Package 'compute.es'

January 13, 2026

Type Package

Title Compute Effect Sizes

Version 0.2-6

Date 2026-01-10

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). A free web application is available at
<https://acdelre.github.io/apps/compute_es/>.

Depends R (>= 2.10.1)

License GPL-2

URL https://acdelre.github.io/apps/compute_es/,
https://acdelre.github.io

NeedsCompilation no

Author AC Del Re [aut, cre]

Maintainer AC Del Re <stats@acdelre.com>

Repository CRAN

Date/Publication 2026-01-13 07:50:09 UTC

Contents

`compute.es-package`   *Compute Effect Sizes in R*

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).

A free web application version of this package is available at https://acdelre.github.io/apps/compute_es/.

Details

Package:	compute.es
Type:	Package
Version:	0.2-6
Date:	2026-01-10
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 <stats@acdelre.com>

References

Borenstein (2009). Effect sizes for continuous data. In H. Cooper, L. V. Hedges, & J. C. Valentine (Eds.), *The handbook of research synthesis and meta analysis* (pp. 279-293). New York: Russell Sage Foundation.

Cooper, H., Hedges, L.V., & Valentine, J.C. (2009). *The handbook of research synthesis and meta-analysis* (2nd edition). New York: Russell Sage Foundation.

Furukawa, T. A., & Leucht, S. (2011). How to obtain NNT from Cohen's d: comparison of two methods. *PloS one, 6*(4), e19070.

McGraw, K. O. & Wong, S. P. (1992). A common language effect size statistic. *Psychological Bulletin, 111,* 361-365.

Valentine, J. C. & Cooper, H. (2003). *Effect size substantive interpretation guidelines: Issues in the interpretation of effect sizes.* Washington, DC: What Works Clearinghouse.

See Also

Official Web App: https://acdelre.github.io/apps/compute_es/

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

```
## 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 fuction 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)
```

---

a.fes   *ANCOVA F-statistic to Effect Size*

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

```
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.
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:

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

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

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.

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

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

Borenstein (2009). Effect sizes for continuous data. In H. Cooper, L. V. Hedges, & J. C. Valentine (Eds.), *The handbook of research synthesis and meta analysis* (pp. 279-293). New York: Russell Sage Foundation.

Cohen, J. (1988). *Statistical power for the behavioral sciences (2nd ed.).* Hillsdale, NJ: Erlbaum.

Furukawa, T. A., & Leucht, S. (2011). How to obtain NNT from Cohen's d: comparison of two methods. *PloS one, 6*(4), e19070.

McGraw, K. O. & Wong, S. P. (1992). A common language effect size statistic. *Psychological Bulletin, 111,* 361-365.

Valentine, J. C. & Cooper, H. (2003). *Effect size substantive interpretation guidelines: Issues in the interpretation of effect sizes.* Washington, DC: What Works Clearinghouse.

See Also

fes

Examples

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

a.fes(3, 30, 30, .4, 2)
```

---

a.mes   *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), U3 (Cohen's $U_{(}3)$ overlapping proportions of distributions), CLES (Common Language Effect Size) and Cliff's Delta.

Usage

```
a.mes(m.1.adj, m.2.adj, sd.adj, n.1, n.2, R, q,
      level = 95, cer = 0.2, dig = 2, verbose = TRUE, id=NULL, data=NULL)
```

Arguments

m.1.adj	Adjusted mean of treatment group from ANCOVA.
m.2.adj	Adjusted mean of comparison group from ANCOVA.
sd.adj	Adjusted standard deviation.
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.
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 adjusted mean AN-COVA 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

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

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

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

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.

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

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

Borenstein (2009). Effect sizes for continuous data. In H. Cooper, L. V. Hedges, & J. C. Valentine (Eds.), *The handbook of research synthesis and meta analysis* (pp. 279-293). New York: Russell Sage Foundation.

Cohen, J. (1988). *Statistical power for the behavioral sciences (2nd ed.)*. Hillsdale, NJ: Erlbaum.

Furukawa, T. A., & Leucht, S. (2011). How to obtain NNT from Cohen's d: comparison of two methods. *PloS one, 6*(4), e19070.

