

# Package: ConsRank (via r-universe)

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**Type** Package

**Title** Compute the Median Ranking(s) According to the Kemeny's Axiomatic Approach

**Version** 2.1.4

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**Maintainer** Antonio D'Ambrosio <antdambr@unina.it>

**Depends** rgl

**Imports** rlist (>= 0.4.2), methods, proxy, gtools, tidyr

**Description** Compute the median ranking according to the Kemeny's axiomatic approach. Rankings can or cannot contain ties, rankings can be both complete or incomplete. The package contains both branch-and-bound algorithms and heuristic solutions recently proposed. The searching space of the solution can either be restricted to the universe of the permutations or unrestricted to all possible ties. The package also provide some useful utilities for deal with preference rankings, including both element-weight Kemeny distance and correlation coefficient. This release declare as deprecated some functions that are still in the package for compatibility. Next release will not contains these functions. Please type '?ConsRank-deprecated' Essential references: Emond, E.J., and Mason, D.W. (2002) <doi:10.1002/mcda.313>; D'Ambrosio, A., Amodio, S., and Iorio, C. (2015) <doi:10.1285/i20705948v8n2p198>; Amodio, S., D'Ambrosio, A., and Siciliano R. (2016) <doi:10.1016/j.ejor.2015.08.048>; D'Ambrosio, A., Mazzeo, G., Iorio, C., and Siciliano, R. (2017) <doi:10.1016/j.cor.2017.01.017>; Albano, A., and Plaia, A. (2021) <doi:10.1285/i20705948v14n1p117>.

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ConsRank-package      *Median Ranking Approach According to the Kemeny's Axiomatic Approach*

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## Description

Compute the median ranking according to the Kemeny's axiomatic approach. Rankings can or cannot contain ties, rankings can be both complete or incomplete. The package contains both branch-and-bound and heuristic solutions as well as routines for computing the median constrained bucket order and the K-median cluster component analysis. The package also contains routines for visualize rankings and for detecting the universe of rankings including ties.

## Details

Package: ConsRank  
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License: GPL-3

## Author(s)

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Giulio Mazzeo [ctb] <giuliomazzeo@gmail.com>

Maintainer: Antonio D'Ambrosio <antdambr@unina.it>

## References

Kemeny, J. G., & Snell, J. L. (1962). *Mathematical models in the social sciences* (Vol. 9). New York: Ginn.

Marden, J. I. (1996). *Analyzing and modeling rank data*. CRC Press.

Emond, E. J., & Mason, D. W. (2002). A new rank correlation coefficient with application to the consensus ranking problem. *Journal of Multi-Criteria Decision Analysis*, 11(1), 17-28.

D'Ambrosio, A. (2008). *Tree based methods for data editing and preference rankings*. Ph.D. thesis. <http://www.fedoa.unina.it/id/eprint/2746>

Heiser, W. J., & D'Ambrosio, A. (2013). Clustering and prediction of rankings within a Kemeny distance framework. In *Algorithms from and for Nature and Life* (pp. 19-31). Springer International Publishing.

Amodio, S., D'Ambrosio, A. & Siciliano, R (2016). Accurate algorithms for identifying the median ranking when dealing with weak and partial rankings under the Kemeny axiomatic approach. *European Journal of Operational Research*, vol. 249(2).

D'Ambrosio, A., Amodio, S. & Iorio, C. (2015). Two algorithms for finding optimal solutions of the Kemeny rank aggregation problem for full rankings. *Electronic Journal of Applied Statistical Analysis*, vol. 8(2).

D'Ambrosio, A., Mazzeo, G., Iorio, C., & Siciliano, R. (2017). A differential evolution algorithm for finding the median ranking under the Kemeny axiomatic approach. *Computers & Operations Research*, vol. 82.

D'Ambrosio, A., & Heiser, W.J. (2019). A Distribution-free Soft Clustering Method for Preference Rankings. *Behaviormetrika*, vol. 46(2), pp. 333–351.

D'Ambrosio, A., Iorio, C., Staiano, M., & Siciliano, R. (2019). Median constrained bucket order rank aggregation. *Computational Statistics*, vol. 34(2), pp. 787–802,

### Examples

```
## load APA data set, full version
data(APAFULL)
## Emond and Mason Branch-and-Bound algorithm.
#CR=consrank(APAFULL)
#use frequency tables
#TR=tabulaterows(APAFULL)
#quick algorithm
#CR2=consrank(TR$X,wk=TR$Wk,algorithm="quick")
#FAST algorithm
#CR3=consrank(TR$X,wk=TR$Wk,algorithm="fast",itermax=10)
#Decor algorithm
#CR4=consrank(TR$X,wk=TR$Wk,algorithm="decor",itermax=10)

#####
### load sports data set
#data(sports)
### FAST algorithm
#CR=consrank(sports,algorithm="fast",itermax=10)
#####

#####
### load Emond and Mason data set
#data(EMD)
### matrix X contains rankings
#X=EMD[,1:15]
### vector Wk contains frequencies
#Wk=EMD[,16]
### QUICK algorithm
#CR=consrank(X,wk=Wk,algorithm="quick")
#####
```

**Description**

The American Psychological Association dataset includes 15449 ballots of the election of the president in 1980, 5738 of which are complete rankings, in which the candidates are ranked from most to least favorite.

**Usage**

```
data(APAFULL)
```

**Source**

Diaconis, P. (1988). Group representations in probability and statistics. Lecture Notes-Monograph Series, i-192., pag. 96.

---

APared	<i>American Psychological Association dataset, reduced version with only full rankings</i>
--------	--

---

**Description**

The American Psychological Association reduced dataset includes 5738 ballots of the election of the president in 1980, in which the candidates are ranked from most to least favorite.

**Usage**

```
data(APared)
```

**Source**

Diaconis, P. (1988). Group representations in probability and statistics. Lecture Notes-Monograph Series, i-192., pag. 96.

---

BBFULL	<i>Branch-and-Bound algorithm to find the median ranking in the space of full (or complete) rankings.</i>
--------	---

---

**Description**

Branch-and-bound algorithm to find consensus ranking as defined by D'Ambrosio et al. (2015). If the number of objects to be ranked is large (greater than 20 or 25), it can work for very long time. Use either QuickCons or FASTcons with the option FULL=TRUE instead

**Usage**

```
BBFULL(X, Wk = NULL, PS = TRUE)
```

**Arguments**

X	A N by M data matrix, in which there are N judges and M objects to be judged. Each row is a ranking of the objects which are represented by the columns. The data matrix can contain both full and tied rankings, or incomplete rankings. Alternatively X can contain the rankings observed only once. In this case the argument Wk must be used
Wk	Optional: the frequency of each ranking in the data
PS	If PS=TRUE, on the screen some information about how many branches are processed are displayed

**Details**

This function is deprecated and it will be removed in the next release of the package. Use function 'consrank' instead.

