Package ‘orddom’

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Type Package

Title Ordinal Dominance Statistics

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Description Computes ordinal, statistics and effect sizes as an alternative to mean comparison: Cliff's delta or success rate difference (SRD), Vargha and Delaney's A or the Area Under a Receiver Operating Characteristic Curve (AUC), the discrete type of McGraw & Wong's Common Language Effect Size (CLES) or Grissom & Kim's Probability of Superiority (PS), and the Number needed to treat (NNT) effect size. Moreover, comparisons to Cohen's d are offered based on Huberty & Lowman's Percentage of Group (Non-)Overlap considerations.

Depends psych

License GPL-2

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R topics documented:

`orddom-package` *Ordinal Dominance Statistics*

Description

This package provides ordinal, nonparametric statistics and effect sizes as an alternative to independent or paired group mean comparisons, with special reference to Cliff's delta statistics (or success rate difference, SRD), but also providing McGraw and Wong's common language effect size for the discrete case (i.e. Grissom and Kim's Probability of Superiority), Vargha and Delaney's A (or the Area Under a Receiver Operating Characteristic Curve AUC), and Cook & Sackett's number needed to treat (NNT) effect size (cf. Kraemer & Kupfer, 2006). For the nonparametric effect sizes, various bootstrap CI estimates may also be obtained. Nonparametric effect sizes are also expressed as Cohen's d based on percentages of group non-overlap (cf. Huberty & Lowman, 2000).

Details

Package:	anRpackage
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Note

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Rogmann, J. J. (2013). *Ordinal Dominance Statistics (orddom): An R Project for Statistical Computing package to compute ordinal, nonparametric alternatives to mean comparison* (Version 3.1). Available online from the CRAN website `http://cran.r-project.org/`.

Major changes from orddom version 3.0 to 3.1

- Correction for dmes list names

Major changes from orddom version 2.0 to 3.0

- New function dmes to easily calculate nonparametric effect size measures independently from orddom

- Easier and more reliable input possible (vectors, lists, arrays, data frames) (by means of new function return1colmatrix)
- Individual variable label and test descriptions can now be assigned
- Outputs now also contain Number Needed to Treat (NNT) effect size
- (Para)metric Common Language effect size McGraw & Wong (1992) added
- Metric d CI in orddom now based on Hedges & Olkin (1985)
- Elimination of negative delta-between variance estimates for paired comparisons
- Correction of symmetric CI for independent Cliff's delta statistics
- New function dmes.boot to calculate bootstrap-based CI for nonparametric effect size measures and Cohen's d,
- dmes.boot was largely based on R code provided by J. Ruscio and T. Mullen (2011) reused with kind permission
- New function delta_gr now yields a graphical and interpretational output for Cliff's delta statistic
- New options for one- and two-tailed CI in orddom and orddom_f, resulting in changes of rows 21 and 22 of independent and rows 18 and 19 of paired orddom result matrix
- New Metric_t function (t, p and df can now be calculated and embedded in orddom as standard or Welch approximated)

Major changes from orddom Version 1.5 to 2.0

- orddom now also accepts simple vectors as x or y.
- New orddom_f() function file allows for file output of statistics for multiple sample comparisons (e.g. csv or analyses in MS Excel or Open Office Calc).
- New orddom_p() function file allows for detailed tab-formatted output for single sample comparisons.
- Package dependency on compute.es package was suspended (tes-Function for metric Cohen's d in orddom).
- New metric_t() function for additional information on metric t-test results.
- The dm() function can now also return difference matrices.
- Improved stability of orddom function as well as minor corrections in orddom output and manuals.

Major changes from orddom Version 1.0 to 1.5

- Calculation of CI and delta z-score-estimates can now be based on Students t-distribution rather than using fixed normal distribution z-scores.
- Symmetric CIs can now be obtained to increase power of the delta statistics in certain cases.
- Formulas used for calculation added in orddom manual.

- Probability of Superiority statistic as well as variance estimates for delta in the independent groups analyses were corrected.
- Minor changes were implemented to allow for calculation of $d = \pm 1$ extreme cases without error abort.
- Output of raw y-dataset in independent group analysis was corrected.
- Dependencies on packages *psych* and *compute.es* declared in DESCRIPTION and NAMESPACE files.

Author(s)

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Ruscio, J. & Mullen, T. (2012). Confidence Intervals for the Probability of Superiority Effect Size Measure and the Area Under a Receiver Operating Characteristic Curve. *Multivariate Behavioral Research, 47*, 221-223. Vargha, A., & Delaney, H. D. (1998). The Kruskal-Wallis test and stochastic homogeneity. *Journal of Educational and Behavioral Statistics, 23*, 170-192.

Vargha, A., & Delaney, H. D. (2000). A critique and improvement of the CL common language effect size statistic of McGraw and Wong. *Journal of Educational and Behavioral Statistics, 25*, 101-132.

See Also

`orddom`, `dmes`, `dmes.boot` and `orddom_f`.

Examples

```
## Not run:
#ordinal comparison and delta statistics for independent groups x and y
#(e.g. x:comparison/control group and y:treatment/experimental group)
orddom(x,y,paired=FALSE)
#
#ordinal comparison and delta statistics for paired data
#(e.g. x:Pretest/Baseline and y:Posttest)
orddom(x,y,paired=TRUE)
#
#Dominance Matrix production
dms(x,y,paired=T)
#
#Print dominance matrix
orddom_p(x,y,sections="4a")
#
#Graphic output and interpretational text for Cliff's delta statistics
```

```
delta_gr(x,y)
#
#nonparametric effect sizes (SRD/delta, A/AUC, CL/PS, NNT)
#(e.g. C:control group scores, T:treatment group scores)
dmes(C,T)
#
#Convert Cliff's delta value to Cohen's d (as distributional non-overlap)
delta2cohd(dmes(C,T)$dc)
#
#Confidence Interval estimate of AUC (by bootstrap)
#cf. Ruscio, J. & Mullen, T. (2012)
#(e.g. C:control group scores, T:treatment group scores)
dmes.boot(C,T,theta.es="Ac")

## End(Not run)
```

`cohd2delta` *Cohen's d to Cliff's delta*

Description

Converts Cohen's d effect size to Cliff's delta as non-overlap between two standard normal distributions

Usage

```
cohd2delta(d)
```

Arguments

`d`	Cohen's d value

Details

Returns delta (or non-overlap, see Table 2.2.1 in Cohen, 1988, p.22).

Value

$$\delta(d) = \frac{2AUC(\frac{d}{2}) - 1}{AUC(\frac{d}{2})}$$

, where $AUC(x) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{x} e^{-t^2/2} \, dt$

Author(s)

Jens Rogmann

References

Cohen, J. (1988). *Statistical Power Analysis for the Behavioral Sciences* (2nd ed.). Hillsdale, NJ, USA: Lawrence Erlbaum Associates.

See Also

delta2cohd

Examples

```
## Not run: > cohd2delta(1.1)
[1] 0.589245
> cohd2delta(2.1)
[1] 0.8278607
> cohd2delta(2.2)
[1] 0.8430398
> cohd2delta(4.0)
[1] 0.9767203
## End(Not run)
```

`delta2cohd` *Cliff's delta to Cohen's d*

Description

Converts Cliff's delta estimate to Cohen's d effect size as non-overlap between two standard normal distributions

Usage

```
delta2cohd(d)
```

Arguments

`d`	Cliff's delta estimate δ.

Details

Returns Cohen's d (or non-overlap, based on U1 in Table 2.2.1, Cohen, 1988, p.22).

Value

$d(\delta) = 2z_{\frac{-1}{\delta-2}}$, where $z_p \equiv \Phi^{-1}(p) = AUC^{-1}(p)$

Author(s)

Jens Rogmann

References

Cohen, J. (1988). *Statistical Power Analysis for the Behavioral Sciences* (2nd ed.). Hillsdale, NJ, USA: Lawrence Erlbaum Associates.