McGraw, K. O. & Wong, S. P. (1992). A common language effect size statistic. *Psychological Bulletin, 111,* 361-365.

Valentine, J. C. & Cooper, H. (2003). *Effect size substantive interpretation guidelines: Issues in the interpretation of effect sizes.* Washington, DC: What Works Clearinghouse.

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)
```

---

a.mes2   *Mean Values from ANCOVA F-statistic with Pooled SD to Effect Size*

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

m.1.adj	Adjusted mean of treatment group from ANCOVA.
m.2.adj	Adjusted mean of comparison group from ANCOVA.
s.pooled	Pooled standard deviation.
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.
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 adjusted mean AN-COVA 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 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

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

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.

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

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

Borenstein (2009). Effect sizes for continuous data. In H. Cooper, L. V. Hedges, & J. C. Valentine (Eds.), *The handbook of research synthesis and meta analysis* (pp. 279-293). New York: Russell Sage Foundation.

Cohen, J. (1988). *Statistical power for the behavioral sciences (2nd ed.).* Hillsdale, NJ: Erlbaum.

Furukawa, T. A., & Leucht, S. (2011). How to obtain NNT from Cohen's d: comparison of two methods. *PloS one, 6*(4), e19070.

McGraw, K. O. & Wong, S. P. (1992). A common language effect size statistic. *Psychological Bulletin, 111,* 361-365.

Valentine, J. C. & Cooper, H. (2003). *Effect size substantive interpretation guidelines: Issues in the interpretation of effect sizes.* Washington, DC: What Works Clearinghouse.

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

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

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

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

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.

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

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

Borenstein (2009). Effect sizes for continuous data. In H. Cooper, L. V. Hedges, & J. C. Valentine (Eds.), *The handbook of research synthesis and meta analysis* (pp. 279-293). New York: Russell Sage Foundation.

Cohen, J. (1988). *Statistical power for the behavioral sciences (2nd ed.).* Hillsdale, NJ: Erlbaum.

Furukawa, T. A., & Leucht, S. (2011). How to obtain NNT from Cohen's d: comparison of two methods. *PloS one, 6*(4), e19070.

McGraw, K. O. & Wong, S. P. (1992). A common language effect size statistic. *Psychological Bulletin, 111,* 361-365.

Valentine, J. C. & Cooper, H. (2003). *Effect size substantive interpretation guidelines: Issues in the interpretation of effect sizes.* Washington, DC: What Works Clearinghouse.

See Also

[pes](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.

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:

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

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

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.

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

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

Borenstein (2009). Effect sizes for continuous data. In H. Cooper, L. V. Hedges, & J. C. Valentine (Eds.), *The handbook of research synthesis and meta analysis* (pp. 279-293). New York: Russell Sage Foundation.

Cohen, J. (1988). *Statistical power for the behavioral sciences (2nd ed.).* Hillsdale, NJ: Erlbaum.

Furukawa, T. A., & Leucht, S. (2011). How to obtain NNT from Cohen's d: comparison of two methods. *PloS one, 6*(4), e19070.

McGraw, K. O. & Wong, S. P. (1992). A common language effect size statistic. *Psychological Bulletin, 111,* 361-365.

Valentine, J. C. & Cooper, H. (2003). *Effect size substantive interpretation guidelines: Issues in the interpretation of effect sizes.* Washington, DC: What Works Clearinghouse.

See Also

[tes](tes)

Examples

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

a.tes(3, 30, 30, .3, 2)
```

---

chies   *Chi-Squared Statistic to Effect Size*

Description

Converting Chi-squared (χ^2) statistic with 1 degree of freedom to 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

```
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 (χ^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 χ^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).
`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:

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 χ^2 degree of freedom = 1. 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

$$r = \sqrt{\frac{\chi^2}{n}}$$

where χ^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

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

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.

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

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

Borenstein (2009). Effect sizes for continuous data. In H. Cooper, L. V. Hedges, & J. C. Valentine (Eds.), *The handbook of research synthesis and meta analysis* (pp. 279-293). New York: Russell Sage Foundation.

Cohen, J. (1988). *Statistical power for the behavioral sciences (2nd ed.)*. Hillsdale, NJ: Erlbaum.

Furukawa, T. A., & Leucht, S. (2011). How to obtain NNT from Cohen's d: comparison of two methods. *PloS one, 6*(4), e19070.

McGraw, K. O. & Wong, S. P. (1992). A common language effect size statistic. *Psychological Bulletin, 111,* 361-365.

Valentine, J. C. & Cooper, H. (2003). *Effect size substantive interpretation guidelines: Issues in the interpretation of effect sizes.* Washington, DC: What Works Clearinghouse.

Examples

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

chies(4, 30)
```