If the objects to be ranked is large (>25 - 30), it can take long time to find the solutions

**Value**

a "list" containing the following components:

Consensus	the Consensus Ranking
Tau	averaged TauX rank correlation coefficient
Eltime	Elapsed time in seconds

**Author(s)**

Antonio D'Ambrosio <antdambr@unina.it>

**References**

D'Ambrosio, A., Amodio, S., and Iorio, C. (2015). Two algorithms for finding optimal solutions of the Kemeny rank aggregation problem for full rankings. *Electronic Journal of Applied Statistical Analysis*, 8(2), 198-213.

**See Also**

[consrank](#)

**Examples**

```
#data(APAFULL)
#CR=BBFULL (APAFULL)
```

---

BU	<i>Brook and Upton data</i>
----	-----------------------------

---

**Description**

The data consist of ballots of three candidates, where the 948 voters rank the candidates from 1 to 3. Data are in form of frequency table.

**Usage**

```
data(BU)
```

**Source**

Brook, D., & Upton, G. J. G. (1974). Biases in local government elections due to position on the ballot paper. *Applied Statistics*, 414-419.

**References**

Marden, J. I. (1996). *Analyzing and modeling rank data*. CRC Press, pag. 153.

**Examples**

```
data(BU)
polyplot(BU[,1:3],Wk=BU[,4])
```

---

combinmatr	<i>Combined input matrix of a data set</i>
------------	--

---

**Description**

Compute the Combined input matrix of a data set as defined by Emond and Mason (2002)

**Usage**

```
combinmatr(X, Wk = NULL)
```

**Arguments**

X	A data matrix N by M, in which there are N judges and M objects to be judged. Each row is a ranking of the objects which are represented by the columns. Alternatively X can contain the rankings observed only once. In this case the argument Wk must be used
Wk	Optional: the frequency of each ranking in the data

**Value**

The M by M combined input matrix

**Author(s)**

Antonio D'Ambrosio <antdambr@unina.it>

**References**

Emond, E. J., and Mason, D. W. (2002). A new rank correlation coefficient with application to the consensus ranking problem. *Journal of Multi-Criteria Decision Analysis*, 11(1), 17-28.

**See Also**

[tabulaterows](#) frequency distribution of a ranking data.

**Examples**

```
data(APared)
CI<-combinmatr(APared)
TR<-tabulaterows(APared)
CI<-combinmatr(TR$X, TR$Wk)
```

---

consrank

*Branch-and-bound and heuristic algorithms to find consensus (median) ranking according to the Kemeny's axiomatic approach*

---

**Description**

Branch-and-bound, Quick , FAST and DECOR algorithms to find consensus (median) ranking according to the Kemeny's axiomatic approach. The median ranking(s) can be restricted to be necessarily a full ranking, namely without ties

**Usage**

```
consrank(
  X,
  wk = NULL,
  ps = TRUE,
  algorithm = "BB",
  full = FALSE,
  itermax = 10,
  np = 15,
  gl = 100,
  ff = 0.4,
  cr = 0.9,
  proc = FALSE
)
```



### Arguments

X	A n by m data matrix, in which there are n judges and m objects to be judged. Each row is a ranking of the objects which are represented by the columns. If X contains the rankings observed only once, the argument wk can be used
wk	Optional: the frequency of each ranking in the data
ps	If PS=TRUE, on the screen some information about how many branches are processed are displayed.
algorithm	Specifies the used algorithm. One among "BB", "quick", "fast" and "decor". algorithm="BB" is the default option.
full	Specifies if the median ranking must be searched in the universe of rankings including all the possible ties (full=FALSE) or in the restricted space of full rankings (permutations). full=FALSE is the default option.
itermax	maximum number of iterations for FAST and DECOR algorithms. itermax=10 is the default option.
np	For DECOR algorithm only: the number of population individuals. np=15 is the default option.
gl	For DECOR algorithm only: generations limit, maximum number of consecutive generations without improvement. gl=100 is the default option.
ff	For DECOR algorithm only: the scaling rate for mutation. Must be in [0,1]. ff=0.4 is the default option.
cr	For DECOR algorithm only: the crossover range. Must be in [0,1]. cr=0.9 is the default option.
proc	For BB algorithm only: proc=TRUE allows the branch and bound algorithm to work in difficult cases, i.e. when the number of objects is larger than 15 or 25. proc=FALSE is the default option

### Details

The BB algorithm can take long time to find the solutions if the number objects to be ranked is large with some missing (>15-20 if full=FALSE, <25-30 if full=TRUE). quick algorithm works with a large number of items to be ranked. The solution is quite accurate. fast algorithm works with a large number of items to be ranked by repeating several times the quick algorithm with different random starting points. decor algorithm works with a very large number of items to be ranked. For decor algorithm, empirical evidence shows that the number of population individuals (the 'np' parameter) can be set equal to 10, 20 or 30 for problems till 20, 50 and 100 items. Both scaling rate and crossover ratio (parameters 'ff' and 'cr') must be set by the user. The default options (ff=0.4, cr=0.9) work well for a large variety of data sets All algorithms allow the user to set the option 'full=TRUE' if the median ranking(s) must be searched in the restricted space of permutations instead of in the unconstrained universe of rankings of n items including all possible ties

### Value

a "list" containing the following components:

Consensus      the Consensus Ranking

Tau	averaged TauX rank correlation coefficient
Eltime	Elapsed time in seconds

#'

**Author(s)**

Antonio D'Ambrosio &lt;antdambr@unina.it&gt;

**References**

Emond, E. J., and Mason, D. W. (2002). A new rank correlation coefficient with application to the consensus ranking problem. *Journal of Multi-Criteria Decision Analysis*, 11(1), 17-28.

D'Ambrosio, A., Amodio, S., and Iorio, C. (2015). Two algorithms for finding optimal solutions of the Kemeny rank aggregation problem for full rankings. *Electronic Journal of Applied Statistical Analysis*, 8(2), 198-213.

