

# Package ‘nFactors’

April 10, 2010

**Type** Package

**Title** Parallel Analysis and Non Graphical Solutions to the Cattell Scree Test

**Version** 2.3.2

**Date** 2010-04-10

**Encoding** latin1

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**Depends** R (>= 2.9.2), MASS, psych, boot, lattice

**Suggests** xtable

**Description** Indices, heuristics and strategies to help determine the number of factors/components to retain: 1. Acceleration factor (af with or without Parallel Analysis); 2. Optimal Coordinates (noc with or without Parallel Analysis); 3. Parallel analysis (components, factors and bootstrap); 4.  $\lambda > \text{mean}(\lambda)$  (Kaiser, CFA and related); 5. Cattell-Nelson-Gorsuch (CNG); 6. Zoski and Jurs multiple regression (b, t and p); 7. Zoski and Jurs standard error of the regression coefficient (sescree); 8. Nelson R2; 9. Bartlett khi-2; 10. Anderson khi-2; 11. Lawley khi-2 and 12. Bentler-Yuan khi-2.

**License** GPL (version 2 or later)

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nFactors-package	<i>Parallel Analysis and Non Graphical Solutions to the Cattell Scree Test</i>
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## Description

Indices, heuristics and strategies to help determine the number of factors/components to retain:

1. - Acceleration factor (*noc* with or without Parallel Analysis)
2. - Optimal Coordinates (*noc* with or without Parallel Analysis)
3. - Parallel analysis (components, factors and bootstrap)
4. -  $\lambda \geq \bar{\lambda}$  (Kaiser, CFA and related rule)
5. - Cattell-Nelson-Gorsuch (*CNG*)
6. - Zoski and Jurs Multiple regression ( $\beta$ ,  $t$  and  $p$ )
7. - Zoski and Jurs standard error of the regression coefficient (sescree,  $S_{Y \bullet X}$ )
8. - Nelson  $R^2$
9. - Bartlett  $\chi^2$
10. - Anderson  $\chi^2$
11. - Lawley  $\chi^2$  and
12. - Bentler-Yuan  $\chi^2$ .

## Details

Package: nFactors  
Type: Package  
Version: 2.3.2  
Date: 2010-04-10  
Depends: R (>= 2.9.2), MASS, psych, boot  
License: GPL

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## References

Raiche, G., Riopel, M. and Blais, J.-G. (2006). *Non graphical solutions for the Cattell's scree test*. Paper presented at the International Annual meeting of the Psychometric Society, Montreal. [<http://www.er.uqam.ca/nobel/r17165/RECHERCHE/COMMUNICATIONS/>]

## See Also

Other packages are also very useful for principal component and factor analysis. The *R* psychometric view is instructive at this point. See <http://cran.stat.sfu.ca/web/views/Psychometrics.html> for further details.

---

bentlerParameters    *Bentler and Yuan's Computation of the LRT Index and the Linear Trend Coefficients*

---

## Description

This function computes the Bentler and Yuan's (1996, 1998) *LRT* index for the linear trend in eigenvalues of a covariance matrix. The related  $\chi^2$  and *p*-value are also computed. This function is generally called from the `nBentler` function. But it could be of use for graphing the linear trend function and to study its behavior.

## Usage

```
bentlerParameters(x, N, nFactors, log=TRUE, cor=TRUE,
  minPar=c(min(lambda) - abs(min(lambda)) + .001,
    0.001),
  maxPar=c(max(lambda),
    lm(lambda~I(length(lambda):1))$coef[2]),
  resParx=c(0.01, 2), resPary=c(0.01, 2),
  graphic=TRUE, resolution=30,
  typePlot="wireframe", ...)
```