---

des | *Mean Difference (d) to Effect size*

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

```
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 μ_2 is the population mean of the second group, μ_1 is the population mean of the first group, and σ is the population standard deviation (assuming $\sigma_2 = \sigma_1$).

The estimate of δ 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.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):

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 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

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

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.

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

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

Borenstein (2009). Effect sizes for continuous data. In H. Cooper, L. V. Hedges, & J. C. Valentine (Eds.), *The handbook of research synthesis and meta analysis* (pp. 279-293). New York: Russell Sage Foundation.

Cohen, J. (1988). *Statistical power for the behavioral sciences (2nd ed.)*. Hillsdale, NJ: Erlbaum.

Furukawa, T. A., & Leucht, S. (2011). How to obtain NNT from Cohen's d: comparison of two methods. *PloS one, 6*(4), e19070.

McGraw, K. O. & Wong, S. P. (1992). A common language effect size statistic. *Psychological Bulletin, 111,* 361-365.

Valentine, J. C. & Cooper, H. (2003). *Effect size substantive interpretation guidelines: Issues in the interpretation of effect sizes.* Washington, DC: What Works Clearinghouse.

Examples

```
# CALCULATE SEVERAL EFFECT SIZES BASED ON d STATISTIC:

library(compute.es)

args(des)  # d STAT TO OTHER ES (INCLUDING HEDGES g)

# SCALAR
des(d=0.8, n.1=30, n.2=30)

## VECTOR OF d VALUES

# SAMPLE DATA
dat <- data.frame(id=1:30,
                  d=rnorm(30, 0.8, 0.1),
                  nT=round(rnorm(30, 30, 5), 0),
                  nC=round(rnorm(30, 30, 5), 0)
                  )
des(d=d, n.1=nT, n.2=nC, id=id, data=dat)

# TO EXTRACT JUST g AND var(g)
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

```
failes(B, D, n.1, n.0, level = 95, cer = 0.2, dig = 2, verbose = TRUE, id=NULL, 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.
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:

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

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

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.

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

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

Borenstein (2009). Effect sizes for continuous data. In H. Cooper, L. V. Hedges, & J. C. Valentine (Eds.), *The handbook of research synthesis and meta analysis* (pp. 279-293). New York: Russell Sage Foundation.

Cohen, J. (1988). *Statistical power for the behavioral sciences (2nd ed.)*. Hillsdale, NJ: Erlbaum.

Furukawa, T. A., & Leucht, S. (2011). How to obtain NNT from Cohen's d: comparison of two methods. *PloS one, 6*(4), e19070.

McGraw, K. O. & Wong, S. P. (1992). A common language effect size statistic. *Psychological Bulletin, 111,* 361-365.

Valentine, J. C. & Cooper, H. (2003). *Effect size substantive interpretation guidelines: Issues in the interpretation of effect sizes.* Washington, DC: What Works Clearinghouse.

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.
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 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

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

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

Borenstein (2009). Effect sizes for continuous data. In H. Cooper, L. V. Hedges, & J. C. Valentine (Eds.), *The handbook of research synthesis and meta analysis* (pp. 279-293). New York: Russell Sage Foundation.

Cohen, J. (1988). *Statistical power for the behavioral sciences (2nd ed.)*. Hillsdale, NJ: Erlbaum.

Furukawa, T. A., & Leucht, S. (2011). How to obtain NNT from Cohen's d: comparison of two methods. *PloS one, 6*(4), e19070.

McGraw, K. O. & Wong, S. P. (1992). A common language effect size statistic. *Psychological Bulletin, 111,* 361-365.

Valentine, J. C. & Cooper, H. (2003). *Effect size substantive interpretation guidelines: Issues in the interpretation of effect sizes.* Washington, DC: What Works Clearinghouse.

See Also

a.fes

Examples