See Also

cohd2delta

Examples

```
## Not run: > delta2cohd(-.10)
[1] -0.1194342
> delta2cohd(-.86)
[1] -0.7725292
> delta2cohd(.10)
[1] 0.1320236
> delta2cohd(.774)
[1] 1.797902

## End(Not run)
```

---

delta_gr *Cliff's delta Graphics and Interpretation*

Description

Returns a graphical representation and interpretation of Cliff's delta

Usage

```
delta_gr(x,y, ... ,dv=2)
```

Arguments

`x`	A 1-column matrix with optional column name containing all n_x values or scores of group X or 1 (e.g. control or pretest group.).
`y`	A 1-column matrix with optional column name containing all n_y values of group Y or 2 (e.g. experimental or post-test group). For paired comparisons (e.g. pre-post), $n_x = n_y$ is required. See `orddom` for details.
`...`	Other arguments to be passed on to the `orddom` function, such as (for example): - *paired*: to compare dependent data (e.g. pre-post) set to *paired=TRUE* , - *alpha* for the respective significance level to be used, e.g.*alpha=.01* for 1 - *onetailed* to generate one-sided testing p and confidence interval (CI) values set to *onetailed=TRUE* ,

- *studdist* to obtain CI based on normal distribution z values (instead of Student distribution t) set to *studdist=FALSE* for 1 - *symmetric* to obtain symmetric rather than asymmetric CIs (see orddom for details) set to *symmetric=TRUE* .
- *onetailed* for one-sided rather than the default two-tailed testing.
- *x.name* to assign an individual label to group x (i.e. 1st or control or pretest group).
- *y.name* to label the y input matrix or group y (i.e. 2nd or experimental or posttest group).
- *description* This argument allows for assigning a string (as title or description) for the ordinal comparison outputs.

`dv` (For paired comparisons (*dv=3*) only.) Determines which ordinal δ statistics are to be returned. Set to:
- *dv=1* [within] to return an analysis for the $n_x = n_y$ within-pair changes,
- *dv=2* [between] to return an analysis for the overall distribution changes, based on all $n^2 - n = n(n-1)$ score comparisons between y and x where $i \neq j$,
- *dv=3* [combined] to return an analysis for the combined inference $d_w + d_b$. It is advisable to use *dv=3* in combination with *symmetric=TRUE*.

Value

Returns a graphical representation and text interpretation of Cliff's delta.

Author(s)

Jens Rogmann

See Also

orddom

Examples

```
## Not run:
#Paired comparison combined inference (Data taken from Long et al. (2003), Table 4)
x2<-t(matrix(c(2,6,6,7,7,8,8,9,9,9,10,10,10,11,11,12,13,14,15,16),1))
colnames(x2)<-c("Incidental")
y2<-t(matrix(c(4,11,8,9,10,11,11,5,14,12,13,10,14,16,14,13,15,15,16,10),1))
colnames(y2)<-c("Intentional")
delta_gr(x2,y2,paired=TRUE,studdist=FALSE,dv=3)
#
#Journal of Statistics Education Dataset: Oral Contraceptive Drug Interaction Study
#Journal of Statistics Education, Volume 12, Number 1 (March 2004).
columns<-c("SubjectNo","Seq","Period","Treatment","EEAUC","EECmax","NETAUC","NETCmax")
data<-read.table("http://www.amstat.org/publications/jse/datasets/ocdrug.dat",col.names=columns)
#
#returns delta (between) and 95
x<-subset(data,data$Treatment==0)[6] #Placebo EECmax
```

```
colnames(x)<-"Placebo Phase"
y<-subset(data,data$Treatment==1)[6] #Treatment EECmax
colnames(y)<-"Treatment Phase"
delta_gr(x,y,paired=TRUE,onetailed=TRUE,dv=2)
#
#checks treatment groups delta equivalence in placebo phase
#returns delta and 95
plac<-subset(data,data$Treatment==0)
x<-subset(plac,plac$Period==1)[6] #control (placebo before drug)
colnames(x)<-"Control (before Drug)"
y<-subset(plac,plac$Period==2)[6] #experimental (placebo after drug)
colnames(y)<-"Exp (Placebo after Drug)"
delta_gr(x,y)
#

## End(Not run)
```

dm *Dominance or Difference Matrix Creation*

Description

Returns a dominance or difference matrix based on the comparison of all values of two 1-column matrices x and y

Usage

```
dm(x, y, diff=FALSE)
```

Arguments

x	1 column matrix with n_1 values (e.g. from group X)
y	1 column matrix with n_2 values (e.g. from group Y)
diff	If argument is set to true, the function will return a difference matrix. Otherwise, a dominance matrix is produced.

Details

Each difference matrix cell value d_{ij} is calculated as $y_j - x_i$ across all $i = 1, 2, 3, ..., n_1$ values (=rows) of x and $i = 1, 2, 3, ..., n_2$ values (=rows) of y. Dominance matrix cell values are calculated as $sign(y_j - x_i)$.

Value

Returns difference or dominance matrix with X values as rownames and with Y values as columnnames

Author(s)

Jens Rogmann

References

Cliff, N. (1996). *Ordinal Methods for Behavioral Data Analysis*. Mahwah, NJ: Lawrence Erlbaum.

See Also

dms

Examples

```
## Not run:
> x<-t(matrix(c(1,1,2,2,2,3,3,3,4,5),1))
> y<-t(matrix(c(1,2,3,4,4,5),1))
> dm(x,y,diff=TRUE)
  1  2  3  4  4  5
1 0 -1 -2 -3 -3 -4
1 0 -1 -2 -3 -3 -4
2 1  0 -1 -2 -2 -3
2 1  0 -1 -2 -2 -3
2 1  0 -1 -2 -2 -3
3 2  1  0 -1 -1 -2
3 2  1  0 -1 -1 -2
3 2  1  0 -1 -1 -2
4 3  2  1  0  0 -1
5 4  3  2  1  1  0
> dm(x,y)
  1  2  3  4  4  5
1 0 -1 -1 -1 -1 -1
1 0 -1 -1 -1 -1 -1
2 1  0 -1 -1 -1 -1
2 1  0 -1 -1 -1 -1
2 1  0 -1 -1 -1 -1
3 1  1  0 -1 -1 -1
3 1  1  0 -1 -1 -1
3 1  1  0 -1 -1 -1
4 1  1  1  0  0 -1
5 1  1  1  1  1  0

## End(Not run)
```

`dmes` *Dominance Matrix Effect Sizes*

Description

Generates simple list of nonparametric ordinal effect size measures such as
-the Probability of Superiority (or discrete case Common Language) effect size,
-the Vargha and Delaney's A (or area under the receiver operating characteristic curve, AUC)
-Cliff's delta (or success rate difference, SRD), and -the number needed to treat (NNT) effect size (based on Cliff's delta value).

Usage

```
dmes(x,y)
```

Arguments

`x`	A vector or 1 column matrix with n_x values from (control or pre-test or comparison) group X
`y`	A vector or 1 column matrix with n_y values from (treatment or post-test) group Y

Details

Based on the dominance matrix created by direct ordinal comparison of values of Y with values of X, an associative list is returned.

Value

`$nx` Vector or sample size of x, n_x.

`$ny` Vector or sample size of y, n_y

`$PSc` Discrete case Common Language CL effect size or Probability of Superiority (PS) of all values of Y over all values of X:

$$PS_c(Y > X) = \frac{\#(y_i > x_j)}{n_y n_x}$$

, where $i = \{1, 2, ..., n_y\}$ and $j = \{1, 2, ..., n_x\}$. See orddom *PS Y>X* for details.)

`$Ac` Vargha & Delaney's A or Area under the receiver operating characteristics curve (AUC) for all possible comparisons:

$$A(Y > X) = [\#(y_i > x_j) + .5(\#(y_i = x_j)](n_y n_x)^{-1}$$

, where $i = \{1, 2, ..., n_y\}$ and $j = \{1, 2, ..., n_x\}$. See orddom *A Y>X* for details.)

`$dc` Success rate difference when comparing all values of Y with all values of X:

$$d_c(Y > X) = \frac{\#(y_i > x_j) - \#(y_i < x_j)}{n_y n_x}$$

, where $i = \{1, 2, ..., n_y\}$ and $j = \{1, 2, ..., n_x\}$. See orddom *Cliff's delta* for

independent groups for details.
Note that in the paired samples case with $n_y = n_x$, $dc does not return the combined estimate, i.e. $\$dc \neq \$dw + \$db$*!*

`$NNTc` Number needed to treat, based on the success rate difference or $\$dc^{-1}$. See orddom "NNT" for details.

