **CER is used exclusively for NNT output. This argument can be ignored if input is not a mean difference effect size.** Note: NNT output (described below) will NOT be meaningful if based on anything other than input from mean difference effect sizes (i.e., input of Cohen’s $d$, Hedges’ $g$ will produce meaningful output, while correlation coefficient input will NOT produce meaningful NNT output).

dig  Number of digits to display. Default is 2 digits.

verbose  Print output from scalar values? If yes, then verbose=TRUE; otherwise, verbose=FALSE. Default is TRUE.

id  Study identifier. Default is NULL, assuming a scalar is used as input. If input is a vector dataset (i.e., data.frame, with multiple values to be computed), enter the name of the study identifier here.

data  name of data.frame. Default is NULL, assuming a scalar is used as input. If input is a vector dataset (i.e., data.frame, with multiple values to be computed), enter the name of the data.frame here.

Details

**Information regarding input ($d$):**

In a study comparing means from independent groups, the population standardized mean difference is defined as

$$\delta = \frac{\mu_2 - \mu_1}{\sigma}$$

where $\mu_2$ is the population mean of the second group, $\mu_1$ is the population mean of the first group, and $\sigma$ is the population standard deviation (assuming $\sigma_2 = \sigma_1$).

The estimate of $\delta$ from independent groups is defined as

$$d = \frac{\bar{Y}_2 - \bar{Y}_1}{S_{within}}$$

where $\bar{Y}_2$ and $\bar{Y}_1$ are the sample means in each group and $S_{within}$ is the standard deviation pooled across both groups and is defined as
\[ S_{within} = \sqrt{\frac{(n_1 - 1)S_1^2 + (n_2 - 1)S_2^2}{n_1 + n_2 - 2}} \]

where \( n_1 \) and \( n_2 \) are the sample sizes of group 1 and 2 respectively and \( S_1^2 \) and \( S_2^2 \) are the standard deviations of each group. The variance of \( d \) is then defined as

\[ v_d = \frac{n_1 + n_2}{n_1 n_2} + \frac{d^2}{2(n_1 n_2)} \]

**Value**

- **d**: Standardized mean difference (\( d \)).
- **var.d**: Variance of \( d \).
- **l.d**: lower confidence limits for \( d \).
- **u.d**: upper confidence limits for \( d \).
- **U3.d**: Cohen’s \( U(3) \), for \( d \).
- **cl.d**: Common Language Effect Size for \( d \).
- **cliffs.d**: Cliff’s Delta for \( d \).
- **p.d**: p-value for \( d \).
- **g**: Unbiased estimate of \( d \).
- **var.g**: Variance of \( g \).
- **l.g**: lower confidence limits for \( g \).
- **u.g**: upper confidence limits for \( g \).
- **U3.g**: Cohen’s \( U(3) \), for \( g \).
- **cl.g**: Common Language Effect Size for \( g \).
- **p.g**: p-value for \( g \).
- **r**: Correlation coefficient.
- **var.r**: Variance of \( r \).
- **l.r**: lower confidence limits for \( r \).
- **u.r**: upper confidence limits for \( r \).
- **p.r**: p-value for \( r \).
- **z**: Fisher’s \( z (z') \).
- **var.z**: Variance of \( z' \).
- **l.z**: lower confidence limits for \( z' \).
- **u.z**: upper confidence limits for \( z' \).
- **p.z**: p-value for \( z' \).
- **OR**: Odds ratio.
- **l.or**: lower confidence limits for \( OR \).
u.or upper confidence limits for OR.
p.or p-value for OR.
lor Log odds ratio.
var.lor Variance of log odds ratio.
l.or lower confidence limits for lOR.
u.lor upper confidence limits for lOR.
p.lor p-value for lOR.
N.total Total sample size.
NNT Number needed to treat.

Note

Detailed information regarding output values of:
(1) Cohen’s d, Hedges’ g (unbiased estimate of d) and variance
(2) Correlation coefficient (r), Fisher’s z’, and variance
(3) Log odds and variance
is provided below (followed by general information about NNT, U3, Common Language Effect Size, and Cliff’s Delta):

Hedges’ g and Variance of g:
The effect size estimate $d$ has a small upward bias (overestimates the population parameter effect size) which can be removed using a correction formula to derive the unbiased estimate of Hedges’ $g$. The correction factor, $j$, is defined as

\[ J = 1 - \frac{3}{4df - 1} \]

where $df =$ degrees of freedom, which is $n_1 + n_2 - 2$ for two independent groups. Then, to calculate $g$

\[ g = Jd \]

and the variance of $g$

\[ v_g = J^2 v_d \]

Correlation Coefficient $r$, Fisher’s $z$, and Variances:
In this particular formula $r$ is calculated as follows

\[ r = \frac{d}{\sqrt{d^2 + a}} \]

where $a$ corrects for imbalance in $n_1$ & $n_2$ and is defined as
\[ a = (n_1 + n_2)^2 \]

The variance of \( r \) is then defined as

\[ v_r = \frac{a^2 v_d}{(d^2 + a)^3} \]

Often researchers are interested in transforming \( r \) to \( z' \) (Fisher’s \( z \)) because \( r \) is not normally distributed, particularly at large values of \( r \). Therefore, converting to \( z' \) will help to normally distribute the estimate. Converting from \( r \) to \( z' \) is defined as

\[ z = \frac{1}{2} \log\left( \frac{1 + r}{1 - r} \right) \]

and the variance of \( z \)

\[ v_z = \frac{1}{n - 3} \]

where \( n \) is the total sample size for groups 1 and 2.

**Log Odds Ratio & Variance of Log Odds:**

In this particular formula, log odds is calculated as follows

\[ \log\left( \pi \right) = \frac{\pi d}{\sqrt{3}} \]

where \( \pi = 3.1459 \). The variance of log odds is defined as

\[ v_{\log(\pi)} = \frac{\pi^2 v_d}{3} \]

**General information about NNT, U3, Common Language Effect Size, and Cliff’s Delta:**

**Number needed to treat (NNT).** NNT is interpreted as the number of participants that would need to be treated in one group (e.g., intervention group) in order to have one additional positive outcome over that of the outcome of a randomly selected participant in the other group (e.g., control group). In the `compute.es` package, NNT is calculated directly from \( d \) (Furukawa & Leucht, 2011), assuming relative normality of distribution and equal variances across groups, as follows:

\[ NNT = \frac{1}{\Phi(d - \Psi(CER)) - CER} \]

**U3.** Cohen (1988) proposed a method for characterizing effect sizes by expressing them in terms of (normal) distribution overlap, called U3. This statistic describes the percentage of scores in one group that are exceeded by the mean score in another group. If the population means are equal then half of the scores in the treatment group exceed half the scores in the comparison group, and U3
= 50%. As the population mean difference increases, U3 approaches 100% (Valentine & Cooper, 2003).

*Common Language Effect Size (CLES).* CLES (McGraw & Wong, 1992) expresses the probability that a randomly selected score from one population will be greater than a randomly sampled score from another population. CLES is computed as the percentage of the normal curve that falls between negative infinity and the effect size (Valentine & Cooper, 2003).

*Cliff’s Delta/success rate difference.* Cliff’s delta (or success rate difference; Furukawa & Leucht (2011)) is a robust alternative to Cohen’s d, when data are either non-normal or ordinal (with truncated/reduced variance). Cliff’s Delta is a non-parametric procedure that provides the probability that individual observations in one group are likely to be greater than the observations in another group. It is the probability that a randomly selected participant of one population has a better outcome than a randomly selected participant of the second population (minus the reverse probability). Cliff’s Delta of negative 1 or positive 1 indicates no overlap between the two groups, whereas a value of 0 indicates complete overlap and equal group distributions.

\[ \delta = 2 \Phi\left(\frac{d}{\sqrt{2}}\right) - 1 \]

**Author(s)**

AC Del Re

Much appreciation to Dr. Jeffrey C. Valentine for his contributions in implementing U3 and CLES procedures and related documentation.

Maintainer: AC Del Re <acdelre@gmail.com>

**References**


**Examples**

```r
# CALCULATE SEVERAL EFFECT SIZES BASED ON d STATISTIC:
library(compute.es)
args(des)  # d STAT TO OTHER ES (INCLUDING HEDGES g)
```
# SCALAR

\[ \text{des}(d=0.8, n.1=30, n.2=30) \]

## VECTOR OF d VALUES

# SAMPLE DATA

\[
dat <- \text{data.frame}(id=1:30, \\
\quad d=\text{rnorm}(30, 0.8, 0.1), \\
\quad nT=\text{round}(\text{rnorm}(30, 30, 5), 0), \\
\quad nC=\text{round}(\text{rnorm}(30, 30, 5), 0) \\
\) 
\]

\[ \text{des}(d=d, n.1=nT, n.2=nC, id=id, data=dat) \]

# TO EXTRACT JUST g AND var(g)

\[ \text{des}(d=d, n.1=nT, n.2=nC, id=id, data=dat)[,13:14] \]

---

**failes**

*Failure groups to Effect Size*

**Description**

Converts binary data, that only reported the number of 'failures' in a group, to \(d\) (mean difference), \(g\) (unbiased estimate of \(d\)), \(r\) (correlation coefficient), \(z'\) (Fisher’s \(z\)), and log odds ratio. The variances, confidence intervals and p-values of these estimates are also computed, along with NNT (number needed to treat), U3 (Cohen’s \(U_3\)) overlapping proportions of distributions), CLES (Common Language Effect Size) and Cliff’s Delta.

**Usage**

\[ \text{failes}(B, D, n.1, n.0, \text{level}=95, \text{cer}=0.2, \text{dig}=2, \text{verbose}=\text{TRUE}, \text{id=NULL}, \text{data=NULL}) \]

**Arguments**

- **B**  
  Treatment failure.

- **D**  
  Non-treatment failure.

- **n.1**  
  Treatment sample size.

- **n.0**  
  Control/comparison sample size.

- **level**  
  Confidence level. Default is 95%.

- **cer**  
  Control group Event Rate (e.g., proportion of cases showing recovery). Default is 0.2 (=20% of cases showing recovery). **CER is used exclusively for NNT output. This argument can be ignored if input is not a mean difference effect size.** Note: NNT output (described below) will NOT be meaningful if based on anything other than input from mean difference effect sizes (i.e., input of Cohen’s \(d\), Hedges’ \(g\) will produce meaningful output, while correlation coefficient input will NOT produce meaningful NNT output).

- **dig**  
  Number of digits to display. Default is 2 digits.
verbose
Print output from scalar values? If yes, then verbose=TRUE; otherwise, verbose=FALSE. Default is TRUE.

id
Study identifier. Default is NULL, assuming a scalar is used as input. If input is a vector dataset (i.e., data.frame, with multiple values to be computed), enter the name of the study identifier here.

data
name of data.frame. Default is NULL, assuming a scalar is used as input. If input is a vector dataset (i.e., data.frame, with multiple values to be computed), enter the name of the data.frame here.

