

Package ‘steepness’

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Title Testing Steepness of Dominance Hierarchies

Author David Leiva <dleivaur@ub.edu> & Han de Vries
<J.deVries1@uu.nl>.

Maintainer David Leiva <dleivaur@ub.edu>

Depends R (>= 4.1.0)

Description The steepness package computes steepness as a property of dominance hierarchies. Steepness is defined as the absolute slope of the straight line fitted to the normalized David's scores. The normalized David's scores can be obtained on the basis of dyadic dominance indices corrected for chance or by means of proportions of wins. Given an observed sociomatrix, it computes hierarchy's steepness and estimates statistical significance by means of a randomization test.

License GPL (>= 2)

NeedsCompilation yes

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Description

Steepness is a package that computes steepness as a property of dominance hierarchies. Steepness is defined as the absolute slope of the straight line fitted to the normalized David's scores. The normalized David's scores can be obtained on the basis of dyadic dominance indices corrected for chance or from the matrix of win proportions. Given an observed sociomatrix, it computes hierarchy's steepness and estimates statistical significance by means of a randomization test (see de Vries, Stevens and Vervaecke, 2006).

Details

Package: steepness
 Version: 0.2-2
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 Depends: >= 3.1.0
 License: GPL version 2 or newer

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<code>getDij</code>	Dyadic dominance index corrected for chance -Dij-
<code>getDS</code>	David's scores -DS-
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<code>getOrderedMatrix</code>	Ordered matrix according to NormDS values
<code>getPij</code>	Matrix of proportions of wins -Pij-
<code>getStp</code>	Hierarchy's steepness measure -Stp-
<code>getwl</code>	Several win and loss measures at individual level
<code>steepstest</code>	Statistical significance for steepness statistic

Author(s)

David Leiva <dleivaur@ub.edu> & Han de Vries <J.deVries1@uu.nl>.

Maintainer: David Leiva <dleivaur@ub.edu>

References

de Vries, H., Stevens, J. M. G., & Vervaecke, H. (2006). Measuring and testing the steepness of dominance hierarchies. *Animal Behaviour*, 71, 585-592.

See Also

For more information see: [getDij](#), [getDS](#), [getNormDS](#), [getOrderedMatrix](#), [getPij](#), [getStp](#), [getwl](#), [steepstest](#).

getDij	<i>Dyadic dominance index corrected for chance -Dij-</i>
--------	--

Description

Function to obtain matrix of dyadic dominance indices corrected for chance from the observed sociomatrix.

Usage

```
getDij(X, names=NULL)
```

Arguments

X	Empirical sociomatrix containing wins-losses frequencies in dyadic encounters.
names	Character vector with the names of individuals. This vector is NULL by default

Details

getDij is only applied for square matrices in which the set of n actors is also the set of n partners. The matrices must also be numeric.

Value

Dij	Matrix of observed dyadic dominance indices corrected for chance.
-----	---

Author(s)

David Leiva <dleivaur@ub.edu> & Han de Vries <J.deVries1@uu.nl>.

References

de Vries, H., Stevens, J. M. G., & Vervaecke, H. (2006). Measuring and testing the steepness of dominance hierarchies. *Animal Behaviour*, 71, 585-592.

See Also

[steepstest](#).

Examples

```
#####
###           Example taken from Vervaecke et al. (2007):           ###
#####

X <- matrix(c(0,58,50,61,32,37,29,39,25,8,0,22,22,9,27,20,10,48,
              3,3,0,19,29,12,13,19,8,5,8,9,0,33,38,35,32,57,
              4,7,9,1,0,28,26,16,23,4,3,0,0,6,0,7,6,12,
              2,0,4,1,4,4,0,5,3,0,2,1,1,5,8,3,0,10,3,1,3,0,0,4,1,2,0),
```

```

nrow=9,byrow=TRUE)

individuals <- c("V","VS","B","FJ","PR","VB","TOR","MU","ZV")

res <- getDij(X,individuals)

print(res,digits=3)

```

getDS

David's scores -DS-

Description

Function to obtain David's scores from the observed sociomatrix.