`$PSw` When sample sizes are equal, this value returns the Probability of Superiority (PS) for within-changes, i.e. alle paired values: $PS_c(Y > X) = \frac{\#(y_i > x_i)}{n_y n_x}$, limited to the $n_x = n_y$ paired cases where $i = \{1, 2, ..., n_x = n_y\}$. (For unequal sample sizes, this equals $PSc.)

`$Aw` When sample sizes are equal, this value returns A for the paired subsample values, i.e. limited to the $n_x = n_y$ paired cases where $i = j = \{1, 2, ..., n_x = n_y\}$. (For unequal sample sizes, this equals $Ac.)

`$dw` When $n_x = n_y$, this value returns *Cliff's delta-within*, i.e. paired comparisons limited to the diagonal of the dominance matrix or those cases where $i = j$. (For unequal sample sizes, this equals $dc.)

`$NNTw` Number needed to treat, based on the within-case-success rate difference or $\$dw^{-1}$. See orddom *NNT within* for dependent groups for details.

`$PSb` When sample sizes are equal, this gives the Probability of Superiority (PS) for all cases but within-pair changes, i.e.:

$$PS_b(Y > X) = \frac{\#(y_i > x_j)}{n_y n_x}$$

,
limited to those cases where $i \neq j$. (For unequal sample sizes, this equals $PSc and $PSw.)

`$Ab` When sample sizes are equal, this value returns A for all cases where $i \neq j$. (For unequal sample sizes, this equals $Ac.)

`$db` When $n_x = n_y$, this value returns Cliff's delta-between, i.e. all but the paired comparisons or excepting the diagonal of the dominance matrix. The parameter is calculated by taking only those ordinal comparisons into account where $i \neq j$. (For unequal sample sizes, this equals $dc.)

`$NNTb` Number needed to treat, based on Cliff's delta-between or $\$db^{-1}$. See orddom *NNT between* for dependent groups for details.

Author(s)

Jens J. Rogmann

References

Delaney, H.D. & Vargha, A. (2002). Comparing Several Robust Tests of Stochastic Equality With Ordinally Scaled Variables and Small to Moderate Sized Samples. *Psychological Methods, 7*, 485-503.

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Ruscio, J. & Mullen, T. (2012). Confidence Intervals for the Probability of Superiority Effect Size Measure and the Area Under a Receiver Operating Characteristic Curve. *Multivariate Behavioral Research, 47*, 221-223. Vargha, A., & Delaney, H. D. (1998). The Kruskal-Wallis test and stochastic homogeneity. *Journal of Educational and Behavioral Statistics, 23*, 170-192.

Vargha, A., & Delaney, H. D. (2000). A critique and improvement of the CL common language effect size statistic of McGraw and Wong. *Journal of Educational and Behavioral Statistics, 25*, 101-132.

See Also

dm, orddom

Examples

```
## Not run:
> #Example from Efron & Tibshirani (1993, Table 2.1, p. 11)
> #cf. Efron, B. & Tibshirani (1993). An Introduction to the Bootstrap. New York/London: Chapman&Hall.
> y<-c(94,197,16,38,99,141,23) # Treatment Group
> x<-c(52,104,146,10,50,31,40,27,46) # Control Group
> dmes(x,y)
$nx
[1] 9

$ny
[1] 7

$PSc
[1] 0.5714286

$Ac
[1] 0.5714286

$dc
[1] 0.1428571

$NNTc
[1] 7

$PSw
[1] 0.5714286

$Aw
[1] 0.5714286

$dw
[1] 0.1428571

$NNTw
```

```
[1] 7

$PSb
[1] 0.5714286

$Ab
[1] 0.5714286

$db
[1] 0.1428571

$NNTb
[1] 7

> ############################################################################
> #Example from Ruscio & Mullen (2012, p. 202)
> #Ruscio, J. & Mullen, T. (2012). Confidence Intervals for the Probability of Superiority Effect Size Measure anc
> x <- c(6,7,8,7,9,6,5,4,7,8,7,6,9,5,4) # Treatment Group
> y <- c(4,3,5,3,6,2,2,1,6,7,4,3,2,4,3) # Control Group
> dmes(y,x)
$nx
[1] 15

$ny
[1] 15

$PSc
[1] 0.8444444

$Ac
[1] 0.8844444

$dc
[1] 0.7688889

$NNTc
[1] 1.300578

$PSw
[1] 1

$Aw
[1] 1

$dw
[1] 1

$NNTw
[1] 1

$PSb
[1] 0.8333333
```

```
$Ab
[1] 0.8761905

$db
[1] 0.752381

$NNTb
[1] 1.329114

## End(Not run)
```

`dmes.boot` *Dominance Matrix Effect Sizes*

Description

Bootstrap-based calculation of standard error and CI constructs for Cohen's d and the statistics used in the Dominance Matrix Effect Size (dmes) function

Usage

```
dmes.boot(x,y,theta.es="dc",ci.meth="BCA",B=1999,alpha=.05,seed=1)
```

Arguments

`x` A vector or 1 column matrix with n_x values from (control or pre-test or comparison) group X

`y` A vector or 1 column matrix with n_y values from (treatment or post-test) group Y

`theta.es` Specification of the nonparametric effect size for which the SE and CI is to be constructed. All output values of the dmes function can be used, e.g. "PSc", "Ac", "dc", "NNTc", "PSw", "Aw", "dw", "NNTw", "PSb", "Ab", "db" or "NNTb".

`ci.meth` Specify type of method used for bootstrap confidence interval construction: "BSE", "BP" or "BCA".

"BSE" uses the bootstrap standard error estimate of the respective nonparametric effect size to construct a confidence interval with $\hat{\theta} \pm z_{\alpha/2} \cdot \widehat{SE_\theta}$, where $\hat{\theta}$ ist the observed effect size, $z_{\alpha/2}$ the z value of the standard normal table at the given (two-tailed) significance level (e.g. z=1.96 when alpha=5 *"BP"* calculates confidence intervals based on bootstrap percentiles. B bootstrap sample estimates of the respective nonparametric effect size θ are generated and ordered, and the $(B \cdot 100 \cdot \alpha)$th as well as the $(B \cdot 100 \cdot (1 - \alpha)$th of these ordered estimates are used to determine the confidence intervals. For example, if B=2000 bootstrap samples are calculated and $\alpha = .05$, then the 100th and 1900th of the ordered values are selected as lower and upper CI limits.

"BCA" calculates bias-corrected and accelerated confidence intervals (also based

on bootstrap percentiles). Here, however, the α levels (or percentiles) are corrected depending on the bias and the rate of change of the standard error with formulas suggested by Efron & Tibshirani (1993, Chapter 14).

`B` Number of bootstrap samples to be used for the estimates.

`alpha` Significance level.

`seed` Integer argument to set random number generation seeds, see Random.

Details

Returns an associative list with the following values:

Value

`$theta` Type and observed value of the respective nonparametric effect size estimate for samples Y and X.

`$theta.SE` The bootstrap-based estimated standard error of the respective nonparametric effect size estimate.

`$bci.meth` String indicating which type of bootstrap (BSE, BP or BCA) was used to construct the confidence interval for the respective nonparametric effect size estimate and Cohen's d.

`$theta.bci.lo` Lower end of the confidence interval for the respective nonparametric effect size estimate as determined by type of bootstrap used (BSE, BP or BCA).

`$theta.bci.up` Upper end of the confidence interval for the respective nonparametric effect size estimate as determined by type of bootstrap used (BSE, BP or BCA).

`$Coh.d` Effect size estimate of Cohen's d based on student's t and assuming pooled variance. For details, see metric_t.

`$Coh.d.bSE` The bootstrap-based estimated standard error of Cohen's d.

`$Coh.d.bci.lo` Lower end of the confidence interval for the Cohen's d estimated through bootstrapping (type BSE, BP or BCA).

`$Coh.d.bci.up` Upper end of the confidence interval for the Cohen's d estimated through bootstrapping (type BSE, BP or BCA).

Note

dmes.boot was largely based on R code provided by John Ruscio and Tara Mullen (2011) which was reused with kind permission from the authors.

Author(s)

Jens J. Rogmann

References

Efron, B. & Tibshirani (1993). *An Introduction to the Bootstrap*. New York/London: Chapman & Hall.