Amodio, S., D'Ambrosio, A. and Siciliano, R. (2016). Accurate algorithms for identifying the median ranking when dealing with weak and partial rankings under the Kemeny axiomatic approach. *European Journal of Operational Research*, 249(2), 667-676.

D'Ambrosio, A., Mazzeo, G., Iorio, C., and Siciliano, R. (2017). A differential evolution algorithm for finding the median ranking under the Kemeny axiomatic approach. *Computers and Operations Research*, vol. 82, pp. 126-138.

**See Also**[iwquickcons](#)**Examples**

```
data(Idea)
RevIdea<-6-Idea
# as 5 means "most associated", it is necessary compute the reverse ranking of
# each rankings to have rank 1 = "most associated" and rank 5 = "least associated"
CR<-consrank(RevIdea)
CR<-consrank(RevIdea,algorithm="quick")
#CR<-consrank(RevIdea,algorithm="fast",itermax=10)
#not run
#data(EMD)
#CRemd<-consrank(EMD[,1:15],wk=EMD[,16],algorithm="decor",itermax=1)
#data(APAFULL)
#CRapa<-consrank(APAFULL,full=TRUE)
```

---

ConsRank-deprecated      *Deprecated functions in ConsRank*

---

## Description

These functions still work but will be removed (defunct) in the next version.

## Details

- [EMCons](#);
- [QuickCons](#);
- [BBFULL](#);
- [FASTcons](#);
- [DECOR](#);
- [FASTDECOR](#);
- [labels](#);

All these functions are deprecated, and will be removed in the next release of this package. The functions still remain in the package for compatibility of ConsRank users

## See Also

[consrank](#)  
[rank2order](#)

---

DECOR      *Differential Evolution algorithm for Median Ranking*

---

## Description

Differential evolution algorithm for median ranking detection. It works with full, tied and partial rankings. The solution can be constrained to be a full ranking or a tied ranking

## Usage

```
DECOR(X, Wk = NULL, NP = 15, L = 100, FF = 0.4, CR = 0.9, FULL = FALSE)
```

**Arguments**

X	A N by M data matrix, in which there are N judges and M objects to be judged. Each row is a ranking of the objects which are represented by the columns. Alternatively X can contain the rankings observed only once. In this case the argument Wk must be used
Wk	Optional: the frequency of each ranking in the data
NP	The number of population individuals
L	Generations limit: maximum number of consecutive generations without improvement
FF	The scaling rate for mutation. Must be in [0,1]
CR	The crossover range. Must be in [0,1]
FULL	Default FULL=FALSE. If FULL=TRUE, the searching is limited to the space of full rankings.

**Details**

This function is deprecated and it will be removed in the next release of the package. Use function 'consrank' instead.

**Value**

a "list" containing the following components:

Consensus	the Consensus Ranking
Tau	averaged TauX rank correlation coefficient
Eltime	Elapsed time in seconds

**Author(s)**

Antonio D'Ambrosio <antdambr@unina.it> and Giulio Mazzeo <giuliomazzeo@gmail.com>

**References**

D'Ambrosio, A., Mazzeo, G., Iorio, C., and Siciliano, R. (2017). A differential evolution algorithm for finding the median ranking under the Kemeny axiomatic approach. *Computers and Operations Research*, vol. 82, pp. 126-138.

**See Also**

[consrank](#)

**Examples**

```
#not run
#data(EMD)
#CR=DECOR(EMD[, 1:15], EMD[, 16])
```

---

EMCons	<i>Branch-and-bound algorithm to find consensus (median) ranking according to the Kemeny's axiomatic approach</i>
--------	---

---

**Description**

Branch-and-bound algorithm to find consensus ranking as defined by Emond and Mason (2002). If the number of objects to be ranked is large (greater than 15 or 20, specially if there are missing rankings), it can work for very long time.

**Usage**

```
EMCons(X, Wk = NULL, PS = TRUE)
```

**Arguments**

X	A N by M data matrix, in which there are N judges and M objects to be judged. Each row is a ranking of the objects which are represented by the columns. Alternatively X can contain the rankings observed only once. In this case the argument Wk must be used
Wk	Optional: the frequency of each ranking in the data
PS	If PS=TRUE, on the screen some information about how many branches are processed are displayed

**Details**

This function is deprecated and it will be removed in the next release of the package. Use function 'consrank' instead.

**Value**

a "list" containing the following components:

Consensus	the Consensus Ranking
Tau	averaged TauX rank correlation coefficient
Eltime	Elapsed time in seconds

**Author(s)**

Antonio D'Ambrosio <antdambr@unina.it>

**References**

Emond, E. J., and Mason, D. W. (2002). A new rank correlation coefficient with application to the consensus ranking problem. *Journal of Multi-Criteria Decision Analysis*, 11(1), 17-28.

**See Also**[consrank](#)**Examples**

```
data(Idea)
RevIdea=6-Idea
# as 5 means "most associated", it is necessary compute the reverse ranking of
# each rankings to have rank 1 = "most associated" and rank 5 = "least associated"
CR=EMCons(RevIdea)
```

---

EMD

*Emond and Mason data*

---

**Description**

Data simulated by Emond and Mason to check their branch-and-bound algorithm. There are 112 voters ranking 15 objects. There are 21 incomplete rankings. Data are in form of frequency table.

**Usage**

```
data(EMD)
```

**Source**

Emond, E. J., & Mason, D. W. (2000). A new technique for high level decision support. Department of National Defence, Operational Research Division, pag. 28.

**References**

Emond, E. J., & Mason, D. W. (2000). A new technique for high level decision support. Department of National Defence, Operational Research Division, pag. 28.

**Examples**

```
data(EMD)
CR=consrank(EMD[,1:15],EMD[,16],algorithm="quick")
```

---

FASTcons	<i>FAST algorithm to find consensus (median) ranking. FAST algorithm to find consensus (median) ranking defined by Amodio, D'Ambrosio and Siciliano (2016). It returns at least one of the solutions. If there are multiple solutions, sometimes it returns all the solutions, sometimes it returns some solutions, always it returns at least one solution.</i>
----------	--

---

### Description

FAST algorithm to find consensus (median) ranking.

FAST algorithm to find consensus (median) ranking defined by Amodio, D'Ambrosio and Siciliano (2016). It returns at least one of the solutions. If there are multiple solutions, sometimes it returns all the solutions, sometimes it returns some solutions, always it returns at least one solution.

