

# Package ‘steepness’

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**Title** Testing Steepness of Dominance Hierarchies

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**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.

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## R topics documented:

steepness-package . . . . .	2
getDij . . . . .	3
getDS . . . . .	4
getNormDS . . . . .	5
getOrderedMatrix . . . . .	7
getPij . . . . .	8
getStp . . . . .	9
getwl . . . . .	10
steeptest . . . . .	12

<b>Index</b>	<b>15</b>
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steepness-package      *Testing Steepness of Dominance Hierarchies*

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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  
 Date: 2014-29-09  
 Depends: >= 3.1.0  
 License: GPL version 2 or newer

### Index:

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

---

### 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

[steeptest](#).

### 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

*Matrix of win proportions -Pij-*


---

**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.
-----	-------------------------------------

**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**

[steepestest](#).

**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 Dij or the sum of proportions of wins Pij by rows, depending on the specification of the *method*. *weighted.w* measures is the sum of individuals' Dij or Pij values weighted by the  $w$  values of their interactants.  $l$  is the sum of individuals' dyadic dominance indices Dij or the sum of individuals' proportions of wins Pij by columns. And finally, *weighted.l* is the columns sum of individuals' Dij or Pij 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 Dij or proportions of wins Pij by rows.
weighted.w	Weighted sum of dyadic dominance indices Dij or proportions of wins Pij.
l	Sum of dyadic dominance indices Dij or proportions of wins Pij by columns.
weighted.l	Weighted sum of dyadic dominance indices Dij or proportions of wins Pij.

**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)
```

---

steepstest

*Statistical significance for steepness of dominance hierarchies statistic*

---

## 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

```
steepstest(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

steepest estimates statistical significance for steepness measures based on dyadic dominance index corrected for chance  $D_{ij}$  or based on the matrix of win proportions  $P_{ij}$ , 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  $D_{ij}$  or  $P_{ij}$ . 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

steepest returns an object of class `steepest` containing the following components:

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

## 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)
```

# Index

## \* **h**test

- getDij, 3
- getDS, 4
- getNormDS, 5
- getOrderedMatrix, 7
- getPij, 8
- getStp, 9

## \* **m**isc

- getDij, 3
- getDS, 4
- getNormDS, 5
- getOrderedMatrix, 7
- getPij, 8
- getStp, 9
- getwl, 10
- steeptest, 12

## \* **p**ackage

- steepness-package, 2

getDij, 2, 3, 5, 6, 10, 11, 14  
getDS, 2, 4, 6, 11  
getNormDS, 2, 5, 7, 10, 13, 14  
getOrderedMatrix, 2, 7  
getPij, 2, 5, 6, 8, 10, 11, 14  
getStp, 2, 9, 13  
getwl, 2, 5, 10

steepness (steepness-package), 2  
steepness-package, 2  
steeptest, 2, 3, 9, 12