Ruscio, J. & Mullen, T. (2011). *Bootstrap CI for A* (R program code, last updated April 11,2011). Retrieved from http://www.tcnj.edu/~ruscio/Bootstrap%20CI%20for%20A.R .

Ruscio, J. & Mullen, T. (2012). Confidence Intervals for the Probability of Superiority Effect Size Measure and the Area Under a Receiver Operating Characteristic Curve. *Multivariate Behavioral Research, 47*, 221-223.

See Also

dmes

Examples

```
## Not run:
> # cf. Efron & Tibshirani (1993, Ch. 14)
> # Spatial Test Data (Table 14.1, p.180)
> A<-c(48,36,20,29,42,42,20,42,22,41,45,14,6,0,33,28,34,4,32,24,47,41,24,26,30,41)
> B<-c(42,33,16,39,38,36,15,33,20,43,34,22,7,15,34,29,41,13,38,25,27,41,28,14,28,40)
> dmes.boot(A,B)
$theta
         dc
-0.08136095

$theta.SE
[1] 0.1656658

$bci.meth
[1] "BCA"

$theta.bci.lo
[1] -0.4008876

$theta.bci.up
[1] 0.2440828

$Coh.d
[1] -0.06364221

$Coh.d.bSE
[1] 0.2895718

$Coh.d.bci.lo
[1] -0.6106167

$Coh.d.bci.up
[1] 0.5031792
```

```
## End(Not run)
## Not run:
> ###############################################################################
> #Example from Ruscio & Mullen (2012, p. 202)
> x <- c(6,7,8,7,9,6,5,4,7,8,7,6,9,5,4) # Treatment Group
> y <- c(4,3,5,3,6,2,2,1,6,7,4,3,2,4,3) # Control Group
> dmes.boot(y,x,theta.es="Ac")          #AUC
$theta
       Ac
0.8844444

$theta.SE
[1] 0.05910963

$bci.meth
[1] "BCA"

$theta.bci.lo
[1] 0.7022222

$theta.bci.up
[1] 0.9644444

$Coh.d
[1] 1.727917

$Coh.d.bSE
[1] 0.4932543

$Coh.d.bci.lo
[1] 0.7753663

$Coh.d.bci.up
[1] 2.573305

## End(Not run)
```

---

dms *Dominance Matrix in Symbols*

Description

Returns a character-based dominance matrix based on the signs of all cell values of a given matrix

Usage

```
dms(dom, paired = FALSE)
```

Arguments

`dom` Input matrix, typically raw difference or dominance matrix

`paired` Should only be set to TRUE if the number of rows equal the number of columns and if the difference data in the matrix diagonal are to be given different symbols.

Details

According to the sign of each input matrix' cell value ($sign(d_{ij})$), a respective symbol is written to the output matrix ("-" for -1, "O" for 0" and "+" for 1).
If paired==TRUE, the diagonal vector of the output matrix receives different symbols (i.e. "<" for -1, "=" for 0, "<" for 1).

Author(s)

Jens Rogmann

References

Cliff, N. (1996). *Ordinal Methods for Behavioral Data Analysis*. Mahwah, NJ: Lawrence Erlbaum.

See Also

dm

Examples

```
## Not run: > x<-t(matrix(c(1,1,2,2,2,3,3,3,4,5),1))
> y<-t(matrix(c(1,2,3,4,4,5),1))
> write.table(dms(dm(x,y)),quote=FALSE,row.names=FALSE,col.names=FALSE,sep="")
0-----
0-----
+0----
+0----
+0----
++0---
++0---
++0---
+++00-
+++++0
## End(Not run)
```

`metric_t` *Metric t-test parameters matrix*

Description

Returns a matrix of independent or paired t-test data for comparison to ordinal alternatives

Usage

```
metric_t(a,b,alpha=0.05,paired=FALSE,t.welch=TRUE)
```

Arguments

`a`	First dataset (vector or matrix).
`b`	Second dataset (vector or matrix).
`alpha`	Significance or α-level used for the calculation of the confidence intervals. Default value is $\alpha = .05$ or 5 Percent.
`paired`	By default, independence of the two groups or data sets is assumed. If the number of cases in x and y are equal and paired (e.g. pre-post) comparisons, this should be set to TRUE.
`t.welch`	By default, the variances of the two datasets are not assumed equal. If the pooled variance is needed for t, p, and df this should be set to FALSE. This setting has no effect on the calculation of Cohens'd.

Value

`[1,1] or ["Diff M" ,1]`
: Mean Difference $\bar{y} - \bar{x}$ or estimate (in the paired case) See t.test for details.

`[2,1] or ["t value" ,1] or ["t(dep.)" ,1]`
: Value of the t-statistic for the independent or the paired case. See t.test for details.

`[3,1] or ["df" ,1] or ["df" ,1]`
: Degrees of freedom for the t-statistic. For independent samples, the Welch approximation of degrees of freedom is returned unless t.welch is set to FALSE. See t.test for details.

`[4,1] or ["p value" ,1]`
: The p-value of the test. See t.test for details. For independent samples, the Welch approximation of degrees of freedom is returned unless t.welch is set to FALSE.

`[5,1] or ["Cohen's d" ,1]`
: Cohen's d effect size for both the independent and the paired case calculated using student's t (i.e. assuming pooled variance) as

$$d_{Cohen} = t_{(pooledvar)} \sqrt{\frac{n_y + n_x}{n_y n_x}},$$

following the advice of Dunlap, Cortina, Vaslow and Burke (1996) who suggested using the independent group t-value and the original standard deviations also for the paired case to avoid overestimation of the effect size.

Author(s)

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References

Dunlap, W. P., Cortina, J. M., Vaslow, J. B., & Burke, M. J. (1996). Meta-analysis of experiments with matched groups or repeated measures designs. *Psychological Methods, 1*, 170-177.

See Also

t.test

Examples

```
## Not run:
> #Example from Dunlap et al. (1996), Table 1
> y<-c(27,25,30,29,30,33,31,35)
> x<-c(21,25,23,26,27,26,29,31)
> metric_t(x,y)
                 [,1]
Diff M     4.00000000
t value    2.52982213
df Welch  14.00000000
p value    0.02403926
Cohen's d  1.26491106
> metric_t(x,y,paired=TRUE)
                 [,1]
Diff M    4.000000000
t(dep.)   4.512608599
df        7.000000000
p value   0.002756406
Cohen's d 1.264911064

## End(Not run)
```

---

orddom *Ordinal Dominance Statistics*

Description

Returns an array of ordinal dominance statistics based on the input of two 1-column matrices as an alternative to independent or paired group mean comparisons (especially for Cliff's delta statistics).

Usage

```
orddom(x,y,alpha=.05,paired=FALSE,outputfile="",studdist=TRUE,
          symmetric=FALSE,onetailed=FALSE,t.welch=TRUE,
  x.name="",y.name="",description="")
```

Arguments

`x` A 1-column matrix with optional column name containing all n_x values or scores of group X or 1 (e.g. control or pretest group.), e.g. declared in R as *x<-t(matrix(c(*$x_1, x_2, x_3, x_4, \ldots, x_{n_x}$*),1))*
colnames(x)<-c("[label of group X]").
If x is a vector, a default column name is assigned.

`y` A 1-column matrix with optional column name containing all n_y values of group Y or 2 (e.g. experimental or post-test group). For paired comparisons (e.g. pre-post), $n_x = n_y$ is required. If y is a vector, a default column name is assigned.

`alpha` Significance or α-level used for the calculation of the confidence intervals. Default value is $\alpha = .05$ or 5 Percent, giving a 95 Percent CI. For multiple dominance comparisons, a Bonferroni procedure may be implemented: Cliff (1996, p.150) suggested dividing α by the number of possible comparisons, i.e. $\alpha(\frac{1}{2}k(k-1))^{-1}$ for comparisons beteen k data sets.

`paired` By default, independence of the two groups or data sets is assumed. If the number of cases in x and y are equal and paired (e.g. pre-post) comparisons, this should be set to TRUE to return the full array of within, between, combined and metric delta statistics.

`outputfile` If a a detailed report of the ordinal dominance analysis is wanted, a filename should be given here. The report as standard text file is written to the current working directory.