Usage

```
getDS(X, names=NULL, method=c("Dij","Pij"))
```

Arguments

X	Empirical sociomatrix containing wins-losses frequencies in dyadic encounters. The matrix must be square and numeric.
names	Character vector with the names of individuals. This vector is NULL by default
method	A character string indicating which dyadic dominance measure is to be used for the computation of David's scores. One of "Dij" or "Pij", can be abbreviated.

Details

getDS is obtained by means of the following expression: $DS = w1 + w2 - l1 - l2$ where $w1$ is the sum of i 's Dij or Pij values (depending on the method specification); $w2$ is the weighted sum of i 's dyadic dominance indices corrected for chance or the weighted sum of i 's win proportions; $l1$ is the sum of i 's Dji or Pji values and $l2$ is the sum of i 's dyadic lose indices corrected for chance or the weighted sum of i 's lose proportions.

Value

DS	David's scores based on dyadic dominance indices corrected for chance or on win proportions.
----	--

Author(s)

David Leiva <dleivaur@ub.edu> & Han de Vries <J.deVries1@uu.nl>.

References

- David, H. A. (1988). *The Method of Paired Comparisons*. London: C. Griffin.
- de Vries, H., Stevens, J. M. G., & Vervaecke, H. (2006). Measuring and testing the steepness of dominance hierarchies. *Animal Behaviour*, 71, 585-592.

See Also

[getDij](#), [getPij](#), [getwl](#).

Examples

```
#####
###           Example taken from Vervaecke et al. (2007):           ###
#####

X <- matrix(c(0,58,50,61,32,37,29,39,25,8,0,22,22,9,27,20,10,48,
              3,3,0,19,29,12,13,19,8,5,8,9,0,33,38,35,32,57,
              4,7,9,1,0,28,26,16,23,4,3,0,0,6,0,7,6,12,
              2,0,4,1,4,4,0,5,3,0,2,1,1,5,8,3,0,10,3,1,3,0,0,4,1,2,0),
            nrow=9,byrow=TRUE)

individuals <- c("V","VS","B","FJ","PR","VB","TOR","MU","ZV")

res <- getDS(X,names=individuals,method="Dij")

print(res,digits=3)
```

getNormDS

Normalized David's scores -NormDS-

Description

Function to obtain normalized David's scores from the observed sociomatrix.

Usage

```
getNormDS(X, names=NULL, method=c("Dij","Pij"))
```

Arguments

- | | |
|--------|--|
| X | Empirical sociomatrix containing wins-losses frequencies in dyadic encounters. The matrix must be square and numeric. |
| names | Character vector with the names of individuals. This vector is NULL by default |
| method | A character string indicating which dyadic dominance measure is to be used for the computation of David's scores. One of "Dij" or "Pij", can be abbreviated. |

Details

getNormDS is obtained by means of the following expression: $NormDS = (DS + N(N-1)/2)/N$

Value

NormDS Normalized David's scores based on dyadic dominance indices corrected for chance or based on the win proportions, depending on the method specified.

Author(s)

David Leiva <dleivaur@ub.edu> & Han de Vries <J.deVries1@uu.nl>.

References

David, H. A. (1988). *The Method of Paired Comparisons*. London: C. Griffin.
 de Vries, H., Stevens, J. M. G., & Vervaecke, H. (2006). Measuring and testing the steepness of dominance hierarchies. *Animal Behaviour*, 71, 585-592.

See Also

[getDij](#), [getPij](#), [getDS](#).

Examples

```
#####
###                               Example taken from Vervaecke et al. (2007):      ###
#####

X <- matrix(c(0,58,50,61,32,37,29,39,25,8,0,22,22,9,27,20,10,48,
              3,3,0,19,29,12,13,19,8,5,8,9,0,33,38,35,32,57,
              4,7,9,1,0,28,26,16,23,4,3,0,0,6,0,7,6,12,
              2,0,4,1,4,4,0,5,3,0,2,1,1,5,8,3,0,10,3,1,3,0,0,4,1,2,0),
            nrow=9,byrow=TRUE)

individuals <- c("V","VS","B","FJ","PR","VB","TOR","MU","ZV")

res <- getNormDS(X,names=individuals,method="Dij")

print(res,digits=3)
```

getOrderedMatrix	<i>Ordered matrix according to NormDS values</i>
------------------	--

Description

Function to order the observed matrix of dyadic dominance encounters according to the individuals' NormDS values.