## Arguments

x	numeric: a vector of eigenvalues, a matrix of correlations or of covariances or a data.frame of data
N	numeric: number of subjects.
nFactors	numeric: number of components to test.
log	logical: if TRUE the minimization is applied on the log values.
cor	logical: if TRUE computes eigenvalues from a correlation matrix, else from a covariance matrix
minPar	numeric: minimums for the coefficient of the linear trend.
maxPar	numeric: maximums for the coefficient of the linear trend.
resParx	numeric: restriction on the $\alpha$ coefficient (x) to graph the function to minimize.
resPary	numeric: restriction on the $\beta$ coefficient (y) to graph the function to minimize.
graphic	logical: if TRUE plots the minimized function "wireframe", "contourplot" or "levelplot".
resolution	numeric: resolution of the 3D graph (number of points from $\alpha$ and from $\beta$ ).
typePlot	character: plots the minimized function according to a 3D plot: "wireframe", "contourplot" or "levelplot".
...	variable: additionnal parameters from the "wireframe", "contourplot" or "levelplot" lattice functions. Also additionnal parameters for the eigenFrom function.

## Details

The implemented Bentler and Yuan's procedure must be used with care because the minimized function is not always stable. In many cases, constraints must be applied to obtain a solution. The actual implementation did, but the user can modify these constraints.

The hypothesis tested (Bentler and Yuan, 1996, equation 10) is:

$$(1) \quad H_k : \lambda_{k+i} = \alpha + \beta x_i, (i = 1, \dots, q)$$

The solution of the following simultaneous equations is needed to find  $(\alpha, \beta) \in$

$$(2) \quad f(x) = \sum_{i=1}^q \frac{[\lambda_{k+i} - N\alpha + \beta x_i]x_i}{(\alpha + \beta x_i)^2} = 0$$

and 
$$g(x) = \sum_{i=1}^q \frac{\lambda_{k+j} - N\alpha + \beta x_j x_j}{(\alpha + \beta x_j)^2} = 0$$

The solution to this system of equations was implemented by minimizing the following equation:

$$(3) \quad (\alpha, \beta) \in \inf [h(x)] = \inf \log [f(x)^2 + g(x)^2]$$

The likelihood ratio test  $LRT$  proposed by Bentler and Yuan (1996, equation 7) follows a  $\chi^2$  probability distribution with  $q - 2$  degrees of freedom and is equal to:

$$(4) \quad LRT = N(k - p) \left\{ \ln \left( \frac{n}{N} \right) + 1 \right\} - N \sum_{j=k+1}^p \ln \left\{ \frac{\lambda_j}{\alpha + \beta x_j} \right\} + n \sum_{j=k+1}^p \left\{ \frac{\lambda_j}{\alpha + \beta x_j} \right\}$$

With  $p$  beeing the number of eigenvalues,  $k$  the number of eigenvalues to test,  $q$  the  $p - k$  remaining eigenvalues,  $N$  the sample size, and  $n = N - 1$ . Note that there is an error in the Bentler and Yuan equation, the variables  $N$  and  $n$  beeing inverted in the preceeding equation 4.

A better strategy proposed by Bentler an Yuan (1998) is to use a minimized  $\chi^2$  solution. This strategy will be implemented in a future version of the **nFactors** package.

## Value

nFactors	numeric: vector of the number of factors retained by the Bentler and Yuan's procedure.
details	numeric: matrix of the details of the computation.

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## References

- Bentler, P. M. and Yuan, K.-H. (1996). Test of linear trend in eigenvalues of a covariance matrix with application to data analysis. *British Journal of Mathematical and Statistical Psychology*, 49, 299-312.
- Bentler, P. M. and Yuan, K.-H. (1998). Test of linear trend in the smallest eigenvalues of the correlation matrix. *Psychometrika*, 63(2), 131-144.

## See Also

[nBartlett](#), [nBentler](#)