`studdist` By default, it is assumed that small samples are being examined. In this case, z-values based on Student's t-distribution are used for estimating upper and lower limits of the confidence intervals (CI) as well as z-probabilities. If larger sample sizes are used, these values approximate estimates based on normally distributed z-values. In this case or if comparing with estimates calculated with orddom versions <1.5 (where z-values based on the Standard Normal Distributions were used), this parameter may be set to FALSE.

`symmetric` By default, asymmetric confidence intervals (CI) are being calculated to compensate for positive correlations between the samples as generally recommended by the literature on the delta statistics. To increase power in certain cases, however - e.g. in small paired samples (cf. Cliff 1996, p. 165) or fur purposes of evaluating the CIs of a combined delta estimate in the paired case - symmetric CIs may also be obtained by setting this argument to TRUE.

`onetailed` By default, calculation of p values and confidence intervals (CI) assumes two-sided testing against the null hypothesis. Set to TRUE if the alternative hypothesis targets at one-tailed testing.

`t.welch` By default, for calculation of the t-test scores and metric p and df values, the Welch approximation is used. If set to FALSE, equal variances are assumed for groups X and Y and a pooled variance is being calculated.

`x.name` By default, the label of group x (i.e. 1st or control or pretest group) is taken from the column name of the x input matrix. This argument allows for assigning an alternative label.

`y.name` This argument allows for assigning an alternative label for the y input matrix or group y (i.e. 2nd or experimental or posttest group).

`description` This argument allows for assigning a string (as title or description) for the ordinal comparison outputs.

Value

INDEPENDENT GROUPS (*paired* argument set to FALSE)

In the case of independent groups or data sets X and Y (e.g. comparison group X vs. treatment group Y), a 2-column-matrix containing 29 rows with values is returned.

The ordinal statistics can be retrieved from the first column (named "ordinal") while the second column (named "metric") contains metric comparison data where appropriate.

`[1 or ["var1_X", col#]` Label assigned to group x (x.name or column name of the x input matrix) or a default "1st var (x)".

`[2 or ["var2_Y", col#]` Label assigned to group x (x.name or column name of the x input matrix) or a default "2nd var (y)".

`[3 or ["type_title", col#]` Column 1: Returns type of the comparison, in this case "indep".
Column2: In case a string header is defined by use of the *comp.name* argument, it is returned in column 2.

`[4 or ["n in X", col#]` Number of cases in x (i.e. group X sample size).

`[5 or ["n in Y", col#]` Number of cases in y (i.e. group Y sample size).

`[6 or ["N #Y>X", col#]` Number of occurences of an observation from group y having a higher value than an observation from group x when comparing all x scores with all y scores: $N_{\#Y>X} = \#(y_i > x_j)$, where \# denotes "the number of times" whilst comparing each $i = 1, 2, 3, \ldots n_y$ score in sample Y with each $j = 1, 2, 3, \ldots n_x$ score in sample X (resulting in $n_x \cdot n_y$ comparisons).

`[7 or ["N #Y=X", col#]` Number of occurences of an observation from group y having the same value as an observation from group x: $N_{\#Y=X} = \#(y_i = x_j)$.

`[8 or ["N #Y<X", col#]`

Number of occurences of an observation from group y having a smaller value than an observation from group x: $N_{\#Y<X} = \#(y_i < x_j)$.

`[9 or ["PS X>Y", col#]`

Common Language CL effect size or Probability of Superiority (PS) of X over Y, see below.

`[10 or ["PS Y>X", col#]`

Column 1: Discrete case Common Language CL effect size or Probability of Superiority (PS) of Y over X,$PS(Y > X) = \frac{\#(y_i > x_j)}{n_y \cdot n_x}$ (cf. Grissom, 1994,Grissom & Kim, 2005,McGraw & Wong, 1992). This effect size reflects the probability that a subject or case randomly chosen from group Y has a higher score than than a randomly chosen subject or case from group X (cf. Acion et al., 2006).

Column 2: Assuming equal variances and population normality, the (para)metric version of the Common Language effect size is calculated as suggested by McGraw & Wong (1992, p. 361) as $PS(Y > X) = \Phi(\frac{M_y - M_x}{\sqrt{s_x^2 + s_y^2}})$ where Φ is the cumulative normal distribution function with $\Phi(z_\alpha) = \alpha$.

`[11 or ["A X>Y", col#]`

Vargha and Delaney's A as stochastic superiority of X over Y, calculated as

$$A_{X>Y} = PS(X > Y) + .5PS(X = Y)$$

(cf. Vargha & Delaney, 1998, 2000,Delaney & Vargha, 2002). This modified probability of superiority effect size has also been called area under the the receiver operating characteristic curve or AUC by Kraemer and Kupfer (2006). If one sampled one single case or subject from group Y and one from group X, respectively, A or AUC is the probability that the sample taken from group Y has a higher score or value than the one sampled from X (given the toss of a coin to break any ties). See also codedmes of this package.

`[12 or ["A Y>X", col#]`

Vargha and Delaney's A as stochastic superiority of Y over X.

`[13 or ["delta", col#]`

For column 1 ("ordinal"): Cliff's delta for independent groups (Cliff, 1996,Long et al., 2003):

$$d = \frac{\#(y_i > x_j) - \#(y_i < x_j)}{n_y \cdot n_x} = \frac{\sum_i \sum_j d_{ij}}{n_y \cdot n_x}$$

where $d_{ij} = sign(y_i - x_j)$ across all score comparisons. Termed *success rate difference (SRD)* effect size by Kraemer and Kupfer, delta denotes the difference between the probability that a randomly chosen Y case or subject (or patient) has a higher score than a randomly chosen case or subject from group X and the probability for the opposite.

Put in simple terms, if higher values reflect better treatment outcomes of study participants, delta is the difference between the probability that a Y treatment group participant has a treatment outcome preferable to an X control group participant and the probability that a X patient has a treatment outcome preferable to a Y patient (cf. Kraemer & Kupfer, 2006, p. 994). In contrast to the PS and

A effect sizes, delta thus takes potentially worse or harmful treatment outcomes into account.

In column 2, the metric differences between the means are given: $\bar{y} - \bar{x} = \bar{d_{ij}}$ between all comparable x and y scores with $d_{ij} = y_i - x_j$.

`[14 or ["1-alpha", col#]`
: Significance or α-level for CI estimation, given as percentage between 0 and 100.

`[15 or ["CI low", col#]`
: Unless the default *symmetric* parameter is explicitly set to *TRUE*, improved formulas are used (Feng & Cliff, 2004) to caculate asymmetric confidence interval (CI) boundary estimates of delta or mean difference:

$$CI_{lower/upper} = \frac{d - d^3 \pm t_{\alpha/2} s_d \sqrt{1 - 2d^2 + d^4 + t^2_{\alpha/2} s^2_d)}}{1 - d^2 + t^2_{\alpha/2} s^2_d},$$

with t-values at the given α-level taken from Student's t distribution by default (unless the *studdist* is set FALSE, in which case t-values are based on z-values from the Standard Normal Distribution).

In case the *symmetric* argument is explicitly set to *TRUE*, however, ordinary CIs are being calculated with $CI_{lower/upper} = d \pm t_{\alpha/2} s_d$.

In any case, if Cliffs' $d = \pm 1$, one CI is assumed being equal to d, the respective other is calculated as

$$CI_{lower/upper} = ((n_b - t^2_{\alpha/2}))(n_b + t^2_{\alpha/2})^{-1},$$

where $t_{\alpha/2}$ is the t-value or z-score at the selected α level (2-tailed) of the respective *studdist*-controlled distribution, and n_b the number of observations or cases in the smaller of the two samples.

`[16 or ["CI high", col#]`
: Confidence interval upper boundary estimate of delta or mean difference.

`[17 or ["s delta", col#]`
: Unbiased sample estimate of the delta standard deviation in column 1.
In column 2 ("metric"): Pooled standard deviation of metric mean difference with $s_{xy} = [((n_x - 1)s_x + (n_y - 1)s_y)/(n_x + n_y - 2)]^{1/2}$.