### Usage

```
FASTcons(X, Wk = NULL, maxiter = 50, FULL = FALSE, PS = FALSE)
```

### Arguments

X	is a ranking data matrix
Wk	is a vector of weights
maxiter	maximum number of iterations: default = 50.
FULL	Default FULL=FALSE. If FULL=TRUE, the searching is limited to the space of full rankings.
PS	Default PS=FALSE. If PS=TRUE the number of current iteration is displayed

### Details

This function is deprecated and it will be removed in the next release of the package. Use function 'consrank' instead.

### Value

a "list" containing the following components:

Consensus	the Consensus Ranking
Tau	averaged TauX rank correlation coefficient
Eltime	Elapsed time in seconds

### Author(s)

Antonio D'Ambrosio <antdambr@unina.it> and Sonia Amodio <sonia.amodio@unina.it>

## References

Amodio, S., D'Ambrosio, A. and Siciliano, R. (2016). Accurate algorithms for identifying the median ranking when dealing with weak and partial rankings under the Kemeny axiomatic approach. *European Journal of Operational Research*, 249(2), 667-676.

## See Also

[EMCons](#) Emond and Mason branch-and-bound algorithm.

[QuickCons](#) Quick algorithm.

## Examples

```
##data(EMD)
##X=EMD[,1:15]
##Wk=matrix(EMD[,16],nrow=nrow(X))
##CR=FASTcons(X,Wk,maxiter=100)
##These lines produce all the three solutions in less than a minute.

data(sports)
CR=FASTcons(sports,maxiter=5)
```

---

FASTDECOR

*FAST algorithm calling DECOR*

---

## Description

FAST algorithm repeats DECOR a prespecified number of time. It returns the best solutions among the iterations

## Usage

```
FASTDECOR(
  X,
  Wk = NULL,
  maxiter = 10,
  NP = 15,
  L = 100,
  FF = 0.4,
  CR = 0.9,
  FULL = FALSE,
  PS = TRUE
)
```



**Arguments**

X	A N by M data matrix, in which there are N judges and M objects to be judged. Each row is a ranking of the objects which are represented by the columns. Alternatively X can contain the rankings observed only once. In this case the argument Wk must be used
Wk	Optional: the frequency of each ranking in the data
maxiter	maximum number of iterations. Default 10
NP	The number of population individuals
L	Generations limit: maximum number of consecutive generations without improvement
FF	The scaling rate for mutation. Must be in [0,1]
CR	The crossover range. Must be in [0,1]
FULL	Default FULL=FALSE. If FULL=TRUE, the searching is limited to the space of full rankings. In this case, the data matrix must contain full rankings.
PS	Default PS=TRUE. If PS=TRUE the number of a multiple of 5 iterations is displayed

**Details**

This function is deprecated and it will be removed in the next release of the package. Use function 'consrank' instead.

**Value**

a "list" containing the following components:

Consensus	the Consensus Ranking
Tau	averaged TauX rank correlation coefficient
Eltime	Elapsed time in seconds

**Author(s)**

Antonio D'Ambrosio <antdambr@unina.it> and Giulio Mazzeo <giuliomazzeo@gmail.com>

**References**

D'Ambrosio, A., Mazzeo, G., Iorio, C., and Siciliano, R. (2017). A differential evolution algorithm for finding the median ranking under the Kemeny axiomatic approach. Computers and Operations Research, vol. 82, pp. 126-138.

**See Also**

[consrank](#)

**Examples**

```
#data(EMD)
#CR=FASTDECOR(EMD[, 1:15],EMD[, 16])
```

---

German *German political goals*

---

### Description

Ranking data of 2262 German respondents about the desirability of the four political goals: a = the maintenance of order in the nation; b = giving people more say in the decisions of government; c = growing rising prices; d = protecting freedom of speech

### Usage

```
data(German)
```

### Source

Croon, M. A. (1989). Latent class models for the analysis of rankings. *Advances in psychology*, 60, 99-121.

### Examples

```
data(German)
TR=tabulaterows(German)
polypplot(TR$X,Wk=TR$Wk,nobj=4)
```

---

Idea *Idea data set*

---

### Description

98 college students were asked to rank five words, (thought, play, theory, dream, attention) regarding its association with the word idea, from 5=most associated to 1=least associated.

### Usage

```
data(Idea)
```

### Source

Fligner, M. A., & Verducci, J. S. (1986). Distance based ranking models. *Journal of the Royal Statistical Society. Series B (Methodological)*, 359-369.

### Examples

```
data(Idea)
revIdea=6-Idea
TR=tabulaterows(revIdea)
CR=consrank(TR$X,wk=TR$Wk,algorithm="quick")
colnames(CR$Consensus)=colnames(Idea)
```

---

`iwcombinmatr`*Item-weighted Combined input matrix of a data set*

---

**Description**

Compute the item-weighted Combined input matrix of a data set as defined by Albano and Plaia (2021)

**Usage**

```
iwcombinmatr(X, w, Wk = NULL)
```

**Arguments**

<code>X</code>	A data matrix N by M, in which there are N judges and M objects to be judged. Each row is a ranking of the objects which are represented by the columns. Alternatively X can contain the rankings observed only once. In this case the argument Wk must be used
<code>w</code>	A M-dimensional row vector (individually weighted items), or a M by M matrix (item similarities)
<code>Wk</code>	Optional: the frequency of each ranking in the data

**Value**

The M by M item-weighted combined input matrix

**Author(s)**

Alessandro Albano <alessandro.albano@unipa.it>  
Antonella Plaia <antonella.plaia@unipa.it>

**References**

Emond, E. J., and Mason, D. W. (2002). A new rank correlation coefficient with application to the consensus ranking problem. *Journal of Multi-Criteria Decision Analysis*, 11(1), 17-28.  
Albano, A. and Plaia, A. (2021). Element weighted Kemeny distance for ranking data. *Electronic Journal of Applied Statistical Analysis*, doi: 10.1285/i20705948v14n1p117

**See Also**

[tabulaterows](#) frequency distribution of a ranking data.  
[combinmatr](#) combined input matrix of a ranking data set.