**Examples**

```
## .....
## SIMPLE EXAMPLE OF THE BENTLER AND YUAN PROCEDURE

# Bentler (1996, p. 309) Table 2 - Example 2 .....
n=649
bentler2<-c(5.785, 3.088, 1.505, 0.582, 0.424, 0.386, 0.360, 0.337, 0.303,
           0.281, 0.246, 0.238, 0.200, 0.160, 0.130)

results <- nBentler(x=bentler2, N=n, details=TRUE)
results

# Two different figures to verify the convergence problem identified with
# the 2th component
bentlerParameters(x=bentler2, N=n, nFactors= 2, graphic=TRUE,
                  typePlot="contourplot",
                  resParx=c(0,9), resPary=c(0,9), cor=FALSE)

bentlerParameters(x=bentler2, N=n, nFactors= 4, graphic=TRUE, drape=TRUE,
                  resParx=c(0,9), resPary=c(0,9),
                  scales = list(arrows = FALSE) )

plotuScree(x=bentler2, model="components",
            main=paste(results$nFactors,
                      " factors retained by the Bentler and Yuan's procedure (1996, p. 309)",
                      sep=""))
# .....

# Bentler (1998, p. 140) Table 3 - Example 1 .....
n <- 145
example1 <- c(8.135, 2.096, 1.693, 1.502, 1.025, 0.943, 0.901, 0.816,
             0.790, 0.707, 0.639, 0.543, 0.533, 0.509, 0.478, 0.390,
             0.382, 0.340, 0.334, 0.316, 0.297, 0.268, 0.190, 0.173)

results <- nBentler(x=example1, N=n, details=TRUE)
results

# Two different figures to verify the convergence problem identified with
# the 10th component
bentlerParameters(x=example1, N=n, nFactors= 10, graphic=TRUE,
                  typePlot="contourplot",
                  resParx=c(0,0.4), resPary=c(0,0.4))

bentlerParameters(x=example1, N=n, nFactors= 10, graphic=TRUE, drape=TRUE,
                  resParx=c(0,0.4), resPary=c(0,0.4),
                  scales = list(arrows = FALSE) )

plotuScree(x=example1, model="components",
            main=paste(results$nFactors,
                      " factors retained by the Bentler and Yuan's procedure (1998, p. 140)",
                      sep=""))
# .....
```

---

componentAxis	<i>Principal Component Analysis With Only <math>n</math> First Components Retained</i>
---------------	--

---

## Description

The `componentAxis` function returns a principal component analysis with the first  $n$  components retained.

## Usage

```
componentAxis(R, nFactors=2)
```

## Arguments

<code>R</code>	numeric: correlation or covariance matrix
<code>nFactors</code>	numeric: number of components/factors to retain

## Value

<code>values</code>	numeric: variance of each component/factor retained
<code>varExplained</code>	numeric: variance explained by each component/factor retained
<code>varExplained</code>	numeric: cumulative variance explained by each component/factor retained
<code>loadings</code>	numeric: loadings of each variable on each component/factor retained

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## References

Kim, J.-O. and Mueller, C. W. (1978). *Introduction to factor analysis. What it is and how to do it.* Beverly Hills, CA: Sage.

Kim, J.-O. and Mueller, C. W. (1987). *Factor analysis. Statistical methods and practical issues.* Beverly Hills, CA: Sage.

## See Also

[principalComponents](#), [iterativePrincipalAxis](#), [rRecovery](#)

## Examples

```
# .....
# Example from Kim and Mueller (1978, p. 10)
# Simulated sample: lower diagonal
R <- matrix(c( 1.000, 0.560, 0.480, 0.224, 0.192, 0.16,
               0.560, 1.000, 0.420, 0.196, 0.168, 0.14,
               0.480, 0.420, 1.000, 0.168, 0.144, 0.12,
               0.224, 0.196, 0.168, 1.000, 0.420, 0.35,
               0.192, 0.168, 0.144, 0.420, 1.000, 0.30,
               0.160, 0.140, 0.120, 0.350, 0.300, 1.00),
            nrow=6, byrow=TRUE)

# Factor analysis: Selected principal components - Kim and Mueller
# (1978, p. 20)
componentAxis(R, nFactors=2)

# .....
```

---

corFA

---

*Insert Communalities in the Diagonal of a Correlation or a Covariance Matrix*


---

## Description

This function inserts communalities in the diagonal of a correlation/covariance matrix.

## Usage

```
corFA(R, method="ginv")
```

## Arguments

R	numeric: correlation matrix.
method	character: actually only "ginv" is supplied to compute the approximation of the communalities by maximum correlation.