`[18 or ["var delta", col#]`
: Column 1: Variance of delta (unbiased sample estimate), calculated as

$$s^2_d = \frac{n^2_y \sum (d_i. - d)^2 + n^2_x \sum (d._j - d)^2 - \sum \sum (d_{ij} - d)^2}{n_x n_y (n_x - 1)(n_y - 1)},$$

or, using the partial variances

$$s^2_d = \frac{n^2_y (n_x - 1) s^2_{d_{i.}} + n^2_x (n_y - 1) s^2_{d_{.j}} - (n_x n_y - 1) s^2_{d_{ij}}}{n_x n_y (n_x - 1)(n_y - 1)},$$

which can also alternatively be put as

$$s_d^2 = \frac{n_y s_{d_{i.}}^2}{n_x(n_y-1)} + \frac{n_x s_{d_{.j}}^2}{n_y(n_x-1)} - \frac{(n_x n_y - 1)s_{d_{ij}}^2}{n_x n_y (n_x-1)(n_y-1)}.$$

(For differences to Cliff's (1996, p. 138) formula see notes to Row 28 ("var dij") below.)

In case this calculation of s_d^2 yields values of less than $(1-d^2)/(n_x n_y - 1)$, this latter formula is used for calculating the variance of delta.

Column 2 contains the pooled s_{xy}^2.

`[19 or ["se delta", col#]`
: Column 2 only: metric Standard error of mean difference: $SE_{xy} = s_{xy}\sqrt{1/n_x + 1/n_y}$.

`[20 or ["z/t score", col#]`
: Column 1: z score of delta on the of the respective *studdist*-controlled distribution (Student's t or standard normal).

  Column 2: Metric z/t-score (= $\bar{d_{ij}}/SE_{xy}$). In the metric case, the *t.welch* decides upon assumption of equal variances for X and Y.

`[21 or ["H1 tails p/CI", col#]`
: Equals *1* for one-tailed and *2* for two-tailed testing of alternative or *H_1*-hypothesis, affecting CI and p values.

`[22 or ["p", col#]`
: Probability of z/t score (1-sided or 2-sided comparison as shown in row 21).

`[23 or ["Cohen's d", col#]`
: Cohen's *d* effect size estimate of delta. For Cliff's delta inferred from distributional non-overlap as suggested by Grissom & Kim (2005, p. 106 f.) as well as Romano, Kromrey, Coraggio, & Skowronek (2006, p. 14-15), relating to the relative positions of the distributions of X and Y. When Cliff's delta equals 0, there is no effect, and the Y and X distributions overlap completely. If there are effects, a certain percentage of non-overlap between X and Y is created, and the relative positions of the X and Y distribtions shift. The degree of non-overlap thus is a measure of effect size and is expressed as Cohen's *d* in terms of non-overlap between two normal distributions (based on U1 in Table 2.2.1, Cohen, 1988, p.22). See `delta2cohd` manual of orddom package.
  Column 2 returns Cohen's d assuming a pooled variance for t. See metric_t for details.

`[24 or ["d CI low", col#]`
: Column 1: Cohen's *d* effect size estimate of the lower boundary of confidence interval (row 15) by using the non-overlap strategy.
  Column 2: Confidence bands for metric Cohen's d are constructed based on the estimated standard deviation of Cohen's d's theoretical sampling distribution, assuming asymptotic normality (Hedges & Olkin, 1985), calculated as $CI_{lower/upper} = d \pm z s_d$, where z is the z-score at the selected α level (2-

tailed) of the standard normal distribution, and

$$s_d = \sqrt{\frac{n_x + n_y}{n_x n_y} + \frac{d^2}{2(n_x + n_y)}}$$

.

`[25 or ["d CI high", col#]`

Column 1:Cohen's d estimate of upper boundary of confidence interval (row 16).
Column 2: see row 24 for details.

`[26 or ["var d.i", col#]`

Row variance of dominance/difference matrix, calculated as $(n_x - 1)^{-1} \sum (d_{i\cdot} - d)^2$. The metric descriptive in column 2 is the variance of x (or s_x^2).

`[27 or ["var dj.", col#]`

Column variance of dominance/difference matrix, calculated as $(n_y - 1)^{-1} \sum (d_{\cdot j} - d)^2$. The metric descriptive in column 2 is the variance of y (or s_y^2).

`[28 or ["var dij", col#]`

Variance of dominance/difference matrix as sample estimate according to Long et al. (2003, section 3.3 before eqn. 67):

$$s_{d_{ij}}^2 = \frac{\sum\sum(d_{ij} - d)^2}{n_x n_y - 1} = \frac{\sum d_{ij}^2 - \frac{(\sum d_{ij})^2}{n_x n_y}}{n_x n_y - 1},$$

thus avoiding Cliff's original (1996, p. 138) suggestion to use $(n_x - 1)(n_y - 1)$ as the denominator).

`[29 or ["df", col#]`

If the *studdist* parameter is not set to FALSE, column 1 returns the degrees of freedom (*df*) used for CI as well as z/t-score and z-probability estimates.
In column 2 ("metric") df as used for metric t-test.

`[30 or ["NNT", col#]`

The *number needed to treat* effect size (NNT, cf. Cook & Sackett, 1995) is returned based on the delta statistic as

$$delta^{-1}$$

as suggested by Kraemer & Kupfer, 2006, p. 994.
In column 2, the NNT is returned based on Cohen's d of the metric between-group comparison.

DEPENDENT/PAIRED GROUPS (*paired* argument set to TRUE)

In the case of paired data (e.g. pretest-posttest comparisons of the $n_x = n_y$ same subjects), a 4-column-matrix containing 29 rows with values is returned.

The ordinal statistics for d_{ij} can be retrieved from the first three columns (named

`within [.,1]` for the $n_x = n_y$ within-pair changes (where $i = j$ in all cases);

`between [.,2]` for the overall distribution changes, based on all $n^2 - n = n(n-1)$ comparisons where $i \neq j$,
and

`combined [.,3]` for combined inferences $d_w + d_b$.

Here, the fourth column (named "metric") contains metric comparison data.

`[1 or ["var1_X_pre", col#]`
: Original column name of the x (or pretest) input matrix.

`[2 or ["var2_Y_post", col#]`
: Original column name of the y (or posttest) input matrix.

`[3 or ["type_title", col#]`
: Columns 1-3: Return type of the comparison, in this case "paired".
Column4: In case a string header is defined by use of the *comp.name* argument, it is returned in column 4.

`[4 or ["N #Y>X", col#]`
: Number of occurences (\#) of a posttest observation y_i having a higher value than a pretest observation x_j: $N_{\#Y>X} = \#(y_i > x_j)$, limited to the respective pairs under observation in *within*, *between* or *combined*.
Column 4 equals column 3.

`[5 or ["N #Y=X", col#]`
: Number of occurences of a posttest observation having the same value as a pretest observation, limited to the respective pairs under observation in *within*, *between* or *combined*.
Column 4 equals column 3.

`[6 or ["N #Y<X", col#]`
: Number of occurences of a posttest observation having a smaller value than a pretest observation, limited to the respective pairs under observation in *within*, *between* or *combined*.
Column 4 equals column 3.

`[7 or ["PS X>Y", col#]`
: Common Language CL effect size or Probability of Superiority (PS) of X over Y (Grissom, 1994,Grissom & Kim, 2005) (limited to the respective pairs under observation in *within*, *between* or *combined*):

$$PS(Y > X) = \frac{\#(y_i > x_j)}{n_y \cdot n_x}.$$

. This effect size reflects the probability that a subject or case randomly chosen from the X- or pre-test-scores under observation has a higher score than than a randomly chosen case from the respective Y- or post-test-subsample (cf. Acion et al., 2006).
Column 4: Assuming equal variances and population normality, the (para)metric version of the Common Language effect size is calculated as suggested by McGraw & Wong (1992, p. 363) for correlated samples by using the variance sum law to adjust the variance on the difference scores with $PS(Y > X) = \Phi(\frac{M_y - M_x}{\sqrt{s_x^2 + s_y^2 - 2r_{xy}s_x s_y}})$ where Φ is the cumulative normal distribution function with $\Phi(z_\alpha) = \alpha$.

`[8 or ["PS Y>X", col#]`

Common Language CL effect size or Probability of Superiority (PS) of Y over X (Grissom, 1994,Grissom & Kim, 2005) (limited to the respective pairs under observation in *within*, *between* or *combined*).
Column 4: CL (para)metric version for the correlated samples case (see row 7 above for details on calculation).