**Examples**

```

data(sports)
np <- dim(sports)[2]
P <- matrix(NA,nrow=np,ncol=np)
P[1,] <- c(0,5,5,10,10,10,10)
P[2,] <- c(5,0,5,10,10,10,10)
P[3,] <- c(5,5,0,10,10,10,10)
P[4,] <- c(10,10,10,0,5,5,5)
P[5,] <- c(10,10,10,5,0,5,5)
P[6,] <- c(10,10,10,5,5,0,5)
P[7,] <- c(10,10,10,5,5,5,0)
CIW <- iwcombinpmatr(sports,w=P)

```

---

iwquickcons

*The item-weighted Quick algorithm to find up to 4 solutions to the consensus ranking problem*

---

**Description**

The item-weighted Quick algorithm finds up to 4 solutions. Solutions reached are most of the time optimal solutions.

**Usage**

```
iwquickcons(X, w, Wk = NULL, full = FALSE, PS = FALSE)
```

**Arguments**

X	A N by M data matrix in which there are N judges and M objects to be judged. Each row is a ranking of the objects which are represented by the columns. Alternatively X can contain the rankings observed only once in the sample. In this case the argument Wk must be used
w	A M-dimensional row vector (individually weighted items), or a M by M matrix (item similarities)
Wk	Optional: the frequency of each ranking in the data
full	Default full=FALSE. If full=TRUE, the searching is limited to the space of full rankings.
PS	Default PS=FALSE. If PS=TRUE the number of evaluated branches is displayed

**Details**

The item-weighted Quick algorithm finds up the consensus (median) ranking according to the Kemeny's axiomatic approach. The median ranking(s) can be restricted to be necessarily a full ranking, namely without ties.

**Value**

a "list" containing the following components:

Consensus	the Consensus Ranking
Tau	averaged item-weighted TauX rank correlation coefficient
Eltime	Elapsed time in seconds

**Author(s)**

Alessandro Albano <alessandro.albano@unipa.it>

Antonella Plaia <antonella.plaia@unipa.it>

**References**

Amodio, S., D'Ambrosio, A. and Siciliano, R. (2016). Accurate algorithms for identifying the median ranking when dealing with weak and partial rankings under the Kemeny axiomatic approach. *European Journal of Operational Research*, 249(2), 667-676.

Albano, A. and Plaia, A. (2021). Element weighted Kemeny distance for ranking data. *Electronic Journal of Applied Statistical Analysis*, doi: 10.1285/i20705948v14n1p117

**See Also**

[consrnk](#)

**Examples**

```
#Individually weighted items
data("German")
w=c(10,5,5,10)
iwquickcons(X= German,w= w)
```

```
#Item similirity weights
data(sports)
dim(sports)
P=matrix(NA,nrow=7,ncol=7)
P[1,]=c(0,5,5,10,10,10,10)
P[2,]=c(5,0,5,10,10,10,10)
P[3,]=c(5,5,0,10,10,10,10)
P[4,]=c(10,10,10,0,5,5,5)
P[5,]=c(10,10,10,5,0,5,5)
P[6,]=c(10,10,10,5,5,0,5)
P[7,]=c(10,10,10,5,5,5,0)
iwquickcons(X= sports, w= P)
```

---

`iw_kemenyd`*Item-weighted Kemeny distance*

---

**Description**

Compute the item-weighted Kemeny distance of a data matrix containing preference rankings, or compute the kemeny distance between two (matrices containing) rankings.

**Usage**

```
iw_kemenyd(x, y = NULL, w)
```

**Arguments**

<code>x</code>	A N by M data matrix, in which there are N judges and M objects to be judged. Each row is a ranking of the objects which are represented by the columns. If there is only x as input, the output is a square distance matrix
<code>y</code>	A row vector, or a N by M data matrix in which there are N judges and the same M objects as x to be judged.
<code>w</code>	A M-dimensional row vector (individually weighted items), or a M by M matrix (item similarities)

**Value**

If there is only x as input, d = square distance matrix. If there is also y as input, d = matrix with N rows and n columns.

**Author(s)**

Alessandro Albano <alessandro.albano@unipa.it>  
Antonella Plaia <antonella.plaia@unipa.it>

**References**

Kemeny, J. G., & Snell, L. J. (1962). Preference ranking: an axiomatic approach. *Mathematical models in the social sciences*, 9-23.  
Albano, A. and Plaia, A. (2021) Element weighted Kemeny distance for ranking data. *Electronic Journal of Applied Statistical Analysis*, doi: 10.1285/i20705948v14n1p117

**See Also**

[iw\\_tau\\_x](#) item-weighted tau\_x rank correlation coefficient  
[kemenyd](#) Kemeny distance

**Examples**

```
#Individually weighted items
data("German")
w=c(10,5,5,10)
iw_kemenyd(x= German[c(1,200,300,500)],,w= w)
iw_kemenyd(x= German[,],y=German[,400],,w= w)

#Item similarity weights
data(sports)
P=matrix(NA,nrow=7,ncol=7)
P[,1]=c(0,5,5,10,10,10,10)
P[,2]=c(5,0,5,10,10,10,10)
P[,3]=c(5,5,0,10,10,10,10)
P[,4]=c(10,10,10,0,5,5,5)
P[,5]=c(10,10,10,5,0,5,5)
P[,6]=c(10,10,10,5,5,0,5)
P[,7]=c(10,10,10,5,5,5,0)
iw_kemenyd(x=sports[c(1,3,5,7)],, w= P)
iw_kemenyd(x=sports[,1],y=sports[,100],, w= P)
```

iw\_tau\_x

*Item-weighted TauX rank correlation coefficient***Description**

Compute the item-weighted TauX rank correlation coefficient of a data matrix containing preference rankings, or compute the item-weighted correlation coefficient between two (matrices containing) rankings.

**Usage**

```
iw_tau_x(x, y = NULL, w)
```

**Arguments**

x	A N by M data matrix, in which there are N judges and M objects to be judged. Each row is a ranking of the objects which are represented by the columns. If there is only x as input, the output is a square matrix
y	A row vector, or a N by M data matrix in which there are N judges and the same M objects as x to be judged.
w	A M-dimensional row vector (individually weighted items), or a M by M matrix (item similarities)

**Value**

Item-weighted TauX rank correlation coefficient

**Author(s)**

Alessandro Albano <alessandro.albano@unipa.it>  
 Antonella Plaia <antonella.plaia@unipa.it>

**References**

Emond, E. J., and Mason, D. W. (2002). A new rank correlation coefficient with application to the consensus ranking problem. *Journal of Multi-Criteria Decision Analysis*, 11(1), 17-28.  
 Albano, A. and Plaia, A. (2021) Element weighted Kemeny distance for ranking data. *Electronic Journal of Applied Statistical Analysis*, doi: 10.1285/i20705948v14n1p117