## Value

values	numeric: matrix of correlation/covariance with communalities in the diagonal.
--------	---

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## See Also

[plotuScree](#), [nScree](#), [plotnScree](#), [plotParallel](#)



## Examples

```
## LOWER CORRELATION MATRIX WITH ZEROS ON UPPER PART
## From Gorsuch (table 1.3.1)
gorsuch <- c(
  1,0,0,0,0,0,0,0,0,0,
  .6283, 1,0,0,0,0,0,0,0,0,
  .5631, .7353, 1,0,0,0,0,0,0,0,
  .8689, .7055, .8444, 1,0,0,0,0,0,0,
  .9030, .8626, .6890, .8874, 1,0,0,0,0,0,
  .6908, .9028, .9155, .8841, .8816, 1,0,0,0,0,
  .8633, .7495, .7378, .9164, .9109, .8572, 1,0,0,0,
  .7694, .7902, .7872, .8857, .8835, .8884, .7872, 1,0,0,
  .8945, .7929, .7656, .9494, .9546, .8942, .9434, .9000, 1,0,
  .5615, .6850, .8153, .7004, .6583, .7720, .6201, .6141, .6378, 1)

## UPPER CORRELATION MATRIX FILLED WITH UPPER CORRELATION MATRIX
gorsuch <- makeCor(gorsuch)

## REPLACE DIAGONAL WITH COMMUNALITIES
gorsuchCfa <- corFA(gorsuch)
gorsuchCfa
```

---

dFactors

*Eigenvalues Vectors From the Literature*


---

## Description

Classical examples of eigenvalues vectors used to study the number of factors to retain in the literature. These examples generally give the number of subjects used to obtain these eigenvalues. The number of subjects is used with the parallel analysis.

## Usage

```
data(dFactors)
```

## Format

A list of examples. For each example, a list is also used to give the eigenvalues vector and the number of subjects.

## Details

Other datasets will be added in future versions of the package.

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## Source

Lawley and Hand dataset: Bartholomew *et al.* (2002, p. 123, 126)  
 Bentler dataset: Bentler and Yuan (1998, p. 139-140)  
 Buja datasets: Buja and Eyuboglu (1992, p. 516, 519) < Number of subjects not specified by Buja and Eyuboglu >  
 Cliff datasets: Cliff (1970, p. 165)  
 Raiche dataset: Raiche, Langevin, Riopel and Mauffette (2006)  
 Raiche dataset: Raiche, Riopel and Blais (2006, p. 9)  
 Tucker datasets: Tucker *et al.* (1969, p. 442)

## References

Bartholomew, D. J., Steele, F., Moustaki, I. and Galbraith, J. I. (2002). *The analysis and interpretation of multivariate data for social scientists*. Boca Raton, FL: Chapman and Hall.

Bentler, P. M. and Yuan, K.-H. (1998). Tests for linear trend in the smallest eigenvalues of the correlation matrix. *Psychometrika*, 63(2), 131-144.

Buja, A. and Eyuboglu, N. (1992). Remarks on parallel analysis. *Multivariate Behavioral Research*, 27(4), 509-540.

Cliff, N. (1970). The relation between sample and population characteristic vectors. *Psychometrika*, 35(2), 163-178.

Hand, D. J., Daly, F., Lunn, A. D., McConway, K. J. and Ostrowski, E. (1994). *A handbook of small data sets*. Boca Raton, FL: Chapman and Hall.

Jaeon Song, B. A., Walls, T. A. and Raiche, G. (2008). *Numerical solutions for Cattell's scree test: application to the adolescent smoking consequences questionnaire (ASCQ)*. Paper presented at the International Annual meeting of the Psychometric Society, Durham, New Hampshire. [<http://www.er.uqam.ca/nobel/r17165/RECHERCHE/COMMUNICATIONS/>]

Lawley, D. N. and Maxwell, A. E. (1971). *Factor analysis as a statistical method* (2nd edition). London: Butterworth.

Raiche, G., Langevin, L., Riopel, M. and Mauffette, Y. (2006). Etude exploratoire de la dimensionnalité et des facteurs expliqués par une traduction française de l'Inventaire des approches d'enseignement de Trigwell et Prosser dans trois universités québécoises. *Mesure et Evaluation en Education*, 29(2), 41-61.