`[9 or ["A X>Y", col#]`

Vargha and Delaney's A as stochastic superiority of X over Y, limited to the respective pairs under observation in *within*, *between* or *combined*. (See codedmes of this orddom package for details.)
Column 4 equals column 3.

`[10 or ["A Y>X", col#]`

Vargha and Delaney's A as stochastic superiority of Y over X, limited to the respective pairs under observation in *within*, *between* or *combined*. (See codedmes of this orddom package for details.)
Column 4 equals column 3.

`[11 or ["delta", col#]`

For columns 1 to 3 ("ordinal"), the respective delta for dependent groups (Cliff, 1996,Long et al., 2003,Feng, 2007) is reported. With $d_{ij} = sign(y_i - x_j)$,

Column 1 reports the (*within*) value, which is the "difference between the proportion of individual subjects who change in one direction and the proportion of individuals who change in the other" (Cliff, 1996, p. 159), calculated as

$$d_w = (\sum_i \mathop{=} \sum_j d_{ii})/n,$$

where $i = j$ in the $n = n_x = n_y$ possible paired comparisons.

"The extent to which the overall distribution has moved, except for the self-comparisons" (Cliff, 1996, p. 160) is given in column 2, the delta-(*between*) statistic. It is estimated by the average between-subject dominance, calculated as

$$d_b = (\sum_i \mathop{\neq} \sum_j d_{ij})/(n(n-1)),$$

where $i \neq j$.

Column 3 reports the combination effect $d_w + d_b$.

In column 4 ("metric"), the differences between subsample means are reported: $\bar{y} - \bar{x}$.

`[12 or ["1-alpha", col#]`
: Significance or α-level for CI estimation, given as percentage between 0 and 100.

`[13 or ["CI low", col#]`
: Confidence interval (CI) lower boundary estimate. Unless the default *symmetric* parameter is explicitly set to *TRUE*, asymmetric Confidence interval (CI) boundary estimates for ordinal differences are calculated (Feng & Cliff, 2004; Feng, 2007) as

$$CI_{lower/upper} = \frac{d - d^3 \pm t_{\alpha/2} s_d \sqrt{1 - 2d^2 + d^4 + t^2_{\alpha/2} s^2_d)}}{1 - d^2 + t^2_{\alpha/2} s^2_d},$$

with t-values at the respective significance level based on either Student's t or on z-values from the Standard Normal Distribution, depending on the *studdist* argument.

However, using an asymmetric CI is not advisable when the combined delta estimate (column 3) is to be used for inferences. An asymmetric CI may also reduce power of d_b value given in '`[10,2]`', especially in small paired samples (Cliff, 1996, p. 165). To obtain symmetric CI estimates with $CI_{lower/upper} = d \pm t_{\alpha/2} s_d$, the default *symmetric* argument must be set to *TRUE*.

In any case, if $d = \pm 1$, one CI is set as equal to d, the other is calculated as

$$CI_{lower/upper} = ((n_b - t^2_{\alpha/2}))(n_b + t^2_{\alpha/2})^{-1},$$

where $t_{\alpha/2}$ is the t-value or z-score at the selected α level (1- or 2-tailed) of the respective *studdist*-controlled distribution, and n_b the number of observations or cases in the smaller of the two samples.

`[14 or ["CI high", col#]`
: Confidence interval upper boundary estimate (see row 13).

`[15 or ["s delta", col#]`
: Estimated standard deviation of the respective delta statistic. Column 4 reports the metric standard deviation of the paired (within) differences.

`[16 or ["var delta", col#]`
: Unbiased estimates of the variances of the respective delta statistic.

Column 1 reports the *within* value, calculated as

$$s^2_{d_w} = (n(n-1))^{-1}(\sum (d_{ii} - d_w)^2).$$

Please note that in various pieces of the available research literature (e.g. Cliff, 1996, eq. 6.8, p. 161), $s^2_{d_w}$ is erroneously reported to be calculated as $s^2_{d_w} =$

$(n-1)^{-1}(\sum(d_{ii}-d_w)^2)$. The denominator, however must read $n(n-1)$ as "using just $(n-1)$ would give the variance of the individual d_{ii} whereas we want the variance of d_w, which is a kind of mean" (Feng, 07.02.2011, personal communication).

The (*between*) unbiased estimate in column 2 is calculated as $s^2_{d_b} = [(n-1)^2(\sum(d_{i\cdot}-d_b)^2 + \sum(d_{\cdot j}-d_b)^2 + 2\sum(d_{i\cdot}-d_b)(d_{\cdot j}-d_b)) - \sum\sum(d_{ij}-d_b)^2 - \sum\sum(d_{ij}-d_b)(d_{ji}-d_b)][n(n-1)(n-2)(n-3)]^{-1}$. In case this formula renderes negative variance estimates for s^2_{db} estimates by use of this formula, the *between* variance is alternatively calculated as $s^2_{db} = (1-d_b^2)/(n^2-n-1)$ (see Long et al. (2003, par after eqn. 66) for a related discussion).

Since d_w and d_b are interdependent, the *combined* effect involves taking into account their estimated covariance when calculating the unbiased estimate for the variance for the sum of d_w and d_b, which is reported in column 3 as $s^2_{d_w+d_b} = s^2_{d_w} + s^2_{d_b} + 2\widehat{cov}(d_b, d_w)$, with $\widehat{cov}(d_b, d_w) = \left(\sum_i[d_{ii}(\sum_j(d_{ij}) + \sum_j(d_{ji})] - 2n(n-1)d_b d_w\right)(n(n-1)(n-2))^{-1}$.

Column 4 reports the metric variance of the paired (within) differences.

`[17 or ["z/t score", col#]`
: z score of delta. In column 4 ("metric") equal to the t-test score (assuming equal variances).

`[18 or ["H1 tails p/CI", col#]`
: Equals *1* for one-tailed and *2* for two-tailed testing of alternative or *H_1*-hypothesis, affecting CI and p values.

`[19 or ["p", col#]`
: Probability of z-score (1 or 2-tailed comparison as shown in row 18).

`[20 or ["Cohen's d", col#]`
: Cohen's *d* estimate of the respective delta value (see above). In the metric case, the between group t-value and the original standard deviations are also used for the paired case to avoid overestimation of the effect size (Dunlap et al., 1996). See `delta2cohd` for details.
Not available for the combined delta in column 3.

`[21 or ["d CI low", col#]`
: Column 1 and 2: Cohen's *d* estimate of lower boundary of the respective confidence interval (row 13) by using the non-overlap calculation strategy.
Column 3: Not available.
Column 4: Confidence bands for metric Cohen's d are constructed based on the estimated standard deviation of Cohen's d's theoretical sampling distribution, assuming asymptotic normality (Hedges & Olkin, 1985), calculated as $CI_{lower/upper} = d \pm z s_d$, where z is the z-score at the selected α level (2-

tailed) of the standard normal distribution, and

$$s_d = \sqrt{\frac{n_x + n_y}{n_x n_y} + \frac{d^2}{2(n_x + n_y)}}$$

.

`[22 or ["d CI high", col#]`

Cohen's *d* estimate of upper boundary of the respective confidence interval (see row 21 for calculation details).

`[23,3] or ["var d.i",combined]`

Component of $s^2_{d_w+d_b}$: $s^2_{di.}$ (Available for the combined analyses in column 3 only.) The metric descriptive in column 4 is the variance of x (or s^2_x.

`[24,3] or ["var dj.",combined]`

Component of $s^2_{d_w+d_b}$: $s^2_{d.i}$ (Third column only.) The metric descriptive in column 4 is the variance of y (or s^2_y.

`[25,3] or ["cov(di,dj)",combined]`

Component of $s^2_{d_w+d_b}$: $cov(d_{i.}, d_{.j})$ (Third column only.)

`[26,3] or ["var dij",combined]`

Component of $s^2_{d_w+d_b}$: $s^2_{d_{ij}}$ (Third column only.)

`[27,3] or ["cov(dih,dhi)",combined]`

Component of $s^2_{d_w+d_b}$: $cov(d_{ih}, d_{hi})$ (Third column only.)

`[28,3] or ["cov(db,dw)",combined]`

Estimated covariance between d_b and d_w: $\widehat{cov}(d_b, d_w)$ (for purposes of combined inferences). (Third column only.)

`[29 or ["df", col#]`

Unless the *studdist* argument is not set to FALSE, the degrees of Freedom *df* used for the CI and z-score calculations are reported in column 1.