Details
This formula will first compute an odds ratio and then a log odds and its variance. From there, Cohen's $d$ is computed and the remaining effect size estimates are then derived from $d$. Computing the odds ratio involves

$$or = \frac{p_1(1 - p_2)}{p_2(1 - p_1)}$$

The conversion to a log odds and its variance is defined as

$$ln(o) = \log(or)$$

$$v_{ln(o)} = \frac{1}{A} + \frac{1}{B} + \frac{1}{C} + \frac{1}{D}$$

Value

d
Standardized mean difference ($d$).

var.d
Variance of $d$.

l.d
lower confidence limits for $d$.

u.d
upper confidence limits for $d$.

U3.d
Cohen's $U(3)$, for $d$.

cl.d
Common Language Effect Size for $d$.

cliffs.d
Cliff's Delta for $d$.

p.d
p-value for $d$.

g
Unbiased estimate of $d$.

var.g
Variance of $g$.

l.g
lower confidence limits for $g$.

u.g
upper confidence limits for $g$.

U3.g
Cohen's $U(3)$, for $g$.

cl.g
Common Language Effect Size for $g$.

p.g
p-value for $g$.

r
Correlation coefficient.

var.r
Variance of $r$. 
1. r  lower confidence limits for r.
2. r  upper confidence limits for r.
3. p.r  p-value for r.
4. z  Fisher’s z (z’).
5. var.z  Variance of z’.
6. l.z  lower confidence limits for z’.
7. u.z  upper confidence limits for z’.
8. p.z  p-value for z’.
9. OR  Odds ratio.
10. l.or  lower confidence limits for OR.
11. u.or  upper confidence limits for OR.
12. p.or  p-value for OR.
13. lOR  Log odds ratio.
14. var.lor  Variance of log odds ratio.
15. l.lor  lower confidence limits for lOR.
16. u.lor  upper confidence limits for lOR.
17. p.lor  p-value for lOR.
18. N.total  Total sample size.
19. NNT  Number needed to treat.

Note

Detailed information regarding output values of:

1. **Cohen’s d, Hedges’ g (unbiased estimate of d) and variance**
2. **Correlation coefficient (r), Fisher’s z’, and variance**
3. **Log odds and variance**

is provided below (followed by general information about NNT, U3, Common Language Effect Size, and Cliff’s Delta):

**Cohen’s d, Hedges’ g and Variance of g:**

In this particular formula Cohen’s d is calculated after r is computed and is also derived from it

\[ d = \frac{\ln(o)\sqrt{3}}{\pi} \]

The variance of d is derived from

\[ v_d = \frac{3v_{\ln(o)}}{\pi^2} \]

The effect size estimate d has a small upward bias (overestimates the population parameter effect size) which can be removed using a correction formula to derive the unbiased estimate of Hedges’ g. The correction factor, j, is defined as
\[ J = 1 - \frac{3}{4df - 1} \]

where \( df \) = degrees of freedom, which is \( n_1 + n_2 - 2 \) for two independent groups. Then, to calculate \( g \)

\[ g = Jd \]

and the variance of \( g \)

\[ v_g = J^2 v_d \]

**Correlation Coefficient \( r \), Fisher’s \( z \), and Variances:**

In this particular formula \( r \) is calculated as follows

\[ r = \frac{d}{\sqrt{d^2 + a}} \]

where \( a \) corrects for inbalance in \( n_1 \) & \( n_2 \) and is defined as

\[ a = \frac{(n_1 + n_2)^2}{n_1 n_2} \]

The variance of \( r \) is then defined as

\[ v_r = \frac{a^2 v_d}{(d^2 + a)^3} \]

Often researchers are interested in transforming \( r \) to \( z' \) (Fisher’s \( z \)) because \( r \) is not normally distributed, particularly at large values of \( r \). Therefore, converting to \( z' \) will help to normally distribute the estimate. Converting from \( r \) to \( z' \) is defined as

\[ z = .5 * \log \left( \frac{1 + r}{1 - r} \right) \]

and the variance of \( z \)

\[ v_z = \frac{1}{n - 3} \]

where \( n \) is the total sample size for groups 1 and 2.

**General information about NNT, U3, Common Language Effect Size, and Cliff’s Delta:**

*Number needed to treat (NNT).* NNT is interpreted as the number of participants that would need to be treated in one group (e.g., intervention group) in order to have one additional positive outcome over that of the outcome of a randomly selected participant in the other group (e.g., control group).
group). In the compute.es package, NNT is calculated directly from d (Furukawa & Leucht, 2011), assuming relative normality of distribution and equal variances across groups, as follows:

\[ NNT = \frac{1}{\Phi(d - \Psi(CER)) - CER} \]

**U3.** Cohen (1988) proposed a method for characterizing effect sizes by expressing them in terms of (normal) distribution overlap, called U3. This statistic describes the percentage of scores in one group that are exceeded by the mean score in another group. If the population means are equal then half of the scores in the treatment group exceed half the scores in the comparison group, and U3 = 50%. As the population mean difference increases, U3 approaches 100% (Valentine & Cooper, 2003).

**Common Language Effect Size (CLES).** CLES (McGraw & Wong, 1992) expresses the probability that a randomly selected score from one population will be greater than a randomly sampled score from another population. CLES is computed as the percentage of the normal curve that falls between negative infinity and the effect size (Valentine & Cooper, 2003).

**Cliff’s Delta/success rate difference.** Cliff’s delta (or success rate difference; Furukawa & Leucht, 2011) is a robust alternative to Cohen’s d, when data are either non-normal or ordinal (with truncated/reduced variance). Cliff’s Delta is a non-parametric procedure that provides the probability that individual observations in one group are likely to be greater than the observations in another group. It is the probability that a randomly selected participant of one population has a better outcome than a randomly selected participant of the second population (minus the reverse probability). Cliff’s Delta of negative 1 or positive 1 indicates no overlap between the two groups, whereas a value of 0 indicates complete overlap and equal group distributions.

\[ \delta = 2 \times \Phi\left(\frac{d}{\sqrt{2}}\right) - 1 \]

**Author(s)**

AC Del Re

Much appreciation to Dr. Jeffrey C. Valentine for his contributions in implementing U3 and CLES procedures and related documentation.

Maintainer: AC Del Re <acdelre@gmail.com>

**References**


See Also

lores, propes

Examples

# CALCULATE SEVERAL EFFECT SIZES BASED ON NUMBER OF 'FAILURES' IN GROUP:

failes(5, 10, 30, 30)

---

**fes**  
*F-test to Effect Size*

**Description**

Converts F-test value to an effect size of d (mean difference), g (unbiased estimate of d), r (correlation coefficient), $z'$ (Fisher's $z$), and log odds ratio. The variances, confidence intervals and p-values of these estimates are also computed, along with NNT (number needed to treat), U3 (Cohen's $U_3$) overlapping proportions of distributions), CLES (Common Language Effect Size) and Cliff's Delta.

**Usage**

fes(f, n.1, n.2, level = 95, cer = 0.2, dig = 2, verbose = TRUE, id=NULL, data=NULL)

**Arguments**

- `f`  
  F-value reported in primary study.

- `n.1`  
  Sample size of treatment group.

- `n.2`  
  Sample size of comparison group.

- `level`  
  Confidence level. Default is 95%.

- `cer`  
  Control group Event Rate (e.g., proportion of cases showing recovery). Default is 0.2 (=20% of cases showing recovery). **CER is used exclusively for NNT output.** This argument can be ignored if input is not a mean difference effect size. Note: NNT output (described below) will NOT be meaningful if based on anything other than input from mean difference effect sizes (i.e., input of Cohen's d, Hedges' $g$ will produce meaningful output, while correlation coefficient input will NOT produce meaningful NNT output).

- `dig`  
  Number of digits to display. Default is 2 digits.

- `verbose`  
  Print output from scalar values? If yes, then verbose=TRUE; otherwise, verbose=FALSE. Default is TRUE.

- `id`  
  Study identifier. Default is NULL, assuming a scalar is used as input. If input is a vector dataset (i.e., data.frame, with multiple values to be computed), enter the name of the study identifier here.

- `data`  
  Name of data.frame. Default is NULL, assuming a scalar is used as input. If input is a vector dataset (i.e., data.frame, with multiple values to be computed), enter the name of the data.frame here.
Value

- **d** Standardized mean difference \( (d) \).
- **var. d** Variance of \( d \).
- **1. d** lower confidence limits for \( d \).
- **u. d** upper confidence limits for \( d \).
- **U3. d** Cohen’s \( U(3) \), for \( d \).
- **cl. d** Common Language Effect Size for \( d \).
- **cliffs. d** Cliff’s Delta for \( d \).
- **p. d** p-value for \( d \).
- **g** Unbiased estimate of \( d \).
- **var. g** Variance of \( g \).
- **1. g** lower confidence limits for \( g \).
- **u. g** upper confidence limits for \( g \).
- **U3. g** Cohen’s \( U(3) \), for \( g \).
- **cl. g** Common Language Effect Size for \( g \).
- **p. g** p-value for \( g \).
- **r** Correlation coefficient.
- **var. r** Variance of \( r \).
- **1. r** lower confidence limits for \( r \).
- **u. r** upper confidence limits for \( r \).
- **p. r** p-value for \( r \).
- **z** Fisher’s \( z (z') \).
- **var. z** Variance of \( z' \).
- **1. z** lower confidence limits for \( z' \).
- **u. z** upper confidence limits for \( z' \).
- **p. z** p-value for \( z' \).
- **OR** Odds ratio.
- **1. or** lower confidence limits for \( OR \).
- **u. or** upper confidence limits for \( OR \).
- **p. or** p-value for \( OR \).
- **lOR** Log odds ratio.
- **var. lor** Variance of log odds ratio.
- **1. lor** lower confidence limits for \( lOR \).
- **u. lor** upper confidence limits for \( lOR \).
- **p. lor** p-value for \( lOR \).
- **N. total** Total sample size.
- **NNT** Number needed to treat.
Note

Detailed information regarding output values of:

1. **Cohen’s d, Hedges’ g (unbiased estimate of d) and variance**
2. **Correlation coefficient (r), Fisher’s z’, and variance**
3. **Log odds and variance**

is provided below (followed by general information about NNT, U3, Common Language Effect Size, and Cliff’s Delta):

**Cohen’s d, Hedges’ g and Variance of g:**

This function will initially calculate Cohen’s d, from the F-test values, and then all other effect size estimates are derived from d and its variance. This parameter is calculated by

\[
d = \sqrt{\frac{F(n_1 + n_2)}{n_1 n_2}}
\]

The variance of d is derived from

\[
v_d = \frac{n_1 + n_2}{n_1 n_2} + \frac{d^2}{2(n_1 + n_2)}
\]

The effect size estimate d has a small upward bias (overestimates the population parameter effect size) which can be removed using a correction formula to derive the unbiased estimate of Hedges’ g. The correction factor, J, is defined as

\[
J = 1 - \frac{3}{4df - 1}
\]

where \(df\) = degrees of freedom, which is \(n_1 + n_2 - 2\) for two independent groups. Then, to calculate g

\[
g = Jd
\]

and the variance of g

\[
v_g = J^2 v_d
\]

**Correlation Coefficient r, Fisher’s z, and Variances:**

In this particular formula r is calculated as follows

\[
r = \frac{d}{\sqrt{d^2 + a}}
\]

where a corrects for inbalance in \(n_1 \& n_2\) and is defined as

\[
a = \frac{(n_1 + n_2)^2}{n_1 n_2}
\]
The variance of \( r \) is then defined as

\[
v_r = \frac{a^2 v_d}{(d^2 + a)^3}
\]

Often researchers are interested in transforming \( r \) to \( z' \) (Fisher’s \( z \)) because \( r \) is not normally distributed, particularly at large values of \( r \). Therefore, converting to \( z' \) will help to normally distribute the estimate. Converting from \( r \) to \( z' \) is defined as

\[
z = .5\log\left(\frac{1 + r}{1 - r}\right)
\]

and the variance of \( z \)

\[
v_z = \frac{1}{n - 3}
\]

where \( n \) is the total sample size for groups 1 and 2.