**See Also**

[tau\\_x](#) TauX rank correlation coefficient  
[iw\\_kemenyd](#) item-weighted Kemeny distance

**Examples**

```
#Individually weighted items
data("German")
w=c(10,5,5,10)
iw_tau_x(x= German[c(1,200,300,500)],w= w)
iw_tau_x(x= German[1,],y=German[400,],w= w)

#Item similarity weights
data(sports)
P=matrix(NA,nrow=7,ncol=7)
P[1,]=c(0,5,5,10,10,10,10)
P[2,]=c(5,0,5,10,10,10,10)
P[3,]=c(5,5,0,10,10,10,10)
P[4,]=c(10,10,10,0,5,5,5)
P[5,]=c(10,10,10,5,0,5,5)
P[6,]=c(10,10,10,5,5,0,5)
P[7,]=c(10,10,10,5,5,5,0)
iw_tau_x(x=sports[c(1,3,5,7)], w= P)
iw_tau_x(x=sports[1,],y=sports[100,], w= P)
```

---

kemenyd

*Kemeny distance*


---

**Description**

Compute the Kemeny distance of a data matrix containing preference rankings, or compute the kemeny distance between two (matrices containing) rankings.

**Usage**

```
kemenyd(X, Y = NULL)
```



**Arguments**

X	A N by M data matrix, in which there are N judges and M objects to be judged. Each row is a ranking of the objects which are represented by the columns. If there is only X as input, the output is a square distance matrix
Y	A row vector, or a n by M data matrix in which there are n judges and the same M objects as X to be judged.

**Value**

If there is only X as input, d = square distance matrix. If there is also Y as input, d = matrix with N rows and n columns.

**Author(s)**

Antonio D'Ambrosio <antdambr@unina.it>

**References**

Kemeny, J. G., & Snell, L. J. (1962). Preference ranking: an axiomatic approach. *Mathematical models in the social sciences*, 9-23.

**See Also**

[tau\\_x](#) TauX rank correlation coefficient

[iw\\_kemenyd](#) item-weighted Kemeny distance

**Examples**

```
data(Idea)
RevIdea<-6-Idea ##as 5 means "most associated", it is necessary compute the reverse
#ranking of each rankings to have rank 1 = "most associated" and rank 5 = "least associated"
KD<-kemenyd(RevIdea)
KD2<-kemenyd(RevIdea[1:10,],RevIdea[55,])
```

---

kemenydesign

*Auxiliary function*

---

**Description**

Define a design matrix to compute Kemeny distance

**Usage**

```
kemenydesign(X)
```

**Arguments**

X                    A N by M data matrix, in which there are N judges and M objects to be judged. Each row is a ranking of the objects represented by the columns.

**Value**

Design matrix

**Author(s)**

Antonio D'Ambrosio <antdambr@unina.it>

**References**

D'Ambrosio, A. (2008). Tree based methods for data editing and preference rankings. Unpublished PhD Thesis. Universita' degli Studi di Napoli Federico II.

---

kemenyscore

*Score matrix according Kemeny (1962)*

---

**Description**

Given a ranking, it computes the score matrix as defined by Emond and Mason (2002)

**Usage**

kemenyscore(X)

**Arguments**

X                    a ranking (must be a row vector or, better, a matrix with one row and M columns)

**Value**

the M by M score matrix

**Author(s)**

Antonio D'Ambrosio <antdambr@unina.it>

**References**

Kemeny, J and Snell, L. (1962). Mathematical models in the social sciences.

**See Also**

[scorematrix](#) The score matrix as defined by Emond and Mason (2002)

**Examples**

```
Y <- matrix(c(1,3,5,4,2),1,5)
SM<-kemenyscore(Y)
#
Z<-c(1,2,3,2)
SM2<-kemenyscore(Z)
```

---

labels	<i>Transform a ranking into a ordering.</i>
--------	---

---

**Description**

Given a ranking (or a matrix of rank data), transforms it into an ordering (or a ordering matrix)

**Usage**

```
labels(x, m, label = 1:m, labs)
```

**Arguments**

x	a ranking, or a n by m data matrix in which there are n judges ranking m objects
m	the number of objects
label	optional: the name of the objects
labs	labs = 1 displays the names of the objects if there is argument "label", otherwise displays the permutation of first m integer. labs = 2 is to be used only if the argument "label" is not defined. In such a case it displays the permutation of the first m letters

**Details**

This function is deprecated and it will be removed in the next release of the package. Use function 'rank2order' instead.

**Value**

the ordering

**Author(s)**

Sonia Amodio <sonia.amodio@unina.it>

**See Also**

[rank2order](#)

**Examples**

```

data(Idea)
TR=tabulaterows(Idea)
Ord=labels(TR$X,ncol(Idea),colnames(Idea),labs=1)
Ord2=labels(TR$X,ncol(Idea),labs=2)
cbind(Ord,TR$Wk)
cbind(Ord2,TR$Wk)

```

---

order2rank

*Given an ordering, it is transformed to a ranking*


---

**Description**

From ordering to rank. **IMPORTANT:** check which symbol denotes tied rankings in the X matrix

**Usage**

```
order2rank(X, TO = "{", TC = "}")
```

**Arguments**

X	A ordering or a matrix containing orderings
TO	symbol indicating the start of a set of items ranked in a tie
TC	symbol indicating the end of a set of items ranked in a tie

**Value**

a ranking or a matrix of rankings:

R      ranking or matrix of rankings

**Author(s)**

Antonio D'Ambrosio <antdambr@unina.it>

**Examples**

```

data(APAred)
ord=rank2order(APAred) #transform rankings into orderings
ran=order2rank(ord) #transform the orderings into rankings

```

---

partitions	<i>Generate partitions of n items constrained into k non empty subsets</i>
------------	--

---

### Description

Generate all possible partitions of n items constrained into k non empty subsets. It does not generate the universe of rankings constrained into k buckets.

### Usage

```
partitions(n, k = NULL, items = NULL, itemtype = "L")
```

### Arguments

n	a (integer) number denoting the number of items
k	The number of the non-empty subsets. Default value is NULL, in this case all the possible partitions are displayed
items	items: the items to be placed into the ordering matrix. Default are the first c small letters
itemtype	to be used only if items is not set. The default value is "L", namely letters. Any other symbol produces items as the first c integers

### Details

If the objects to be ranked is large (>15-20) with some missing, it can take long time to find the solutions. If the searching space is limited to the space of full rankings (also incomplete rankings, but without ties), use the function BBFULL or the functions FASTcons and QuickCons with the option FULL=TRUE.