```
# CALCULATE SEVERAL EFFECT SIZES BASED ON F-STATISTIC:

fes(3, 30, 30)
```

---

lores	*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

lor	Log odds ratio reported in the primary study.
var.lor	Variance of the log odds ratio.
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 Co-
                hen'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, ver-
                bose=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 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

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

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.
`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:

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 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). 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

Borenstein (2009). Effect sizes for continuous data. In H. Cooper, L. V. Hedges, & J. C. Valentine (Eds.), *The handbook of research synthesis and meta analysis* (pp. 279-293). New York: Russell Sage Foundation.

Cohen, J. (1988). *Statistical power for the behavioral sciences (2nd ed.).* Hillsdale, NJ: Erlbaum.

Furukawa, T. A., & Leucht, S. (2011). How to obtain NNT from Cohen's d: comparison of two methods. *PloS one, 6*(4), e19070.

McGraw, K. O. & Wong, S. P. (1992). A common language effect size statistic. *Psychological Bulletin, 111,* 361-365.

Valentine, J. C. & Cooper, H. (2003). *Effect size substantive interpretation guidelines: Issues in the interpretation of effect sizes.* Washington, DC: What Works Clearinghouse.

See Also

[propes](#), [failes](#)

Examples

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

lores(2, .3, 30, 30)
```

---

mes   *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

```
mes(m.1, m.2, sd.1, sd.2, 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.
sd.1	Standard deviation of group one.
sd.2	Standard deviation of group two.
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 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 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

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

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.

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

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

Borenstein (2009). Effect sizes for continuous data. In H. Cooper, L. V. Hedges, & J. C. Valentine (Eds.), *The handbook of research synthesis and meta analysis* (pp. 279-293). New York: Russell Sage Foundation.

Cohen, J. (1988). *Statistical power for the behavioral sciences (2nd ed.).* Hillsdale, NJ: Erlbaum.

Furukawa, T. A., & Leucht, S. (2011). How to obtain NNT from Cohen's d: comparison of two methods. *PloS one, 6*(4), e19070.

McGraw, K. O. & Wong, S. P. (1992). A common language effect size statistic. *Psychological Bulletin, 111,* 361-365.

Valentine, J. C. & Cooper, H. (2003). *Effect size substantive interpretation guidelines: Issues in the interpretation of effect sizes.* Washington, DC: What Works Clearinghouse.

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

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

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

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

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.

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

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

Borenstein (2009). Effect sizes for continuous data. In H. Cooper, L. V. Hedges, & J. C. Valentine (Eds.), *The handbook of research synthesis and meta analysis* (pp. 279-293). New York: Russell Sage Foundation.

Cohen, J. (1988). *Statistical power for the behavioral sciences (2nd ed.).* Hillsdale, NJ: Erlbaum.

Furukawa, T. A., & Leucht, S. (2011). How to obtain NNT from Cohen's d: comparison of two methods. *PloS one, 6*(4), e19070.

McGraw, K. O. & Wong, S. P. (1992). A common language effect size statistic. *Psychological Bulletin, 111,* 361-365.

Valentine, J. C. & Cooper, H. (2003). *Effect size substantive interpretation guidelines: Issues in the interpretation of effect sizes.* Washington, DC: What Works Clearinghouse.

See Also

mes, a.mes, a.mes2

Examples

```
# CALCULATE SEVERAL EFFECT SIZES BASED ON MEANS (WITH POOLED SD) STATISTIC:

mes2(10, 12, 1, 30, 30)
```

---

pes   *p-value to Effect Size*

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

```
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

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, 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

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

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

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

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.

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

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

Borenstein (2009). Effect sizes for continuous data. In H. Cooper, L. V. Hedges, & J. C. Valentine (Eds.), *The handbook of research synthesis and meta analysis* (pp. 279-293). New York: Russell Sage Foundation.

Cohen, J. (1988). *Statistical power for the behavioral sciences (2nd ed.).* Hillsdale, NJ: Erlbaum.