**Log Odds Ratio & Variance of Log Odds:**

In this particular formula, log odds is calculated as follows

\[
\log(o) = \frac{\pi d}{\sqrt{3}}
\]

where \( \pi = 3.1459 \). The variance of log odds is defined as

\[
v_{log(o)} = \frac{\pi^2 v_d}{3}
\]

**General information about NNT, U3, Common Language Effect Size, and Cliff’s Delta:**

*Number needed to treat (NNT).* NNT is interpreted as the number of participants that would need to be treated in one group (e.g., intervention group) in order to have one additional positive outcome over that of the outcome of a randomly selected participant in the other group (e.g., control group). In the *compute.es* package, NNT is calculated directly from \( d \) (Furukawa & Leucht, 2011), assuming relative normality of distribution and equal variances across groups, as follows:

\[
NNT = \frac{1}{\Phi(d - \Psi(CER)) - CER}
\]

*U3.* Cohen (1988) proposed a method for characterizing effect sizes by expressing them in terms of (normal) distribution overlap, called U3. This statistic describes the percentage of scores in one group that are exceeded by the mean score in another group. If the population means are equal then half of the scores in the treatment group exceed half the scores in the comparison group, and U3 = 50%. As the population mean difference increases, U3 approaches 100% (Valentine & Cooper, 2003).

*Common Language Effect Size (CLES).* CLES (McGraw & Wong, 1992) expresses the probability that a randomly selected score from one population will be greater than a randomly sampled score
from another population. CLES is computed as the percentage of the normal curve that falls between negative infinity and the effect size (Valentine & Cooper, 2003).

Cliff’s Delta/success rate difference. Cliff’s delta (or success rate difference; Furukawa & Leucht (2011)) is a robust alternative to Cohen’s d, when data are either non-normal or ordinal (with truncated/reduced variance). Cliff’s Delta is a non-parametric procedure that provides the probability that individual observations in one group are likely to be greater than the observations in another group. It is the probability that a randomly selected participant of one population has a better outcome than a randomly selected participant of the second population (minus the reverse probability). Cliff’s Delta of negative 1 or positive 1 indicates no overlap between the two groups, whereas a value of 0 indicates complete overlap and equal group distributions.

$$\delta = 2 \cdot \Phi\left(\frac{d}{\sqrt{2}}\right) - 1$$

Author(s)

AC Del Re

Much appreciation to Dr. Jeffrey C. Valentine for his contributions in implementing U3 and CLES procedures and related documentation.

Maintainer: AC Del Re <acdelre@gmail.com>

References


See Also

a.fes

Examples

# CALCULATE SEVERAL EFFECT SIZES BASED ON F-STATISTIC:

fes(3, 30, 30)
lores \hspace{4cm} Log Odds Ratio to Effect Size

Description

Converts a log odds ratio to an effect size of $d$ (mean difference), $g$ (unbiased estimate of $d$), $r$ (correlation coefficient), $z'$ (Fisher’s $z$), and log odds ratio. The variances, confidence intervals and p-values of these estimates are also computed, along with NNT (number needed to treat), U3 (Cohen’s $U_3$) overlapping proportions of distributions), CLES (Common Language Effect Size) and Cliff’s Delta.

Usage

lores(lor, var.lor, n.1, n.2,
level = 95, cer = 0.2, dig = 2, verbose = TRUE, id=NULL, data=NULL)

Arguments

<table>
<thead>
<tr>
<th>lor</th>
<th>Log odds ratio reported in the primary study.</th>
</tr>
</thead>
<tbody>
<tr>
<td>var.lor</td>
<td>Variance of the log odds ratio.</td>
</tr>
<tr>
<td>n.1</td>
<td>Sample size of treatment group.</td>
</tr>
<tr>
<td>n.2</td>
<td>Sample size of comparison group.</td>
</tr>
<tr>
<td>level</td>
<td>Confidence level. Default is 95%.</td>
</tr>
<tr>
<td>cer</td>
<td>Control group Event Rate (e.g., proportion of cases showing recovery). Default is 0.2 (=20% of cases showing recovery). <strong>CER is used exclusively for NNT output. This argument can be ignored if input is not a mean difference effect size.</strong> Note: NNT output (described below) will NOT be meaningful if based on anything other than input from mean difference effect sizes (i.e., input of Cohen’s d, Hedges’ $g$ will produce meaningful output, while correlation coefficient input will NOT produce meaningful NNT output).</td>
</tr>
<tr>
<td>dig</td>
<td>Number of digits to display. Default is 2 digits.</td>
</tr>
<tr>
<td>verbose</td>
<td>Print output from scalar values? If yes, then verbose=TRUE; otherwise, verbose=FALSE. Default is TRUE.</td>
</tr>
<tr>
<td>id</td>
<td>Study identifier. Default is NULL, assuming a scalar is used as input. If input is a vector dataset (i.e., data.frame, with multiple values to be computed), enter the name of the study identifier here.</td>
</tr>
<tr>
<td>data</td>
<td>name of data.frame. Default is NULL, assuming a scalar is used as input. If input is a vector dataset (i.e., data.frame, with multiple values to be computed), enter the name of the data.frame here.</td>
</tr>
</tbody>
</table>
**Details**

This formula will first convert a log odds and its variance to Cohen’s \( d \). This value will then be used to compute the remaining effect size estimates. One method for deriving the odds ratio involves

\[
\text{or} = \frac{p_1(1 - p_2)}{p_2(1 - p_1)}
\]

The conversion to a log odds and its variance is defined as

\[
\ln(o) = \log(\text{or})
\]

\[
v_{\ln(o)} = \frac{1}{A} + \frac{1}{B} + \frac{1}{C} + \frac{1}{D}
\]

**Value**

- \( d \): Standardized mean difference (\( d \)).
- \( \text{var}.d \): Variance of \( d \).
- \( 1.d \): lower confidence limits for \( d \).
- \( u.d \): upper confidence limits for \( d \).
- \( U3.d \): Cohen’s \( U(3) \), for \( d \).
- \( \text{cl}.d \): Common Language Effect Size for \( d \).
- \( \text{cliffs}.d \): Cliff’s Delta for \( d \).
- \( p.d \): p-value for \( d \).
- \( g \): Unbiased estimate of \( d \).
- \( \text{var}.g \): Variance of \( g \).
- \( 1.g \): lower confidence limits for \( g \).
- \( u.g \): upper confidence limits for \( g \).
- \( U3.g \): Cohen’s \( U(3) \), for \( g \).
- \( \text{cl}.g \): Common Language Effect Size for \( g \).
- \( p.g \): p-value for \( g \).
- \( r \): Correlation coefficient.
- \( \text{var}.r \): Variance of \( r \).
- \( 1.r \): lower confidence limits for \( r \).
- \( u.r \): upper confidence limits for \( r \).
- \( p.r \): p-value for \( r \).
- \( z \): Fisher’s \( z \) (\( z' \)).
- \( \text{var}.z \): Variance of \( z' \).
- \( 1.z \): lower confidence limits for \( z' \).
- \( u.z \): upper confidence limits for \( z' \).
**Note**

**Detailed information regarding output values of:**

(1) *Cohen’s d, Hedges’ g (unbiased estimate of d) and variance*

(2) *Correlation coefficient (r), Fisher’s z’, and variance*

(3) *Log odds and variance*

is provided below (followed by general information about NNT, U3, Common Language Effect Size, and Cliff’s Delta):

**Cohen’s d, Hedges’ g and Variance of g:**

In this particular formula Cohen’s *d* is calculated from the log odds as follows

\[ d = \frac{\ln(o)\sqrt{3}}{\pi} \]

The variance of *d* is derived from

\[ v_d = \frac{3v_{\ln(o)}}{\pi^2} \]

The effect size estimate *d* has a small upward bias (overestimates the population parameter effect size) which can be removed using a correction formula to derive the unbiased estimate of Hedges’ *g*. The correction factor, *j*, is defined as

\[ J = 1 - \frac{3}{4df - 1} \]

where *df* = degrees of freedom, which is \(n_1 + n_2 - 2\) for two independent groups. Then, to calculate *g*

\[ g = Jd \]
and the variance of $g$

$$v_g = J^2 v_d$$

**Correlation Coefficient $r$, Fisher’s $z$, and Variances:**

In this particular formula $r$ is calculated as follows

$$r = \frac{d}{\sqrt{d^2 + a}}$$

where $a$ corrects for imbalance in $n_1$ & $n_2$ and is defined as

$$a = \frac{(n_1 + n_2)^2}{n_1 n_2}$$

The variance of $r$ is then defined as

$$v_r = \frac{a^2 v_d}{(d^2 + a)^3}$$

Often researchers are interested in transforming $r$ to $z'$ (Fisher’s $z$) because $r$ is not normally distributed, particularly at large values of $r$. Therefore, converting to $z'$ will help to normally distribute the estimate. Converting from $r$ to $z'$ is defined as

$$z = .5 \cdot \log \left( \frac{1 + r}{1 - r} \right)$$

and the variance of $z$

$$v_z = \frac{1}{n - 3}$$

where $n$ is the total sample size for groups 1 and 2.