Column 2 returns the *df* used for the metric t-test for dependent samples.

`[30 or ["NNT", col#]`

In column 1 and 2, the *number needed to treat* effect size (NNT, cf. Cook & Sackett, 1995) are returned, based on the underlying delta statistics with NNT=

$$delta^{-1}$$

as suggested by Kraemer & Kupfer, 2006, p. 994. (Column 3 is empty.).
In column 4, the NNT is returned based on Cohen's d of the metric comparison.

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See Also

`orddom_f` and `orddom_p`.

Examples

```
## Not run:
#Independent Samples (Data taken from Long et al. (2003), Table 3
## End(Not run)
x<-t(matrix(c(3,3,3,4,5,6,12,12,13,14,15,15,15,15,15,16,18,18,18,23,23,27,28,28,43),1))
colnames(x)<-c("Nonalcohol.")
y<-t(matrix(c(1,4,6,7,7,14,14,18,19,20,21,24,25,26,26,26,27,28,28,30,33,33,44,45,50),1))
colnames(y)<-c("Alcoholic")
orddom(x,y,paired=FALSE,outputfile="tmp_r.txt")
## Not run:
#Paired Comparison with data written to file (Data taken from Long et al. (2003), Table 4
## End(Not run)
x<-t(matrix(c(2,6,6,7,7,8,8,9,9,9,10,10,10,11,11,12,13,14,15,16),1))
colnames(x)<-c("Incidental")
y<-t(matrix(c(4,11,8,9,10,11,11,5,14,12,13,10,14,16,14,13,15,15,16,10),1))
colnames(y)<-c("Intentional")
orddom_f(y,x,paired=TRUE,symmetric=FALSE)
## Not run:
#Directly returns d_b of the paired comparison
## End(Not run)
orddom(x,y,,TRUE,,,)[11,2]
```

---

orddom_f — *Ordinal Dominance Statistics: File output of statistics for multiple comparisons*

Description

Writes ordinal dominance statistics to tailored target output file, e.g. for purposes of multiple comparisons.

Usage

```
orddom_f(x,y, ... ,outputfile="orddom_csv.txt",quotechar=TRUE,decimalpt=".",
                 separator="\t",notavailable="NA",endofline="\n")
```

Arguments

- `x` — A 1-column matrix with optional column name containing all n_x values or scores of group X or 1 (e.g. control or pretest group.); see `orddom` for details.
- `y` — A 1-column matrix with optional column name containing all n_y values of group Y or 2 (e.g. treatment or post-test group); see `orddom` for details.
- `...` — Other arguments to be passed on to the `orddom` function (such as e.g. *paired, studdist, symmetric, x.name, description* etc.; see `orddom` for details.)
- `outputfile` — A filename for the report should be given here. The report as standard text file is written to the current working directory. All data are appended to this file. If the file does not exist initially, row headers are produced.
- `quotechar` — By default, string outputs are quoted.
- `decimalpt` — By default, numeric outputs use the colon as decimal point. Where commas are used instead, this argument should be set to *...,decimalpt=",",...* .
- `separator` — By default, field entries are separated by tabulators (*...,separator="\tab",...*). If, for example, .csv files are to be produced using the semicolon as the field separator, this argument should be set to *...,separator=";",...*.
- `notavailable` — By default, if field entries are ot available, *"NA"* is printed to the file. Other values to be printed can be given, e.g. *...,notavailable="",...* or *...,notavailable="NULL",...*.
- `endofline` — By default, a carriage return denotes the end of the single output line. Other values may be given, such as the IETF standard for csv files (*...,endofline="\r\n",...*).

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See Also

`orddom`

Examples

```
## Not run:
# Example: Experiment with experimental group "ex" and control group "con"
# Data sets:
ex_pre<-c(52,53,55,59,57)
con_pre<-c(51,56,54,60,56)
ex_post<-c(58,62,63,64,69)
con_post<-c(48,58,57,62,55)
# Two independent and two paired comparisons are possible
# These are to be written to a csv-file
# Alpha-level = 10
orddom_f(con_pre,ex_pre,alpha=0.025,decimalpt=",",description="EXP 01: Between groups at time 01")
# result delta=-.04
orddom_f(con_post,ex_post,alpha=0.025,decimalpt=",",description="EXP 01: Between groups at time 02")
```

```
# result delta=.84
orddom_f(ex_pre,ex_post,alpha=0.025,paired=TRUE,decimalpt=",",description="EXP 01: Within exp 01 to 02")
# result delta_b=.9
orddom_f(con_pre,con_post,alpha=0.025,paired=TRUE,decimalpt=",",description="EXP 01: Within con 01 to 02")
# result delta_b=.2
file.show(file.path(getwd()),"orddom_csv.txt")

## End(Not run)
```

`orddom_p` *Ordinal Dominance Matrices and Statistics: Printer-friendly Tab-Delimited Report Output File*

Description

Generates a sectioned report file with ordinal dominance matrices and statistics.

Usage

```
orddom_p(x,y,alpha=.05,paired=FALSE,sections="1234a4b5a5b",header="Y",sorted="XY",
      outfile="orddom_csv_tab.txt",appendfile=FALSE,show=1,description="")
```

Arguments

`x` A 1-column matrix with optional column name containing all n_x values or scores of group X or 1 (e.g. control or pretest group.); see `orddom` for details.

`y` A 1-column matrix with optional column name containing all n_y values of group Y or 2 (e.g. experimental or post-test group); see `orddom` for details.

`alpha` Significance or α-level used for the calculation of the confidence intervals; see `orddom` for details.

`paired` By default, independence of the two groups or data sets is assumed. For paired comparisons, set to TRUE; see `orddom` for details.

`sections` By default all of the following report sections are written to the file. If only a selection of all sections is needed, a string should be given containing all section numbers needed in the output, e.g. *...,sections="135a",...* for sections 1, 3 and 5a.
The following sections are available for output:
"1" - Raw data of the x and y data sets
"2" - Metric descriptives for x and y
"3" - Metric difference tests
"4a" - Metric difference matrix with x in rows and y in columns
"4b" - Metric difference matrix with y in rows and x in columns
"5a" - Ordinal dominance matrix with x in rows and y in columns
"5b" - Ordinal dominance matrix with y in rows and x in columns

`header` By default, section headers are part of the output. If headers are to be omitted, this argument should be set to FALSE.

`sorted`	All outputs in sections 1,4a,4b,5a and 5b may be automatically sorted ascendingly for the x data set (string is to contain "X") and/or for the y data set (string is to contain "Y"). This is the default option.
`outfile`	A filename for the report should be given here. The report as standard text file is written to the current working directory.
`appendfile`	By default, new report files are created. If a given report file ist to be appended, set to TRUE.
`show`	By default, the generated file is displayed. Set to FALSE to avoid the resulting file to be shown.
`description`	This argument allows for assigning a string (as title or description) for the ordinal comparison outputs.

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See Also

`orddom`.

Examples

```
## Not run:
#Independent Samples (Data taken from Long et al. (2003), Table 4
## End(Not run)
x<-t(matrix(c(3,3,3,4,5,6,12,12,13,14,15,15,15,15,15,16,18,18,18,23,23,27,28,28,43),1))
colnames(x)<-c("Nonalcohol.")
y<-t(matrix(c(1,4,6,7,7,14,14,18,19,20,21,24,25,26,26,26,27,28,28,30,33,33,44,45,50),1))
colnames(y)<-c("Alcoholic")
orddom_p(x,y,,paired=FALSE,outfile="orddom_csv_tab.txt")
```

`return1colmatrix` *Convert vectors, data frames, lists, or arrays to 1-column matrix for use in orddom*

Description

Converts vectors, data frames, lists, and arrays to 1-column matrix with optional column name and sorting option for use in various orddom functions

Usage

```
return1colmatrix(x,grp.name="",sortx=FALSE)
```

Arguments

`x`	Vector, data frame, list or array with n_x values and an optional header or name
`grp.name`	A name or column title for x may be assigned. By default, the variable name is returned as *var(x)*.
`sortx`	If argument is set to *TRUE*, the function will return a matrix with sorted scores.

Value

Returns a 1-column matrix with n scores in n rows with X columnname.

Author(s)

Jens Rogmann

See Also

orddom

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