### Value

the ordering matrix (or vector)

### Author(s)

Antonio D'Ambrosio <antdambr@unina.it>

### See Also

[stirling2](#) Stirling number of second kind.

[rank2order](#) Convert rankings into orderings.

[order2rank](#) Convert orderings into ranks.

[univranks](#) Generate the universe of rankings given the input partition

**Examples**

```
X<-partitions(4,3)
#shows all the ways to partition 4 items (say "a", "b", "c" and "d" into 3 non-empty subsets
#(i.e., into 3 buckets). The Stirling number of the second kind (4,3) indicates that there
#are 6 ways.
s2<-stirling2(4,3)$S
X2<-order2rank(X) #it transform the ordering into ranking
```

---

polyplot

*Plot rankings on a permutation polytope of 3 or 4 objects containing all possible ties*

---

**Description**

Plot rankings a permutation polytope that is the geometrical space of preference rankings. The plot is available for 3 or for 4 objects

**Usage**

```
polyplot(X = NULL, L = NULL, Wk = NULL, nobj = 3)
```

**Arguments**

X	the sample of rankings. Most of the time it is returned by tabulaterows
L	labels of the objects
Wk	frequency associated to each ranking
nobj	number of objects. It must be either 3 or 4

**Details**

polyplot() plots the universe of 3 objects. polyplot(nobj=4) plots the universe of 4 objects.

**Value**

the permutation polytope

**Author(s)**

Antonio D'Ambrosio <antdambr@unina.it> and Sonia Amodio <sonia.amodio@unina.it>

**References**

Thompson, G. L. (1993). Generalized permutation polytopes and exploratory graphical methods for ranked data. *The Annals of Statistics*, 1401-1430. # Heiser, W. J., and D'Ambrosio, A. (2013). Clustering and prediction of rankings within a Kemeny distance framework. In *Algorithms from and for Nature and Life* (pp. 19-31). Springer International Publishing.

**See Also**

[tabulaterows](#) frequency distribution for ranking data.

**Examples**

```
polyplot()
#polyplot(nobj=4)
data(BU)
polyplot(BU[,1:3],Wk=BU[,4])
```

---

QuickCons

*Quick algorithm to find up to 4 solutions to the consensus ranking problem*

---

**Description**

The Quick algorithm finds up to 4 solutions. Solutions reached are most of the time optimal solutions.

**Usage**

```
QuickCons(X, Wk = NULL, FULL = FALSE, PS = FALSE)
```

**Arguments**

X	A N by M data matrix in which there are N judges and M objects to be judged. Each row is a ranking of the objects which are represented by the columns. Alternatively X can contain the rankings observed only once in the sample. In this case the argument Wk must be used
Wk	Optional: the frequency of each ranking in the data
FULL	Default FULL=FALSE. If FULL=TRUE, the searching is limited to the space of full rankings.
PS	Default PS=FALSE. If PS=TRUE the number of evaluated branches is displayed

**Details**

This function is deprecated and it will be removed in the next release of the package. Use function 'consrank' instead.

**Value**

a "list" containing the following components:

Consensus	the Consensus Ranking
Tau	averaged TauX rank correlation coefficient
Eltime	Elapsed time in seconds

**Author(s)**

Antonio D'Ambrosio <antdambr@unina.it>

**References**

Amodio, S., D'Ambrosio, A. and Siciliano, R. (2016). Accurate algorithms for identifying the median ranking when dealing with weak and partial rankings under the Kemeny axiomatic approach. *European Journal of Operational Research*, 249(2), 667-676.

**See Also**

[consrank](#)

**Examples**

```
data(EMD)
CR=QuickCons(EMD[,1:15],EMD[,16])
```

---

rank2order

*Given a rank, it is transformed to a ordering*

---

**Description**

From ranking to ordering. IMPORTANT: check which symbol denotes tied rankings in the X matrix

**Usage**

```
rank2order(X, items = NULL, TO = "{", TC = "}", itemtype = "L")
```

**Arguments**

X	A ordering or a matrix containing orderings
items	items to be placed into the ordering matrix. Default are the
TO	symbol indicating the start of a set of items ranked in a tie
TC	symbol indicating the end of a set of items ranked in a tie
itemtype	to be used only if items=NULL. The default value is "L", namely



**Value**

a ordering or a matrix of orderings:

out      ranking or matrix of rankings

**Author(s)**

Antonio D'Ambrosio <antdambr@unina.it>

**Examples**

```
data(APAred)
ord<-rank2order(APAred)
```

---

reordering

*Given a vector (or a matrix), returns an ordered vector (or a matrix with ordered vectors)*

---

**Description**

Given a ranking of M objects (or a matrix with M columns), it reduces it in "natural" form (i.e., with integers from 1 to M)

**Usage**

```
reordering(X)
```

**Arguments**

X              a ranking, or a ranking data matrix

**Value**

a ranking in natural form

**Author(s)**

Antonio D'Ambrosio <antdambr@unina.it>

---

`scorematrix`*Score matrix according Emond and Mason (2002)*

---

**Description**

Given a ranking, it computes the score matrix as defined by Emond and Mason (2002)

**Usage**

```
scorematrix(X)
```

**Arguments**

`X` a ranking (must be a row vector or, better, a matrix with one row and M columns)

**Value**

the M by M score matrix

**Author(s)**

Antonio D'Ambrosio <antdambr@unina.it>

**References**

Emond, E. J., and Mason, D. W. (2002). A new rank correlation coefficient with application to the consensus ranking problem. *Journal of Multi-Criteria Decision Analysis*, 11(1), 17-28.

**See Also**

[combinpmat](#) The combined input matrix

**Examples**

```
Y <- matrix(c(1,3,5,4,2),1,5)
SM<-scorematrix(Y)
#
Z<-c(1,2,4,3)
SM2<-scorematrix(Z)
```

---

sports	<i>sports data</i>
--------	--------------------

---

**Description**

130 students at the University of Illinois ranked seven sports according to their preference (Baseball, Football, Basketball, Tennis, Cycling, Swimming, Jogging).

**Usage**

```
data(sports)
```

**Source**

Marden, J. I. (1996). Analyzing and modeling rank data. CRC Press.