**General information about NNT, U3, Common Language Effect Size, and Cliff’s Delta:**

*Number needed to treat (NNT).* NNT is interpreted as the number of participants that would need to be treated in one group (e.g., intervention group) in order to have one additional positive outcome over that of the outcome of a randomly selected participant in the other group (e.g., control group). In the `compute.es` package, NNT is calculated directly from $d$ (Furukawa & Leucht, 2011), assuming relative normality of distribution and equal variances across groups, as follows:

$$NNT = \frac{1}{\Phi(d - \Phi(CER)) - CER}$$

*U3.* Cohen (1988) proposed a method for characterizing effect sizes by expressing them in terms of (normal) distribution overlap, called U3. This statistic describes the percentage of scores in one group that are exceeded by the mean score in another group. If the population means are equal then half of the scores in the treatment group exceed half the scores in the comparison group, and U3
= 50%. As the population mean difference increases, \( U_3 \) approaches 100% (Valentine & Cooper, 2003).

**Common Language Effect Size (CLES).** CLES (McGraw & Wong, 1992) expresses the probability that a randomly selected score from one population will be greater than a randomly sampled score from another population. CLES is computed as the percentage of the normal curve that falls between negative infinity and the effect size (Valentine & Cooper, 2003).

**Cliff’s Delta/Success Rate Difference.** Cliff’s delta (or success rate difference; Furukawa & Leucht, 2011) is a robust alternative to Cohen’s \( d \), when data are either non-normal or ordinal (with truncated/reduced variance). Cliff’s Delta is a non-parametric procedure that provides the probability that individual observations in one group are likely to be greater than the observations in another group. It is the probability that a randomly selected participant of one population has a better outcome than a randomly selected participant of the second population (minus the reverse probability). Cliff’s Delta of negative 1 or positive 1 indicates no overlap between the two groups, whereas a value of 0 indicates complete overlap and equal group distributions.

\[
\delta = 2 \times \Phi\left(\frac{d}{\sqrt{2}}\right) - 1
\]

**Author(s)**

AC Del Re

Much appreciation to Dr. Jeffrey C. Valentine for his contributions in implementing \( U_3 \) and CLES procedures and related documentation.

Maintainer: AC Del Re <acdelre@gmail.com>

**References**


**See Also**

`propes`, `failes`

**Examples**

```r
# CALCULATE SEVERAL EFFECT SIZES BASED ON LOG ODDS RATIO STATISTIC:

lores(2, .3, 30, 30)
```
Means to Effect Size

Description

Converts raw mean scores to an effect size of \(d\) (mean difference), \(g\) (unbiased estimate of \(d\)), \(r\) (correlation coefficient), \(z'\) (Fisher’s \(z\)), and log odds ratio. The variances, confidence intervals and p-values of these estimates are also computed, along with NNT (number needed to treat), U3 (Cohen’s \(U_3\)) overlapping proportions of distributions), CLES (Common Language Effect Size) and Cliff’s Delta.

Usage

\[
\text{mes}(m.1, m.2, sd.1, sd.2, n.1, n.2, \\
\text{level} = 95, \text{cer} = 0.2, \text{dig} = 2, \text{verbose} = \text{TRUE}, \text{id}=\text{NULL}, \text{data}=\text{NULL})
\]

Arguments

\begin{itemize}
  \item \texttt{m.1} Mean of group one.
  \item \texttt{m.2} Mean of group two.
  \item \texttt{sd.1} Standard deviation of group one.
  \item \texttt{sd.2} Standard deviation of group two.
  \item \texttt{n.1} Sample size of group one.
  \item \texttt{n.2} Sample size of group two.
  \item \texttt{level} Confidence level. Default is 95%.
  \item \texttt{cer} Control group Event Rate (e.g., proportion of cases showing recovery). Default is 0.2 (=20% of cases showing recovery). \textbf{CER is used exclusively for NNT output. This argument can be ignored if input is not a mean difference effect size}. Note: NNT output (described below) will NOT be meaningful if based on anything other than input from mean difference effect sizes (i.e., input of Cohen’s \(d\), Hedges’ \(g\) will produce meaningful output, while correlation coefficient input will NOT produce meaningful NNT output).
  \item \texttt{dig} Number of digits to display. Default is 2 digits.
  \item \texttt{verbose} Print output from scalar values? If yes, then verbose=TRUE; otherwise, verbose=FALSE. Default is TRUE.
  \item \texttt{id} Study identifier. Default is NULL, assuming a scalar is used as input. If input is a vector dataset (i.e., \texttt{data.frame}, with multiple values to be computed), enter the name of the study identifier here.
  \item \texttt{data} name of \texttt{data.frame}. Default is NULL, assuming a scalar is used as input. If input is a vector dataset (i.e., \texttt{data.frame}, with multiple values to be computed), enter the name of the \texttt{data.frame} here.
\end{itemize}
<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>d</td>
<td>Standardized mean difference ($d$).</td>
</tr>
<tr>
<td>var.d</td>
<td>Variance of $d$.</td>
</tr>
<tr>
<td>l.d</td>
<td>Lower confidence limits for $d$.</td>
</tr>
<tr>
<td>u.d</td>
<td>Upper confidence limits for $d$.</td>
</tr>
<tr>
<td>U3.d</td>
<td>Cohen’s $U(3)$, for $d$.</td>
</tr>
<tr>
<td>cl.d</td>
<td>Common Language Effect Size for $d$.</td>
</tr>
<tr>
<td>cliffs.d</td>
<td>Cliff’s Delta for $d$.</td>
</tr>
<tr>
<td>p.d</td>
<td>p-value for $d$.</td>
</tr>
<tr>
<td>g</td>
<td>Unbiased estimate of $d$.</td>
</tr>
<tr>
<td>var.g</td>
<td>Variance of $g$.</td>
</tr>
<tr>
<td>l.g</td>
<td>Lower confidence limits for $g$.</td>
</tr>
<tr>
<td>u.g</td>
<td>Upper confidence limits for $g$.</td>
</tr>
<tr>
<td>U3.g</td>
<td>Cohen’s $U(3)$, for $g$.</td>
</tr>
<tr>
<td>cl.g</td>
<td>Common Language Effect Size for $g$.</td>
</tr>
<tr>
<td>p.g</td>
<td>p-value for $g$.</td>
</tr>
<tr>
<td>r</td>
<td>Correlation coefficient.</td>
</tr>
<tr>
<td>var.r</td>
<td>Variance of $r$.</td>
</tr>
<tr>
<td>l.r</td>
<td>Lower confidence limits for $r$.</td>
</tr>
<tr>
<td>u.r</td>
<td>Upper confidence limits for $r$.</td>
</tr>
<tr>
<td>p.r</td>
<td>p-value for $r$.</td>
</tr>
<tr>
<td>z</td>
<td>Fisher’s $z$ ($z'$).</td>
</tr>
<tr>
<td>var.z</td>
<td>Variance of $z'$.</td>
</tr>
<tr>
<td>l.z</td>
<td>Lower confidence limits for $z'$.</td>
</tr>
<tr>
<td>u.z</td>
<td>Upper confidence limits for $z'$.</td>
</tr>
<tr>
<td>p.z</td>
<td>p-value for $z'$.</td>
</tr>
<tr>
<td>OR</td>
<td>Odds ratio.</td>
</tr>
<tr>
<td>l.or</td>
<td>Lower confidence limits for $OR$.</td>
</tr>
<tr>
<td>u.or</td>
<td>Upper confidence limits for $OR$.</td>
</tr>
<tr>
<td>p.or</td>
<td>p-value for $OR$.</td>
</tr>
<tr>
<td>lOR</td>
<td>Log odds ratio.</td>
</tr>
<tr>
<td>var.lor</td>
<td>Variance of log odds ratio.</td>
</tr>
<tr>
<td>l.lor</td>
<td>Lower confidence limits for $lOR$.</td>
</tr>
<tr>
<td>u.lor</td>
<td>Upper confidence limits for $lOR$.</td>
</tr>
<tr>
<td>p.lor</td>
<td>p-value for $lOR$.</td>
</tr>
<tr>
<td>N.total</td>
<td>Total sample size.</td>
</tr>
<tr>
<td>NNT</td>
<td>Number needed to treat.</td>
</tr>
</tbody>
</table>
Note

Detailed information regarding output values of:

1. Cohen’s $d$, Hedges’ $g$ (unbiased estimate of $d$) and variance
2. Correlation coefficient ($r$), Fisher’s $z'$, and variance
3. Log odds and variance

is provided below (followed by general information about NNT, U3, Common Language Effect Size, and Cliff’s Delta):

**Cohen’s $d$, Hedges’ $g$ and Variance of $g$**

This function will initially calculate Cohen’s $d$, from the raw mean values. Then, all other effect size estimates are derived from $d$ and its variance. This parameter is calculated by

$$d = \frac{\bar{Y}_1 - \bar{Y}_2}{S_{within}}$$

where $\bar{Y}_1$ and $\bar{Y}_2$ are the adjusted sample means in each group and $S_{within}$ is the ‘readjusted’ standard deviation defined as

$$S_{within} = \sqrt{\frac{(n_1 - 1)S_1^2 + (n_2 - 1)S_2^2}{n_1 + n_2 - 2}}$$

where $S_1$ and $S_2$ = standard deviation of groups one and two.

The variance of $d$ is derived from

$$v_d = \frac{n_1 + n_2}{n_1 n_2} + \frac{d^2}{2(n_1 + n_2)}$$

The effect size estimate $d$ has a small upward bias (overestimates the population parameter effect size) which can be removed using a correction formula to derive the unbiased estimate of Hedges’ $g$. The correction factor, $J$, is defined as

$$J = 1 - \frac{3}{4df - 1}$$

where $df$ = degrees of freedom, which is $n_1 + n_2 - 2$ for two independent groups. Then, to calculate $g$

$$g = Jd$$

and the variance of $g$

$$v_g = J^2 v_d$$

**Correlation Coefficient $r$, Fisher’s $z'$, and Variances:**

In this particular formula $r$ is calculated as follows
\[ r = \frac{d}{\sqrt{d^2 + a}} \]

where \( a \) corrects for imbalance in \( n_1 \) & \( n_2 \) and is defined as
\[ a = \frac{(n_1 + n_2)^2}{n_1 n_2} \]

The variance of \( r \) is then defined as
\[ v_r = \frac{a^2 v_d}{(d^2 + a)^3} \]

Often researchers are interested in transforming \( r \) to \( z' \) (Fisher's \( z \)) because \( r \) is not normally distributed, particularly at large values of \( r \). Therefore, converting to \( z' \) will help to normally distribute the estimate. Converting from \( r \) to \( z' \) is defined as
\[ z = .5 \times \log\left(\frac{1 + \frac{r}{1 - r}}{1 - \frac{r}{1 + r}}\right) \]

and the variance of \( z \)
\[ v_z = \frac{1}{n - 3} \]

where \( n \) is the total sample size for groups 1 and 2.