Usage

```
getOrderedMatrix(X, names=NULL, method=c("Dij", "Pij"))
```

Arguments

X	Empirical sociomatrix containing wins-losses frequencies in dyadic encounters.
names	Character vector with the names of individuals. This vector is NULL by default
method	A character string indicating which dyadic dominance measure is to be used for the computation of David's scores. One of "Dij" or "Pij", can be abbreviated.

Details

getOrderedMatrix is only applied for square matrices in which the set of n actors is also the set of n partners. The matrices must also be numeric.

Value

ordered.matrix	Matrix of observed dyadic dominance encounters ordered according to the individuals' NormDS values.
ordered.names	Vector of individuals' names ordered according to their NormDS values.
order.seq	Sequence used in the order of the matrix of dyadic encounters and the vector of names.

Author(s)

David Leiva <dleivaur@ub.edu> & Han de Vries <J.deVries1@uu.nl>.

References

de Vries, H., Stevens, J. M. G., & Vervaecke, H. (2006). Measuring and testing the steepness of dominance hierarchies. *Animal Behaviour*, 71, 585-592.

See Also

[getNormDS](#).

Examples

```
#####
###           Example taken from Vervaecke et al. (2007):           ###
#####

X <- matrix(c(0,58,50,61,32,37,29,39,25,8,0,22,22,9,27,20,10,48,
              3,3,0,19,29,12,13,19,8,5,8,9,0,33,38,35,32,57,
              4,7,9,1,0,28,26,16,23,4,3,0,0,6,0,7,6,12,
              2,0,4,1,4,4,0,5,3,0,2,1,1,5,8,3,0,10,3,1,3,0,0,4,1,2,0),
            nrow=9,byrow=TRUE)

individuals <- c("V","VS","B","FJ","PR","VB","TOR","MU","ZV")
```

```
res <- getOrderedMatrix(X, individuals, method="Dij")$ordered.matrix
print(res, digits=3)
```

getPij	<i>Matrix of win proportions -Pij-</i>
--------	--

Description

Function to obtain matrix of win proportions from the observed sociomatrix.

Usage

```
getPij(X, names=NULL)
```

Arguments

X	Empirical sociomatrix containing wins-losses frequencies in dyadic encounters.
names	Character vector with the names of individuals. This vector is NULL by default

Details

getPij is only applied for square matrices in which the set of n actors is also the set of n partners. The matrices must also be numeric.

Value

Pij	Matrix of observed win proportions.
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Author(s)

David Leiva <dleivaur@ub.edu> & Han de Vries <J.deVries1@uu.nl>.

References

de Vries, H., Stevens, J. M. G., & Vervaecke, H. (2006). Measuring and testing the steepness of dominance hierarchies. *Animal Behaviour*, 71, 585-592.

See Also

[steepetest](#).

Examples

```
#####
###           Example taken from Vervaecke et al. (2007):           ###
#####

X <- matrix(c(0,58,50,61,32,37,29,39,25,8,0,22,22,9,27,20,10,48,
              3,3,0,19,29,12,13,19,8,5,8,9,0,33,38,35,32,57,
              4,7,9,1,0,28,26,16,23,4,3,0,0,6,0,7,6,12,
              2,0,4,1,4,4,0,5,3,0,2,1,1,5,8,3,0,10,3,1,3,0,0,4,1,2,0),
            nrow=9,byrow=TRUE)

individuals <- c("V","VS","B","FJ","PR","VB","TOR","MU","ZV")

res <- getPij(X,individuals)

print(res,digits=3)
```

getStp

Steepness measure of dominance hierarchies -Stp-

Description

Function to obtain hierarchy's steepness measure from the observed sociomatrix.

Usage

```
getStp(X, method=c("Dij", "Pij"))
```

Arguments

X	Empirical sociomatrix containing wins-losses frequencies in dyadic encounters. The matrix must be square and numeric.
method	A character string indicating which dyadic dominance measure is to be used for the computation of David's scores. One of "Dij" or "Pij", can be abbreviated.