Furukawa, T. A., & Leucht, S. (2011). How to obtain NNT from Cohen's d: comparison of two methods. *PloS one, 6*(4), e19070.

McGraw, K. O. & Wong, S. P. (1992). A common language effect size statistic. *Psychological Bulletin, 111,* 361-365.

Valentine, J. C. & Cooper, H. (2003). *Effect size substantive interpretation guidelines: Issues in the interpretation of effect sizes.* Washington, DC: What Works Clearinghouse.

See Also

[a.pes](a.pes)

Examples

```
# CALCULATE SEVERAL EFFECT SIZES BASED ON P-VALUE:

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

---

propes   *Proportions to Effect Size*

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), U3 (Cohen's $U_{(}3)$ overlapping proportions of distributions), CLES (Common Language Effect Size) and Cliff's Delta.

Usage

```
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.
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:

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 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

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

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.

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

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

Borenstein (2009). Effect sizes for continuous data. In H. Cooper, L. V. Hedges, & J. C. Valentine (Eds.), *The handbook of research synthesis and meta analysis* (pp. 279-293). New York: Russell Sage Foundation.

Cohen, J. (1988). *Statistical power for the behavioral sciences (2nd ed.).* Hillsdale, NJ: Erlbaum.

Furukawa, T. A., & Leucht, S. (2011). How to obtain NNT from Cohen's d: comparison of two methods. *PloS one, 6*(4), e19070.

McGraw, K. O. & Wong, S. P. (1992). A common language effect size statistic. *Psychological Bulletin, 111,* 361-365.

Valentine, J. C. & Cooper, H. (2003). *Effect size substantive interpretation guidelines: Issues in the interpretation of effect sizes.* Washington, DC: What Works Clearinghouse.

See Also

failes, lores

Examples

```
# CALCULATE SEVERAL EFFECT SIZES BASED ON PROPORTIONS:

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

---

res   *Correlation coefficient (r) to Effect Size*

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 $U_{(}3)$ overlapping proportions of distributions), CLES (Common Language Effect Size) and Cliff's Delta.

Usage

```
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.

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:

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 $n_1 + n_2 - 2$ 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

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

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.

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

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

Borenstein (2009). Effect sizes for continuous data. In H. Cooper, L. V. Hedges, & J. C. Valentine (Eds.), *The handbook of research synthesis and meta analysis* (pp. 279-293). New York: Russell Sage Foundation.

Cohen, J. (1988). *Statistical power for the behavioral sciences (2nd ed.)*. Hillsdale, NJ: Erlbaum.

Furukawa, T. A., & Leucht, S. (2011). How to obtain NNT from Cohen's d: comparison of two methods. *PloS one, 6*(4), e19070.

McGraw, K. O. & Wong, S. P. (1992). A common language effect size statistic. *Psychological Bulletin, 111,* 361-365.

Valentine, J. C. & Cooper, H. (2003). *Effect size substantive interpretation guidelines: Issues in the interpretation of effect sizes.* Washington, DC: What Works Clearinghouse.

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), U3 (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.

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 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

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

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

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

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.

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

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

Borenstein (2009). Effect sizes for continuous data. In H. Cooper, L. V. Hedges, & J. C. Valentine (Eds.), *The handbook of research synthesis and meta analysis* (pp. 279-293). New York: Russell Sage Foundation.

Cohen, J. (1988). *Statistical power for the behavioral sciences (2nd ed.)*. Hillsdale, NJ: Erlbaum.

Furukawa, T. A., & Leucht, S. (2011). How to obtain NNT from Cohen's d: comparison of two methods. *PloS one, 6*(4), e19070.

McGraw, K. O. & Wong, S. P. (1992). A common language effect size statistic. *Psychological Bulletin, 111,* 361-365.

Valentine, J. C. & Cooper, H. (2003). *Effect size substantive interpretation guidelines: Issues in the interpretation of effect sizes.* Washington, DC: What Works Clearinghouse.

See Also

a.tes

Examples

```
# CALCULATE SEVERAL EFFECT SIZES BASED ON T STATISTIC:

tes(3, 30, 30)
```

Index