**Log Odds Ratio & Variance of Log Odds:**

In this particular formula, log odds is calculated as follows
\[ \log(o) = \frac{\pi d}{\sqrt{3}} \]

where \( \pi = 3.1459 \). The variance of log odds is defined as
\[ v_{\log(o)} = \frac{\pi^2 v_d}{3} \]

**General information about NNT, U3, Common Language Effect Size, and Cliff’s Delta:**

**Number needed to treat (NNT).** NNT is interpreted as the number of participants that would need to be treated in one group (e.g., intervention group) in order to have one additional positive outcome over that of the outcome of a randomly selected participant in the other group (e.g., control group). In the compute.es package, NNT is calculated directly from \( d \) (Furukawa & Leucht, 2011), assuming relative normality of distribution and equal variances across groups, as follows:
\[ NNT = \frac{1}{\Phi(d - \Psi(CER)) - CER} \]
U3. Cohen (1988) proposed a method for characterizing effect sizes by expressing them in terms of (normal) distribution overlap, called U3. This statistic describes the percentage of scores in one group that are exceeded by the mean score in another group. If the population means are equal then half of the scores in the treatment group exceed half the scores in the comparison group, and U3 = 50%. As the population mean difference increases, U3 approaches 100% (Valentine & Cooper, 2003).

**Common Language Effect Size (CLES).** CLES (McGraw & Wong, 1992) expresses the probability that a randomly selected score from one population will be greater than a randomly sampled score from another population. CLES is computed as the percentage of the normal curve that falls between negative infinity and the effect size (Valentine & Cooper, 2003).

Cliff’s Delta/success rate difference. Cliff’s delta (or success rate difference; Furukawa & Leucht (2011)) is a robust alternative to Cohen’s d, when data are either non-normal or ordinal (with truncated/reduced variance). Cliff’s Delta is a non-parametric procedure that provides the probability that individual observations in one group are likely to be greater than the observations in another group. It is the probability that a randomly selected participant of one population has a better outcome than a randomly selected participant of the second population (minus the reverse probability). Cliff’s Delta of negative 1 or positive 1 indicates no overlap between the two groups, whereas a value of 0 indicates complete overlap and equal group distributions.

\[
\delta = 2 \times \Phi \left( \frac{d}{\sqrt{2}} \right) - 1
\]

**Author(s)**

AC Del Re

Much appreciation to Dr. Jeffrey C. Valentine for his contributions in implementing U3 and CLES procedures and related documentation.

Maintainer: AC Del Re <acdelre@gmail.com>

**References**


**See Also**

`mes2`, `a.mes`, `a.mes2`
Examples

# CALCULATE SEVERAL EFFECT SIZES BASED ON GROUP MEANS:

mes(10, 12, 1, 1.3, 30, 30)

mes2

Means with Pooled SD to Effect Size

Description

Converts raw mean scores (with pooled standard deviation reported) to an effect size of \( d \) (mean difference), \( g \) (unbiased estimate of \( d \)), \( r \) (correlation coefficient), \( z' \) (Fisher’s \( z \)), and log odds ratio. The variances, confidence intervals and p-values of these estimates are also computed, along with NNT (number needed to treat), U3 (Cohen’s \( U_3 \)) overlapping proportions of distributions), CLES (Common Language Effect Size) and Cliff’s Delta.

Usage

mes2(m.1, m.2, s.pooled, n.1, n.2,
     level = 95, cer = 0.2, dig = 2, verbose = TRUE, id=NULL, data=NULL)

Arguments

m.1 Mean of group one.
m.2 Mean of group two.
s.pooled Pooled standard deviation.
n.1 Sample size of group one.
n.2 Sample size of group two.
level Confidence level. Default is 95%.
cer Control group Event Rate (e.g., proportion of cases showing recovery). Default is 0.2 (=20% of cases showing recovery). **CER is used exclusively for NNT output. This argument can be ignored if input is not a mean difference effect size.** Note: NNT output (described below) will NOT be meaningful if based on anything other than input from mean difference effect sizes (i.e., input of Cohen’s \( d \), Hedges’ \( g \) will produce meaningful output, while correlation coefficient input will NOT produce meaningful NNT output).
dig Number of digits to display. Default is 2 digits.
verbose Print output from scalar values? If yes, then verbose=TRUE; otherwise, verbose=FALSE. Default is TRUE.
id Study identifier. Default is NULL, assuming a scalar is used as input. If input is a vector dataset (i.e., data.frame, with multiple values to be computed), enter the name of the study identifier here.
data name of data.frame. Default is NULL, assuming a scalar is used as input. If input is a vector dataset (i.e., data.frame, with multiple values to be computed), enter the name of the data.frame here.
### Value

- **d**: Standardized mean difference ($d$).
- **var.**$d$: Variance of $d$.
- **l.**$d$: lower confidence limits for $d$.
- **u.**$d$: upper confidence limits for $d$.
- **U3.**$d$: Cohen’s $U(3)$, for $d$.
- **cl.**$d$: Common Language Effect Size for $d$.
- **cliffs.**$d$: Cliff’s Delta for $d$.
- **p.**$d$: p-value for $d$.
- **g**: Unbiased estimate of $d$.
- **var.**$g$: Variance of $g$.
- **l.**$g$: lower confidence limits for $g$.
- **u.**$g$: upper confidence limits for $g$.
- **U3.**$g$: Cohen’s $U(3)$, for $g$.
- **cl.**$g$: Common Language Effect Size for $g$.
- **p.**$g$: p-value for $g$.
- **r**: Correlation coefficient.
- **var.**$r$: Variance of $r$.
- **l.**$r$: lower confidence limits for $r$.
- **u.**$r$: upper confidence limits for $r$.
- **p.**$r$: p-value for $r$.
- **z**: Fisher’s $z$ ($z'$).
- **var.**$z$: Variance of $z'$.
- **l.**$z$: lower confidence limits for $z'$.
- **u.**$z$: upper confidence limits for $z'$.
- **p.**$z$: p-value for $z'$.
- **OR**: Odds ratio.
- **l.**OR: lower confidence limits for $OR$.
- **u.**OR: upper confidence limits for $OR$.
- **p.**OR: p-value for $OR$.
- **lOR**: Log odds ratio.
- **var.**lOR: Variance of log odds ratio.
- **l.**lOR: lower confidence limits for $lOR$.
- **u.**lOR: upper confidence limits for $lOR$.
- **p.**lOR: p-value for $lOR$.
- **N.**total: Total sample size.
- **NNT**: Number needed to treat.
Note

Detailed information regarding output values of:

1. Cohen’s d, Hedges’ g (unbiased estimate of d) and variance
2. Correlation coefficient (r), Fisher’s z’, and variance
3. Log odds and variance

is provided below (followed by general information about NNT, U3, Common Language Effect Size, and Cliff’s Delta):

**Cohen’s d, Hedges’ g and Variance of g:**

This function will initially calculate Cohen’s d from the independent groups raw mean values and pooled standard deviation. Then, all other effect size estimates are derived from d and its variance. This parameter is calculated by

\[
d = \frac{\bar{Y}_1 - \bar{Y}_2}{S_{pooled}}
\]

where \(\bar{Y}_1\) and \(\bar{Y}_2\) are the sample means in each group and \(S_{pooled}\) is the pooled standard deviation for both groups.

The variance of d is derived from

\[
v_d = \frac{n_1 + n_2}{n_1 n_2} + \frac{d^2}{2(n_1 + n_2)}
\]

The effect size estimate d has a small upward bias (overestimates the population parameter effect size) which can be removed using a correction formula to derive the unbiased estimate of Hedges’ g. The correction factor, \(J\), is defined as

\[
J = 1 - \frac{3}{4df - 1}
\]

where \(df\) = degrees of freedom, which is \(n_1 + n_2 - 2\) for two independent groups. Then, to calculate g

\[
g = Jd
\]

and the variance of g

\[
v_g = J^2 v_d
\]

**Correlation Coefficient r, Fisher’s z, and Variances:**

In this particular formula r is calculated as follows

\[
r = \frac{d}{\sqrt{d^2 + a}}
\]

where a corrects for inbalance in \(n_1\) & \(n_2\) and is defined as
\[
\begin{align*}
  a &= \frac{(n_1 + n_2)^2}{n_1 n_2} \\
  v_r &= \frac{a^2 v_d}{(a^2 + d^2)^2}
\end{align*}
\]

The variance of \( r \) is then defined as

\[
v_r = \frac{a^2 v_d}{(a^2 + d^2)^2}
\]

Often researchers are interested in transforming \( r \) to \( z' \) (Fisher’s \( z \)) because \( r \) is not normally distributed, particularly at large values of \( r \). Therefore, converting to \( z' \) will help to normally distribute the estimate. Converting from \( r \) to \( z' \) is defined as

\[
z = 0.5 \log\left( \frac{1 + r}{1 - r} \right)
\]

and the variance of \( z \)

\[
v_z = \frac{1}{n - 3}
\]

where \( n \) is the total sample size for groups 1 and 2.

**Log Odds Ratio & Variance of Log Odds:**

In this particular formula, log odds is calculated as follows

\[
\log(o) = \frac{\pi d}{\sqrt{3}}
\]

where \( \pi = 3.1459 \). The variance of log odds is defined as

\[
v_{\log(o)} = \frac{\pi^2 v_d}{3}
\]

**General information about NNT, U3, Common Language Effect Size, and Cliff’s Delta:**

**Number needed to treat (NNT).** NNT is interpreted as the number of participants that would need to be treated in one group (e.g., intervention group) in order to have one additional positive outcome over that of the outcome of a randomly selected participant in the other group (e.g., control group). In the `compute.es` package, NNT is calculated directly from \( d \) (Furukawa & Leucht, 2011), assuming relative normality of distribution and equal variances across groups, as follows:

\[
\text{NNT} = \frac{1}{\Phi(d - \Psi(CER)) - CER}
\]

**U3.** Cohen (1988) proposed a method for characterizing effect sizes by expressing them in terms of (normal) distribution overlap, called U3. This statistic describes the percentage of scores in one group that are exceeded by the mean score in another group. If the population means are equal then half of the scores in the treatment group exceed half the scores in the comparison group, and U3
As the population mean difference increases, $U_3$ approaches 100% (Valentine & Cooper, 2003).

**Common Language Effect Size (CLES).** CLES (McGraw & Wong, 1992) expresses the probability that a randomly selected score from one population will be greater than a randomly sampled score from another population. CLES is computed as the percentage of the normal curve that falls between negative infinity and the effect size (Valentine & Cooper, 2003).

**Cliff’s Delta/success rate difference.** Cliff’s delta (or success rate difference; Furukawa & Leucht, 2011) is a robust alternative to Cohen’s $d$, when data are either non-normal or ordinal (with truncated/reduced variance). Cliff’s Delta is a non-parametric procedure that provides the probability that individual observations in one group are likely to be greater than the observations in another group. It is the probability that a randomly selected participant of one population has a better outcome than a randomly selected participant of the second population (minus the reverse probability). Cliff’s Delta of negative 1 or positive 1 indicates no overlap between the two groups, whereas a value of 0 indicates complete overlap and equal group distributions.

$$
\delta = 2 \times \Phi\left(\frac{d}{\sqrt{2}}\right) - 1
$$

**Author(s)**

AC Del Re

Much appreciation to Dr. Jeffrey C. Valentine for his contributions in implementing $U_3$ and **CLES** procedures and related documentation.