**Examples**

```
data(sports)
```

---

stirling2	<i>Stirling numbers of the second kind</i>
-----------	--

---

**Description**

Denote the number of ways to partition a set of  $n$  objects into  $k$  non-empty subsets

**Usage**

```
stirling2(n, k)
```

**Arguments**

$n$	(integer): the number of the objects
$k$	(integer $\leq n$ ): the number of the non-empty subsets (buckets)

**Value**

a "list" containing the following components:

S	the stirling number of the second kind
SM	a matrix showing, for each $k$ (on the columns) in how many ways the $n$ objects (on the rows) can be partitioned

**Author(s)**

Antonio D'Ambrosio <antdambr@unina.it>

**References**

Comtet, L. (1974). *Advanced Combinatorics: The art of finite and infinite expansions*. D. Reidel, Dordrecht, The Netherlands.

**Examples**

```
parts<-stirling2(4,2)
```

---

tabulaterows	<i>Frequency distribution of a sample of rankings</i>
--------------	---

---

**Description**

Given a sample of preference rankings, it compute the frequency associated to each ranking

**Usage**

```
tabulaterows(X, miss = FALSE)
```

**Arguments**

X	a N by M data matrix containing N judges judging M objects
miss	TRUE if there are missing data (either partial or incomplete rankings): default: FALSE

**Value**

a "list" containing the following components:

X	the unique rankings
Wk	the frequency associated to each ranking
tabfreq	frequency table

**Author(s)**

Antonio D'Ambrosio <antdambr@unina.it>

**Examples**

```
data(Idea)
TR<-tabulaterows(Idea)
FR<-TR$Wk/sum(TR$Wk)
RF<-cbind(TR$X,FR)
colnames(RF)<-c(colnames(Idea),"fi")
#compute modal ranking
maxfreq<-which(RF[,6]==max(RF[,6]))
rank2order(RF[maxfreq,1:5],items=colnames(Idea))
```

```

#
data(APAred)
TR<-tabulaterows(APAred)
#
data(APAFULL)
TR<-tabulaterows(APAFULL)
CR1<-consrnk(TR$X,wk=TR$Wk)
CR2<-consrnk(TR$X,wk=TR$Wk,algorithm="fast",itermax=15)
CR3<-consrnk(TR$X,wk=TR$Wk,algorithm="quick")

```

tau\_x

*TauX (tau extension) rank correlation coefficient***Description**

Tau extension is a new rank correlation coefficient defined by Emond and Mason (2002)

**Usage**

```
tau_x(X, Y = NULL)
```

```
Tau_X(X, Y = NULL)
```

**Arguments**

**X** a M by N data matrix, in which there are N judges and M objects to be judged. Each row is a ranking of the objects which are represented by the columns. If there is only X as input, the output is a square matrix containing the Tau\_X rcc.

**Y** A row vector, or a n by M data matrix in which there are n judges and the same M objects as X to be judged.

**Value**

Tau\_x rank correlation coefficient

**Author(s)**

Antonio D'Ambrosio <antdambr@unina.it>

**References**

Emond, E. J., and Mason, D. W. (2002). A new rank correlation coefficient with application to the consensus ranking problem. *Journal of Multi-Criteria Decision Analysis*, 11(1), 17-28.

**See Also**

[kemeny](#) Kemeny distance

[iw\\_tau\\_x](#) item-weighted tau\_x rank correlation coefficient

**Examples**

```

data(BU)
RD<-BU[,1:3]
Tau<-tau_x(RD)
Tau1_3<-tau_x(RD[1,],RD[3,])

```

---

univranks	<i>Generate the universe of rankings</i>
-----------	--

---

**Description**

Generate the universe of rankings given the input partition

**Usage**

```
univranks(X, k = NULL, ordering = TRUE)
```

**Arguments**

X	A ranking, an ordering, a matrix of rankings, a matrix of orderings or a number
k	Optional: the number of the non-empty subsets. It has to be used only if X is a number. The default value is NULL, In this case the universe of rankings with n=X items are computed
ordering	The universe of rankings must be returned as orderings (default) or rankings?

**Details**

The function should be used with small numbers because it can generate a large number of permutations. The use of X greater than 9, of X matrices with more than 9 columns as input is not recommended.

**Value**

a "list" containing the following components:

Runiv	The universe of rankings
Cuniv	A list containing:
R	The universe of rankings in terms of rankings;
Parts	for each ranking in input the produced rankings
Univinbuckets	the universe of rankings within each bucket

**Author(s)**

Antonio D'Ambrosio <antdambr@unina.it>

**See Also**

[stirling2](#) Stirling number of second kind.  
[rank2order](#) Convert rankings into orderings.  
[order2rank](#) Convert orderings into ranks.  
[partitions](#) Generate partitions of n items constrained into k non empty subsets.

**Examples**

```
S2<-stirling2(4,4)$SM[4,] #indicates in how many ways 4 objects
                        #can be placed, respectively, into 1, 2,
                        #3 or 4 non-empty subsets.
CardConstr<-factorial(c(1,2,3,4))*S2 #the cardinality of rankings
                                     #constrained into 1, 2, 3 and 4
                                     #buckets
Card<-sum(CardConstr) #Cardinality of the universe of rankings with 4
                     #objects
U<-univrank(4)$Runiv #the universe of rankings with four objects
                    # we know that the universe counts 75
                    #different rankings
Uk<-univrank(4,2)$Runiv #the universe of rankings of four objects
                       #constrained into k=2 buckets, we know they are 14
Up<-univrank(c(1,4,3,1))$Runiv #the universe of rankings with 4 objects
                              #for which the first and the fourth item
                              #are tied
```

---

 USAranks

*USA rank data*


---

**Description**

Random subset of the rankings collected by O’Leary Morgan and Morgon (2010) on the 50 American States. The 368 number of items (the number of American States) is equal to 50, and the number of rankings is equal to 104. These data concern rankings of the 50 American States on three particular aspects: socio-demographic characteristics, health care expenditures and crime statistics.

**Usage**

```
data(USAranks)
```

**Source**

Amodio, S., D’Ambrosio, A. & Siciliano, R (2015). Accurate algorithms for identifying the median ranking when dealing with weak and partial rankings under the Kemeny axiomatic approach. *European Journal of Operational Research*. DOI: 10.1016/j.ejor.2015.08.048

**References**

O'Leary Morgan, K., Morgon, S., (2010). State Rankings 2010: A Statistical view of America; Crime State Ranking 2010: Crime Across America; Health Care State Rankings 2010: Health Care Across America. CQ Press.

**Examples**

```
data(USAranks)
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