Details

getStp is the absolute value of the slope of the best-fitted line between the normalized David's scores and the rank dominance in a decreasing order. The regression is obtained by Ordinary Least Squares method.

Value

getStp	Steepness measure based on dyadic dominance indices corrected for chance or based on the matrix of win proportions, depending on the method specified.
--------	--

Author(s)

David Leiva <dleivaur@ub.edu> & Han de Vries <J.deVries1@uu.nl>.

References

de Vries, H., Stevens, J. M. G., & Vervaecke, H. (2006). Measuring and testing the steepness of dominance hierarchies. *Animal Behaviour*, 71, 585-592.

See Also

[getDij](#), [getPij](#), [getNormDS](#).

Examples

```
#####
###                               Example taken from Vervaecke et al. (2007):          ###
#####

X <- matrix(c(0,58,50,61,32,37,29,39,25,8,0,22,22,9,27,20,10,48,
              3,3,0,19,29,12,13,19,8,5,8,9,0,33,38,35,32,57,
              4,7,9,1,0,28,26,16,23,4,3,0,0,6,0,7,6,12,
              2,0,4,1,4,4,0,5,3,0,2,1,1,5,8,3,0,10,3,1,3,0,0,4,1,2,0),
            nrow=9,byrow=TRUE)

individuals <- c("V","VS","B","FJ","PR","VB","TOR","MU","ZV")

print(getStp(X,method="Dij"),digits=3)
```

getwl

Win-loss measures at individual level

Description

Function to obtain win and loss measures at individual level from the observed sociomatrix.

Usage

```
getwl(X, names=NULL, method=c("Dij","Pij"))
```

Arguments

X	Empirical sociomatrix containing wins-losses frequencies in dyadic encounters. The matrix must be square and numeric.
names	Character vector with the names of individuals. This vector is NULL by default
method	A character string indicating which dyadic dominance measure is to be used for the computation of David's scores. One of "Dij" or "Pij", can be abbreviated.

Details

By means of the empirical sociomatrix of wins and losses this function computes several win-loss measures at individual level. Specifically, it computes w , *weighted.w*, l and *weighted.l*. w is the sum of individuals' dyadic dominances D_{ij} or the sum of proportions of wins P_{ij} by rows, depending on the specification of the *method*. *weighted.w* measures is the sum of individuals' D_{ij} or P_{ij} values weighted by the w values of their interactants. l is the sum of individuals' dyadic dominance indices D_{ij} or the sum of individuals' proportions of wins P_{ij} by columns. And finally, *weighted.l* is the columns sum of individuals' D_{ij} or P_{ij} values weighted by the l values of their interactants. These measures are used when computing David's scores.

Value

The result is a data frame with the following components:

w	Sum of dyadic dominance indices D_{ij} or proportions of wins P_{ij} by rows.
<i>weighted.w</i>	Weighted sum of dyadic dominance indices D_{ij} or proportions of wins P_{ij} .
l	Sum of dyadic dominance indices D_{ij} or proportions of wins P_{ij} by columns.
<i>weighted.l</i>	Weighted sum of dyadic dominance indices D_{ij} or proportions of wins P_{ij} .

Author(s)

David Leiva <dleivaur@ub.edu> & Han de Vries <J.deVries1@uu.nl>.

References

- David, H. A. (1988). *The Method of Paired Comparisons*. London: C. Griffin.
- de Vries, H., Stevens, J. M. G., & Vervaecke, H. (2006). Measuring and testing the steepness of dominance hierarchies. *Animal Behaviour*, 71, 585-592.

See Also

[getDij](#), [getPij](#), [getDS](#).

Examples

```
#####
###           Example taken from Vervaecke et al. (2007):           ###
#####

X <- matrix(c(0,58,50,61,32,37,29,39,25,8,0,22,22,9,27,20,10,48,
              3,3,0,19,29,12,13,19,8,5,8,9,0,33,38,35,32,57,
              4,7,9,1,0,28,26,16,23,4,3,0,0,6,0,7,6,12,
              2,0,4,1,4,4,0,5,3,0,2,1,1,5,8,3,0,10,3,1,3,0,0,4,1,2,0),
            nrow=9,byrow=TRUE)

individuals <- c("V","VS","B","FJ","PR","VB","TOR","MU","ZV")

res <- getwl(X,names=individuals,method="Dij")
```

```
print(res,digits=3)
```

steepTest	<i>Statistical significance for steepness of dominance hierarchies statistic</i>
-----------	--

Description

Estimates statistical significance for steepness measure on the basis of dyadic dominance indices corrected for chance *Dij* or based on proportions of wins *Pij*.