Maintainer: AC Del Re <acdelre@gmail.com>

**References**


**See Also**

`mes, a.mes, a.mes2`

**Examples**

```r
# CALCULATE SEVERAL EFFECT SIZES BASED ON MEANS (WITH POOLED SD) STATISTIC:
mes2(10, 12, 1, 30, 30)
```
Description

One or two tailed p-value from independent groups to an effect size of $d$ (mean difference), $g$ (unbiased estimate of $d$), $r$ (correlation coefficient), $z'$ (Fisher’s $z$), and log odds ratio. The variances, confidence intervals and p-values of these estimates are also computed, along with NNT (number needed to treat), U3 (Cohen’s $U_3$) overlapping proportions of distributions), CLES (Common Language Effect Size) and Cliff’s Delta.

Usage

```r
pes(p, n.1, n.2, tail = "two",
    level = 95, cer = 0.2, dig = 2, verbose = TRUE, id=NULL, data=NULL)
```

Arguments

- **p** p-value.
- **n.1** Sample size of treatment group.
- **n.2** Sample size of comparison group.
- **tail** One or two-tailed p-value. The argument is scalar only–it can only take on a single value of 'one' or 'two'. Default is two.
- **level** Confidence level. Default is 95%.
- **cer** Control group Event Rate (e.g., proportion of cases showing recovery). Default is 0.2 (=20% of cases showing recovery). **CER is used exclusively for NNT output.** This argument can be ignored if input is not a mean difference effect size. Note: NNT output (described below) will NOT be meaningful if based on anything other than input from mean difference effect sizes (i.e., input of Cohen’s $d$, Hedges’ $g$ will produce meaningful output, while correlation coefficient input will NOT produce meaningful NNT output).
- **dig** Number of digits to display. Default is 2 digits.
- **verbose** Print output from scalar values? If yes, then verbose=TRUE; otherwise, verbose=FALSE. Default is TRUE.
- **id** Study identifier. Default is NULL, assuming a scalar is used as input. If input is a vector dataset (i.e., data.frame, with multiple values to be computed), enter the name of the study identifier here.
- **data** name of data.frame. Default is NULL, assuming a scalar is used as input. If input is a vector dataset (i.e., data.frame, with multiple values to be computed), enter the name of the data.frame here.
### Value

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>d</td>
<td>Standardized mean difference ((d)).</td>
</tr>
<tr>
<td>var.(d)</td>
<td>Variance of (d).</td>
</tr>
<tr>
<td>l.(d)</td>
<td>Lower confidence limits for (d).</td>
</tr>
<tr>
<td>u.(d)</td>
<td>Upper confidence limits for (d).</td>
</tr>
<tr>
<td>U3.(d)</td>
<td>Cohen’s (U(3)), for (d).</td>
</tr>
<tr>
<td>cl.(d)</td>
<td>Common Language Effect Size for (d).</td>
</tr>
<tr>
<td>clifs.(d)</td>
<td>Cliff’s Delta for (d).</td>
</tr>
<tr>
<td>p.d</td>
<td>(p)-value for (d).</td>
</tr>
<tr>
<td>g</td>
<td>Unbiased estimate of (d).</td>
</tr>
<tr>
<td>var.(g)</td>
<td>Variance of (g).</td>
</tr>
<tr>
<td>l.(g)</td>
<td>Lower confidence limits for (g).</td>
</tr>
<tr>
<td>u.(g)</td>
<td>Upper confidence limits for (g).</td>
</tr>
<tr>
<td>U3.(g)</td>
<td>Cohen’s (U(3)), for (g).</td>
</tr>
<tr>
<td>cl.(g)</td>
<td>Common Language Effect Size for (g).</td>
</tr>
<tr>
<td>p.g</td>
<td>(p)-value for (g).</td>
</tr>
<tr>
<td>r</td>
<td>Correlation coefficient.</td>
</tr>
<tr>
<td>var.(r)</td>
<td>Variance of (r).</td>
</tr>
<tr>
<td>l.(r)</td>
<td>Lower confidence limits for (r).</td>
</tr>
<tr>
<td>u.(r)</td>
<td>Upper confidence limits for (r).</td>
</tr>
<tr>
<td>p.r</td>
<td>(p)-value for (r).</td>
</tr>
<tr>
<td>z</td>
<td>Fisher’s (z) ((z')).</td>
</tr>
<tr>
<td>var.(z)</td>
<td>Variance of (z').</td>
</tr>
<tr>
<td>l.(z)</td>
<td>Lower confidence limits for (z').</td>
</tr>
<tr>
<td>u.(z)</td>
<td>Upper confidence limits for (z').</td>
</tr>
<tr>
<td>p.z</td>
<td>(p)-value for (z').</td>
</tr>
<tr>
<td>OR</td>
<td>Odds ratio.</td>
</tr>
<tr>
<td>1.or</td>
<td>Lower confidence limits for (OR).</td>
</tr>
<tr>
<td>u.or</td>
<td>Upper confidence limits for (OR).</td>
</tr>
<tr>
<td>p.or</td>
<td>(p)-value for (OR).</td>
</tr>
<tr>
<td>lOR</td>
<td>Log odds ratio.</td>
</tr>
<tr>
<td>var.lor</td>
<td>Variance of log odds ratio.</td>
</tr>
<tr>
<td>l.lor</td>
<td>Lower confidence limits for (lOR).</td>
</tr>
<tr>
<td>u.lor</td>
<td>Upper confidence limits for (lOR).</td>
</tr>
<tr>
<td>p.lor</td>
<td>(p)-value for (lOR).</td>
</tr>
<tr>
<td>N.total</td>
<td>Total sample size.</td>
</tr>
<tr>
<td>NNT</td>
<td>Number needed to treat.</td>
</tr>
</tbody>
</table>
Note

Detailed information regarding output values of:
1. Cohen’s \( d \), Hedges’ \( g \) (unbiased estimate of \( d \)) and variance
2. Correlation coefficient (\( r \)), Fisher’s \( z’ \), and variance
3. Log odds and variance

is provided below (followed by general information about NNT, U3, Common Language Effect Size, and Cliff’s Delta):

Cohen’s \( d \), Hedges’ \( g \) and Variance of \( g \):

This function will initially calculate Cohen’s \( d \), from a one or two-tailed \( p \)-value, and then all other effect size estimates are derived from \( d \) and its variance. This parameter estimate is calculated from a one-tailed \( p \) by

\[
d = t^{-1}(p) \sqrt{\frac{n_1 + n_2}{n_1 n_2}}
\]

where \( t^{-1} \) is the inverse of t-distribution with \( n - 1 \) degrees of freedom and \( p \) is the one-tailed \( p \)-value. The two-tailed parameter estimate is calculated from

\[
d = t^{-1}(\frac{p}{2}) \sqrt{\frac{n_1 + n_2}{n_1 n_2}}
\]

\( p \) is the two-tailed \( p \)-value.

The variance of \( d \) from either a one or two-tailed \( p \)-value is defined as

\[
v_d = \frac{n_1 + n_2}{n_1 n_2} + \frac{d^2}{2(n_1 + n_2)}
\]

The effect size estimate \( d \) has a small upward bias (overestimates the population parameter effect size) which can be removed using a correction formula to derive the unbiased estimate of Hedges’ \( g \). The correction factor, \( J \), is defined as

\[
J = 1 - \frac{3}{4df - 1}
\]

where \( df = \) degrees of freedom, which is \( n_1 + n_2 - 2 \) for two independent groups. Then, to calculate \( g \)

\[
g = Jd
\]

and the variance of \( g \)

\[
v_g = J^2 v_d
\]

Correlation Coefficient \( r \), Fisher’s \( z’ \), and Variances:

In this particular formula \( r \) is calculated as follows
The variance of \( r \) is then defined as

\[
v_r = \frac{a^2 \sigma^2}{(d^2 + a)^3}
\]

Often researchers are interested in transforming \( r \) to \( z' \) (Fisher’s \( z \)) because \( r \) is not normally distributed, particularly at large values of \( r \). Therefore, converting to \( z' \) will help to normally distribute the estimate. Converting from \( r \) to \( z' \) is defined as

\[
z = 0.5 \log\left( \frac{1 + r}{1 - r} \right)
\]

and the variance of \( z \)

\[
v_z = \frac{1}{n - 3}
\]

where \( n \) is the total sample size for groups 1 and 2.

**Log Odds Ratio & Variance of Log Odds:**

In this particular formula, log odds is calculated as follows

\[
\log(\phi) = \frac{\pi d}{\sqrt{3}}
\]

where \( \pi \approx 3.1459 \). The variance of log odds is defined as

\[
v_{\log(\phi)} = \frac{\pi^2 \sigma^2}{3}
\]

**General information about NNT, U3, Common Language Effect Size, and Cliff’s Delta:**

*Number needed to treat (NNT).* NNT is interpreted as the number of participants that would need to be treated in one group (e.g., intervention group) in order to have one additional positive outcome over that of the outcome of a randomly selected participant in the other group (e.g., control group). In the compute.es package, NNT is calculated directly from \( d \) (Furukawa & Leucht, 2011), assuming relative normality of distribution and equal variances across groups, as follows:

\[
NNT = \frac{1}{\Phi(d - \Psi(CER)) - CER}
\]
Cohen (1988) proposed a method for characterizing effect sizes by expressing them in terms of (normal) distribution overlap, called U3. This statistic describes the percentage of scores in one group that are exceeded by the mean score in another group. If the population means are equal then half of the scores in the treatment group exceed half the scores in the comparison group, and U3 = 50%. As the population mean difference increases, U3 approaches 100% (Valentine & Cooper, 2003).

Common Language Effect Size (CLES). CLES (McGraw & Wong, 1992) expresses the probability that a randomly selected score from one population will be greater than a randomly sampled score from another population. CLES is computed as the percentage of the normal curve that falls between negative infinity and the effect size (Valentine & Cooper, 2003).

Cliff’s Delta/success rate difference. Cliff’s delta (or success rate difference; Furukawa & Leucht (2011)) is a robust alternative to Cohen’s d, when data are either non-normal or ordinal (with truncated/reduced variance). Cliff’s Delta is a non-parametric procedure that provides the probability that individual observations in one group are likely to be greater than the observations in another group. It is the probability that a randomly selected participant of one population has a better outcome than a randomly selected participant of the second population (minus the reverse probability). Cliff’s Delta of negative 1 or positive 1 indicates no overlap between the two groups, whereas a value of 0 indicates complete overlap and equal group distributions.

\[ \delta = 2 \times \Phi \left( \frac{d}{\sqrt{2}} \right) - 1 \]

Author(s)

AC Del Re

Much appreciation to Dr. Jeffrey C. Valentine for his contributions in implementing U3 and CLES procedures and related documentation.

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References


See Also

a.pes
# CALCULATE SEVERAL EFFECT SIZES BASED ON P-VALUE:

```r
pes(.045,30,30)
```

### Description

Converts proportions (typically seen in studies reporting odds ratios) to an effect size of $d$ (mean difference), $g$ (unbiased estimate of $d$), $r$ (correlation coefficient), $z'$ (Fisher’s $z$), and log odds ratio. The variances, confidence intervals and p-values of these estimates are also computed, along with NNT (number needed to treat), $U_3$ (Cohen’s $U_3$) overlapping proportions of distributions), CLES (Common Language Effect Size) and Cliff’s Delta.

### Usage

```r
propes(p1, p2, n.ab, n.cd,
       level = 95, cer = 0.2, dig = 2, verbose = TRUE, id=NULL, data=NULL)
```

### Arguments

- **p1**: Proportion one.
- **p2**: Proportion two.
- **n.ab**: Total sample size for group A and B.
- **n.cd**: Total sample size for group C and D.
- **level**: Confidence level. Default is 95%.
- **cer**: Control group Event Rate (e.g., proportion of cases showing recovery). Default is 0.2 (=20% of cases showing recovery). **CER is used exclusively for NNT output. This argument can be ignored if input is not a mean difference effect size.** Note: NNT output (described below) will NOT be meaningful if based on anything other than input from mean difference effect sizes (i.e., input of Cohen’s d, Hedges’ g will produce meaningful output, while correlation coefficient input will NOT produce meaningful NNT output).
- **dig**: Number of digits to display. Default is 2 digits.
- **verbose**: Print output from scalar values? If yes, then verbose=TRUE; otherwise, verbose=FALSE. Default is TRUE.
- **id**: Study identifier. Default is NULL, assuming a scalar is used as input. If input is a vector dataset (i.e., data.frame, with multiple values to be computed), enter the name of the study identifier here.
- **data**: Name of data.frame. Default is NULL, assuming a scalar is used as input. If input is a vector dataset (i.e., data.frame, with multiple values to be computed), enter the name of the data.frame here.
Details

This formula will first compute an odds ratio and then transform to log odds and its variance. Then, Cohen’s $d$ will be calculated and this value will then be used to compute the remaining effect size estimates. The odds ratio is derived as follows

$$or = \frac{p_1(1 - p_2)}{p_2(1 - p_1)}$$

The conversion to a log odds and its variance is defined as

$$ln(o) = log(or)$$

$$v_{ln(o)} = \frac{1}{n_{AB}p_1(1 - p_1)} + \frac{1}{n_{CD}p_2(1 - p_2)}$$

where $n_{AB}$ is the sum of group A and B sample size, $n_{CD}$ is the sum of group C and D sample size, $p_1$ is the proportion for group 1 and $p_2$ is the proportion for group 2.

Value

d Standardized mean difference ($d$).

var. $d$ Variance of $d$.

1. $d$ lower confidence limits for $d$.

u. $d$ upper confidence limits for $d$.

U3. $d$ Cohen’s $U(3)$, for $d$.

cl. $d$ Common Language Effect Size for $d$.

cliffs. $d$ Cliff’s Delta for $d$.

p. $d$ p-value for $d$.

g Unbiased estimate of $d$.

var. $g$ Variance of $g$.

1. $g$ lower confidence limits for $g$.

u. $g$ upper confidence limits for $g$.

U3. $g$ Cohen’s $U(3)$, for $g$.

cl. $g$ Common Language Effect Size for $g$.

p. $g$ p-value for $g$.

r Correlation coefficient.

var. $r$ Variance of $r$.

1. $r$ lower confidence limits for $r$.

u. $r$ upper confidence limits for $r$.

p. $r$ p-value for $r$.

z Fisher’s $z$ ($z'$).
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**Note**

**Detailed information regarding output values of:**

1. **Cohen’s d, Hedges’ g (unbiased estimate of d) and variance**
2. **Correlation coefficient (r), Fisher’s z’, and variance**
3. **Log odds and variance**

is provided below (followed by general information about NNT, U3, Common Language Effect Size, and Cliff’s Delta):

**Cohen’s d, Hedges’ g and Variance of g:**

In this particular formula Cohen’s $d$ is calculated from the log odds as follows

$$d = \frac{\ln(o) \sqrt{3}}{\pi}$$

The variance of $d$ is derived from

$$v_d = \frac{3\ln(o)}{\pi^2}$$

The effect size estimate $d$ has a small upward bias (overestimates the population parameter effect size) which can be removed using a correction formula to derive the unbiased estimate of Hedges’ $g$. The correction factor, $j$, is defined as

$$J = 1 - \frac{3}{4df - 1}$$

where $df$ = degrees of freedom, which is $n_1 + n_2 - 2$ for two independent groups. Then, to calculate $g$
\[ g = Jd \]

and the variance of \( g \)

\[ v_g = J^2 v_d \]

**Correlation Coefficient \( r \), Fisher’s \( z \), and Variances:**

In this particular formula \( r \) is calculated as follows

\[ r = \frac{d}{\sqrt{d^2 + a}} \]

where \( a \) corrects for inbalance in \( n_1 \) & \( n_2 \) and is defined as

\[ a = \frac{(n_1 + n_2)^2}{n_1 n_2} \]

The variance of \( r \) is then defined as

\[ v_r = \frac{a^2 v_d}{(d^2 + a)^3} \]

Often researchers are interested in transforming \( r \) to \( z' \) (Fisher’s \( z \)) because \( r \) is not normally distributed, particularly at large values of \( r \). Therefore, converting to \( z' \) will help to normally distribute the estimate. Converting from \( r \) to \( z' \) is defined as

\[ z = .5 \times \log \left( \frac{1 + r}{1 - r} \right) \]

and the variance of \( z \)

\[ v_z = \frac{1}{n - 3} \]

where \( n \) is the total sample size for groups 1 and 2.

**General information about NNT, U3, Common Language Effect Size, and Cliff’s Delta:**

*Number needed to treat (NNT).* NNT is interpreted as the number of participants that would need to be treated in one group (e.g., intervention group) in order to have one additional positive outcome over that of the outcome of a randomly selected participant in the other group (e.g., control group). In the compute.es package, NNT is calculated directly from \( d \) (Furukawa & Leucht, 2011), assuming relative normality of distribution and equal variances across groups, as follows:

\[ NNT = \frac{1}{\Phi(d - \Psi(CER)) - CER} \]

*U3.* Cohen (1988) proposed a method for characterizing effect sizes by expressing them in terms of (normal) distribution overlap, called U3. This statistic describes the percentage of scores in one
group that are exceeded by the mean score in another group. If the population means are equal then half of the scores in the treatment group exceed half the scores in the comparison group, and $U_3 = 50\%$. As the population mean difference increases, $U_3$ approaches 100\% (Valentine & Cooper, 2003).

**Common Language Effect Size (CLES).** CLES (McGraw & Wong, 1992) expresses the probability that a randomly selected score from one population will be greater than a randomly sampled score from another population. CLES is computed as the percentage of the normal curve that falls between negative infinity and the effect size (Valentine & Cooper, 2003).

**Cliff’s Delta/success rate difference.** Cliff’s delta (or success rate difference; Furukawa & Leucht (2011)) is a robust alternative to Cohen’s $d$, when data are either non-normal or ordinal (with truncated/reduced variance). Cliff’s Delta is a non-parametric procedure that provides the probability that individual observations in one group are likely to be greater than the observations in another group. It is the probability that a randomly selected participant of one population has a better outcome than a randomly selected participant of the second population (minus the reverse probability). Cliff’s Delta of negative 1 or positive 1 indicates no overlap between the two groups, whereas a value of 0 indicates complete overlap and equal group distributions.

$$\delta = 2 * \Phi\left(\frac{d}{\sqrt{2}}\right) - 1$$

**Author(s)**

AC Del Re

Much appreciation to Dr. Jeffrey C. Valentine for his contributions in implementing $U_3$ and CLES procedures and related documentation.

Maintainer: AC Del Re <acdelre@gmail.com>

**References**


**See Also**

failes, lores
Examples

# CALCULATE SEVERAL EFFECT SIZES BASED ON PROPORTIONS:

```r
propes(.50, .30, 30, 30)
```

**Description**

Converts correlation (r) to an effect size of $d$ (mean difference), $g$ (unbiased estimate of $d$), $r$ (correlation coefficient), $z'$ (Fisher’s $z$), and log odds ratio. The variances, confidence intervals and p-values of these estimates are also computed, along with NNT (number needed to treat), $U3$ (Cohen’s $U3$ overlapping proportions of distributions), CLES (Common Language Effect Size) and Cliff’s Delta.

**Usage**

```r
res(r, var.r = NULL, n,
   level = 95, cer = 0.2, dig = 2, verbose = TRUE, id=NULL, data=NULL)
```

**Arguments**

- **r**
  - Correlation coefficient.

- **var.r**
  - Variance of r. If value is not reported then leave it blank and variances will be computed based on sample size. Otherwise, enter this value (e.g., `r_to_es(.27, var.r = .02, 30)`).

- **n**
  - Total sample size.

- **level**
  - Confidence level. Default is 95%.

- **cer**
  - Control group Event Rate (e.g., proportion of cases showing recovery). Default is 0.2 (=20% of cases showing recovery). **CER is used exclusively for NNT output. This argument can be ignored if input is not a mean difference effect size.** Note: NNT output (described below) will NOT be meaningful if based on anything other than input from mean difference effect sizes (i.e., input of Cohen’s d, Hedges’ g will produce meaningful output, while correlation coefficient input will NOT produce meaningful NNT output).

- **dig**
  - Number of digits to display. Default is 2 digits.

- **verbose**
  - Print output from scalar values? If yes, then verbose=TRUE; otherwise, verbose=FALSE. Default is TRUE.

- **id**
  - Study identifier. Default is NULL, assuming a scalar is used as input. If input is a vector dataset (i.e., data.frame, with multiple values to be computed), enter the name of the study identifier here.