Usage

```
steepTest(X, rep, names=NULL, method=c("Dij","Pij"), order=TRUE)
```

Arguments

X	Empirical sociomatrix containing wins-losses frequencies in dyadic encounters. The matrix must be square and numeric.
rep	Number of simulations for carrying out the randomization test.
names	Character vector with individuals' names.
method	A character string indicating which dyadic dominance measure is to be used for the computation of David's scores. One of "Dij" or "Pij", can be abbreviated.
order	Logical, if TRUE, results for Dij, DS and NormDS are ordered according to the individuals' NormDS values. TRUE by default.

Details

steepTest estimates statistical significance for steepness measures based on dyadic dominance index corrected for chance *Dij* or based on the matrix of win proportions *Pij*, depending on the method specified. This procedure simulates a number of sociomatrices under a uniform distribution by means of callings to C routine *steep*, then computes steepness based on *Dij* or *Pij*. Specifically, it computes normalized David's scores, see [getNormDS](#) for more details. Then it computes the steepness measure based on these indices, see [getStp](#). After rep simulations the sampling distribution for the statistic (*Stp*) is estimated. Then statistical significance is computed as follows when results are shown by means of summary method: $p = NS + 1 / NOS + 1$ Where *NS* is computed as:

1. The number of times that simulated values are greater than or equal to the empirical value, if right-tailed p value is calculated.
2. And the number of times that simulated values are lower than or equal to the empirical value, if left-tailed p value is calculated.

And *NOS* represents the number of simulated values.

Value

steepTest returns an object of class steepTest containing the following components:

call	Function call.
names	Character vector with individuals' names.
method	A character string indicating which dyadic dominance measure is used for the computation of David's scores.
rep	Number of simulations for carrying out the randomization test.
matdom	If method is set to be <i>Dij</i> the function returns the matrix of observed dyadic dominance indices corrected for chance. If method is <i>Pij</i> the matrix of proportions of wins is returned as a part of the output.
DS	David's scores based on <i>Dij</i> or <i>Pij</i> , depending on the specification of the method.
NormDS	Normalized David's scores based on dyadic dominance indices corrected for chance or on proportions of wins in dyadic encounters.
Stp	Steepness value based on Normalized David's scores.
interc	Intercept of the fitted line based on Normalized David's scores.
Stpsim	The function provides results of the randomization procedure for the steepness measure based on <i>NormDS</i> .

Author(s)

David Leiva <dleivaur@ub.edu> & Han de Vries <J.deVries1@uu.nl>.

References

David, H. A. (1988). *The Method of Paired Comparisons*. London: C. Griffin.

de Vries, H., Stevens, J. M. G., & Vervaecke, H. (2006). Measuring and testing the steepness of dominance hierarchies. *Animal Behaviour*, 71, 585-592.

See Also

[getDij](#), [getPij](#), [getNormDS](#)

Examples

```
#####
###           Example taken from Vervaecke et al. (2007):           ###
#####
X <- matrix(c(0,58,50,61,32,37,29,39,25,8,0,22,22,9,27,20,10,48,
              3,3,0,19,29,12,13,19,8,5,8,9,0,33,38,35,32,57,
              4,7,9,1,0,28,26,16,23,4,3,0,0,6,0,7,6,12,
              2,0,4,1,4,4,0,5,3,0,2,1,1,5,8,3,0,10,3,1,3,0,0,4,1,2,0),
              nrow=9,byrow=TRUE)

individuals <- c("V", "VS", "B", "FJ", "PR", "VB", "TOR", "MU", "ZV")

STP <- steepTest(X, rep=9999, names=individuals, method="Dij", order=TRUE)
```

```
summary(STP)
plot(STP)
```

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