- **data**
  - name of data.frame. Default is NULL, assuming a scalar is used as input. If input is a vector dataset (i.e., data.frame, with multiple values to be computed), enter the name of the data.frame here.
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<td>Total sample size.</td>
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<td>$\text{NNT}$</td>
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Note

Detailed information regarding output values of:
(1) Cohen’s $d$, Hedges’ $g$ (unbiased estimate of $d$) and variance
(2) Correlation coefficient ($r$), Fisher’s $z'$, and variance
(3) Log odds and variance

is provided below (followed by general information about NNT, U3, Common Language Effect Size, and Cliff’s Delta):

**Cohen’s $d$, Hedges’ $g$ and Variance of $g$:**

In this particular formula Cohen’s $d$ is calculated after $r$ is computed and then derived from it

$$d = \frac{2r}{\sqrt{1 - r^2}}$$

The variance of $d$ is derived from

$$v_d = \frac{4v}{(1 - r^2)^3}$$

The effect size estimate $d$ has a small upward bias (overestimates the population parameter effect size) which can be removed using a correction formula to derive the unbiased estimate of Hedges’ $g$. The correction factor, $J$, is defined as

$$J = 1 - \frac{3}{4df - 1}$$

where $df = \text{degrees of freedom}$, which is $n_1 + n_2 - 2$ for two independent groups. Then, to calculate $g$

$$g = Jd$$

and the variance of $g$

$$v_g = J^2v_d$$

**Correlation Coefficient $r$, Fisher’s $z$, and Variances:**

In this particular formula $r$ is calculated as follows

$$r = \frac{d}{\sqrt{d^2 + a}}$$

where $a$ corrects for inbalance in $n_1$ & $n_2$ and is defined as

$$a = \frac{(n_1 + n_2)^2}{n_1n_2}$$

The variance of $r$ is then defined as
Often researchers are interested in transforming \( r \) to \( z' \) (Fisher’s \( z \)) because \( r \) is not normally distributed, particularly at large values of \( r \). Therefore, converting to \( z' \) will help to normally distribute the estimate. Converting from \( r \) to \( z' \) is defined as

\[
z = .5 \times \log\left(\frac{1 + r}{1 - r}\right)
\]

and the variance of \( z \)

\[
v_z = \frac{1}{n - 3}
\]

where \( n \) is the total sample size for groups 1 and 2.

**General information about NNT, U3, Common Language Effect Size, and Cliff’s Delta:**

**Number needed to treat (NNT).** NNT is interpreted as the number of participants that would need to be treated in one group (e.g., intervention group) in order to have one additional positive outcome over that of the outcome of a randomly selected participant in the other group (e.g., control group). In the compute.es package, NNT is calculated directly from \( d \) (Furukawa & Leucht, 2011), assuming relative normality of distribution and equal variances across groups, as follows:

\[
NNT = \frac{1}{\Phi(d - \Psi(CER)) - CER}
\]

**U3.** Cohen (1988) proposed a method for characterizing effect sizes by expressing them in terms of (normal) distribution overlap, called U3. This statistic describes the percentage of scores in one group that are exceeded by the mean score in another group. If the population means are equal then half of the scores in the treatment group exceed half the scores in the comparison group, and U3 = 50%. As the population mean difference increases, U3 approaches 100% (Valentine & Cooper, 2003).

**Common Language Effect Size (CLES).** CLES (McGraw & Wong, 1992) expresses the probability that a randomly selected score from one population will be greater than a randomly sampled score from another population. CLES is computed as the percentage of the normal curve that falls between negative infinity and the effect size (Valentine & Cooper, 2003).

**Cliff’s Delta/success rate difference.** Cliff’s delta (or success rate difference; Furukawa & Leucht (2011)) is a robust alternative to Cohen’s \( d \), when data are either non-normal or ordinal (with truncated/reduced variance). Cliff’s Delta is a non-parametric procedure that provides the probability that individual observations in one group are likely to be greater than the observations in another group. It is the probability that a randomly selected participant of one population has a better outcome than a randomly selected participant of the second population (minus the reverse probability). Cliff’s Delta of negative 1 or positive 1 indicates no overlap between the two groups, whereas a value of 0 indicates complete overlap and equal group distributions.

\[
\delta = 2 \times \Phi\left(\frac{d}{\sqrt{2}}\right) - 1
\]
Author(s)
AC Del Re

Much appreciation to Dr. Jeffrey C. Valentine for his contributions in implementing $U_3$ and $CLES$ procedures and related documentation.

Maintainer: AC Del Re <acdelre@gmail.com>

References


Examples

# CALCULATE SEVERAL EFFECT SIZES BASED ON CORRELATION STATISTIC:
res(.3, n=30)

tes                               t-test Value to Effect Size

Description

Converts a t-test value to an effect size of $d$ (mean difference), $g$ (unbiased estimate of $d$), $r$ (correlation coefficient), $z'$ (Fisher’s $z$), and log odds ratio. The variances, confidence intervals and p-values of these estimates are also computed, along with NNT (number needed to treat), $U_3$ (Cohen’s $U_3$ overlapping proportions of distributions), CLES (Common Language Effect Size) and Cliff’s Delta.

Usage
tes(t, n.1, n.2, level = 95, cer = 0.2, dig = 2, verbose = TRUE, id=NULL, data=NULL)
Arguments

- **t**: t-test value reported in primary study.
- **n.1**: Sample size of treatment group.
- **n.2**: Sample size of comparison group.
- **level**: Confidence level. Default is 95%.
- **cer**: Control group Event Rate (e.g., proportion of cases showing recovery). Default is 0.2 (=20% of cases showing recovery). **CER is used exclusively for NNT output.** This argument can be ignored if input is not a mean difference effect size. Note: NNT output (described below) will NOT be meaningful if based on anything other than input from mean difference effect sizes (i.e., input of Cohen’s d, Hedges’ g will produce meaningful output, while correlation coefficient input will NOT produce meaningful NNT output).
- **dig**: Number of digits to display. Default is 2 digits.
- **verbose**: Print output from scalar values? If yes, then verbose=TRUE; otherwise, verbose=FALSE. Default is TRUE.
- **id**: Study identifier. Default is NULL, assuming a scalar is used as input. If input is a vector dataset (i.e., data.frame, with multiple values to be computed), enter the name of the study identifier here.
- **data**: name of data.frame. Default is NULL, assuming a scalar is used as input. If input is a vector dataset (i.e., data.frame, with multiple values to be computed), enter the name of the data.frame here.

Value

- **d**: Standardized mean difference (d).
- **var.d**: Variance of d.
- **l.d**: lower confidence limits for d.
- **u.d**: upper confidence limits for d.
- **U3.d**: Cohen’s $U(3)$, for d.
- **cl.d**: Common Language Effect Size for d.
- **cliffs.d**: Cliff’s Delta for d.
- **p.d**: p-value for d.
- **g**: Unbiased estimate of d.
- **var.g**: Variance of g.
- **l.g**: lower confidence limits for g.
- **u.g**: upper confidence limits for g.
- **U3.g**: Cohen’s $U(3)$, for g.
- **cl.g**: Common Language Effect Size for g.
- **p.g**: p-value for g.
- **r**: Correlation coefficient.
- **var.r**: Variance of r.
tes

1. \( r \) lower confidence limits for \( r \).
   
   \( u. r \) upper confidence limits for \( r \).
   
   \( p. r \) p-value for \( r \).
   
   \( z \) Fisher’s z \((z')\).
   
   \( \text{var. } z \) Variance of \( z' \).
   
   \( l. z \) lower confidence limits for \( z' \).
   
   \( u. z \) upper confidence limits for \( z' \).
   
   \( p. z \) p-value for \( z' \).

\( \text{OR} \) Odds ratio.

1. \( \text{OR} \) lower confidence limits for \( \text{OR} \).
   
   \( u. \text{OR} \) upper confidence limits for \( \text{OR} \).
   
   \( p. \text{OR} \) p-value for \( \text{OR} \).

\( \text{lor} \) Log odds ratio.

\( \text{var. lor} \) Variance of log odds ratio.

1. \( \text{lor} \) lower confidence limits for \( \text{lor} \).
   
   \( u. \text{lor} \) upper confidence limits for \( \text{lor} \).
   
   \( p. \text{lor} \) p-value for \( \text{lor} \).

\( N. \text{total} \) Total sample size.

\( \text{NNT} \) Number needed to treat.

\section*{Note}

Detailed information regarding output values of:

(1) Cohen’s \( d \), Hedges’ \( g \) \((\text{unbiased estimate of } d)\) and variance

(2) Correlation coefficient \((r)\), Fisher’s \( z' \), and variance

(3) Log odds and variance

is provided below (followed by general information about NNT, U3, Common Language Effect Size, and Cliff’s Delta):

\textbf{Cohen’s }\( d \), Hedges’ \( g \) and Variance of \( g \):

This function will initially calculate Cohen’s \( d \) from the t-test values. Then, all other effect size estimates are derived from \( d \) and its variance. This parameter is calculated by

\[ d = t \sqrt{\frac{n_1 + n_2}{n_1 n_2}} \]

The variance of \( d \) is derived from

\[ \text{var.} \ d = \frac{n_1 + n_2}{n_1 n_2} + \frac{d^2}{2(n_1 + n_2)} \]
The effect size estimate $d$ has a small upward bias (overestimates the population parameter effect size) which can be removed using a correction formula to derive the unbiased estimate of Hedges’ $g$. The correction factor, $J$, is defined as

$$J = 1 - \frac{3}{4df - 1}$$

where $df =$ degrees of freedom, which is $n_1 + n_2 - 2$ for two independent groups. Then, to calculate $g$

$$g = Jd$$

and the variance of $g$

$$v_g = J^2v_d$$

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In this particular formula $r$ is calculated as follows

$$r = \frac{d}{\sqrt{d^2 + a}}$$

where $a$ corrects for inbalance in $n_1$ & $n_2$ and is defined as

$$a = \frac{(n_1 + n_2)^2}{n_1n_2}$$

The variance of $r$ is then defined as

$$v_r = \frac{a^2v_d}{(d^2 + a)^3}$$

Often researchers are interested in transforming $r$ to $z'$ (Fisher’s $z$) because $r$ is not normally distributed, particularly at large values of $r$. Therefore, converting to $z'$ will help to normally distribute the estimate. Converting from $r$ to $z'$ is defined as

$$z = .5\times\log\left(\frac{1 + r}{1 - r}\right)$$

and the variance of $z$

$$v_z = \frac{1}{n - 3}$$

where $n$ is the total sample size for groups 1 and 2.

**Log Odds Ratio & Variance of Log Odds:**

In this particular formula, log odds is calculated as follows
\[
\log(o) = \frac{\pi d}{\sqrt{3}}
\]

where \(\pi \approx 3.1459\). The variance of log odds is defined as

\[
\nu_{\log(o)} = \frac{\pi^2 \nu_d}{3}
\]

**General information about NNT, U3, Common Language Effect Size, and Cliff’s Delta:**

**Number needed to treat (NNT).** NNT is interpreted as the number of participants that would need to be treated in one group (e.g., intervention group) in order to have one additional positive outcome over that of the outcome of a randomly selected participant in the other group (e.g., control group). In the compute.es package, NNT is calculated directly from \(d\) (Furukawa & Leucht, 2011), assuming relative normality of distribution and equal variances across groups, as follows:

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\[
\delta = 2 \Phi\left(\frac{d}{\sqrt{2}}\right) - 1
\]

**Author(s)**

AC Del Re

Much appreciation to Dr. Jeffrey C. Valentine for his contributions in implementing \(U3\) and \(CLES\) procedures and related documentation.

Maintainer: AC Del Re <acdelre@gmail.com>
References


See Also

a.tes

Examples

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