Raiche, G., Riopel, M. and Blais, J.-G. (2006). *Non graphical solutions for the Cattell's scree test*. Paper presented at the International Annual meeting of the Psychometric Society, Montreal. [<http://www.er.uqam.ca/nobel/r17165/RECHERCHE/COMMUNICATIONS/>]

Tucker, L. D., Koopman, R. F. and Linn, R. L. (1969). Evaluation of factor analytic research procedures by means of simulated correlation matrices. *Psychometrika*, 34(4), 421-459.

Zoski, K. and Jurs, S. (1993). Using multiple regression to determine the number of factors to retain in factor analysis. *Multiple Linear Regression Viewpoint*, 20(1), 5-9.

## Examples

```
# EXAMPLES FROM DATASET
data(dFactors)

# COMMAND TO VISUALIZE THE CONTENT AND ATTRIBUTES OF THE DATASETS
names(dFactors)
attributes(dFactors)
```

```

dFactors$Cliff1$eigenvalues
dFactors$Cliff1$nsubjects

# SCREE PLOT
plotuScree(dFactors$Cliff1$eigenvalues)

```

---

diagReplace	<i>Replacing Upper or Lower Diagonal of a Correlation or Covariance Matrix</i>
-------------	--

---

## Description

The `diagReplace` function returns a modified correlation or covariance matrix by replacing upper diagonal with lower diagonal, or lower diagonal with upper diagonal.

## Usage

```
diagReplace(R, upper=TRUE)
```

## Arguments

R	numeric: correlation or covariance matrix
upper	logical: if TRUE upper diagonal is replaced with lower diagonal. If FALSE, lower diagonal is replaced with upper diagonal.

## Value

R	numeric: correlation or covariance matrix
---	---

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## Examples

```

# .....
# Example from Kim and Mueller (1978, p. 10)
# Population: upper diagonal
# Simulated sample: lower diagonal
R <- matrix(c( 1.000, .6008, .4984, .1920, .1959, .3466,
               .5600, 1.000, .4749, .2196, .1912, .2979,
               .4800, .4200, 1.000, .2079, .2010, .2445,
               .2240, .1960, .1680, 1.000, .4334, .3197,
               .1920, .1680, .1440, .4200, 1.000, .4207,
               .1600, .1400, .1200, .3500, .3000, 1.000),
            nrow=6, byrow=TRUE)

# Replace upper diagonal with lower diagonal

```

```

RU <- diagReplace(R, upper=TRUE)

# Replace lower diagonal with upper diagonal
RL <- diagReplace(R, upper=FALSE)
# .....

```

---

eigenBootParallel    *Bootstrapping of the Eigenvalues From a Data Frame*

---

## Description

The `eigenBootParallel` function samples observations from a `data.frame` to produce correlation or covariance matrices from which eigenvalues are computed. The function returns statistics about these bootstrapped eigenvalues. Their means or their quantile could be used later to replace the eigenvalues inputted to a parallel analysis. The `eigenBootParallel` can also compute random eigenvalues from empirical data by column permutation (Buja and Eyuboglu, 1992).

## Usage

```

eigenBootParallel(x, quantile=0.95, nboot=30, option="permutation",
                  cor=TRUE, model="components", ...)

```

## Arguments

<code>x</code>	data.frame: data from which a correlation matrix will be obtained
<code>quantile</code>	numeric: eigenvalues quantile to be reported
<code>nboot</code>	numeric: number of bootstrap samples
<code>option</code>	character: "permutation" or "bootstrap"
<code>cor</code>	logical: if TRUE computes eigenvalues from a correlation matrix, else from a covariance matrix ( <code>eigenComputes</code> )
<code>model</code>	character: bootstraps from a principal component analysis ("components") or from a factor analysis ("factors")
<code>...</code>	variable: additionnal parameters to give to the <code>cor</code> or <code>cov</code> functions

## Value

<code>values</code>	data.frame: mean, median, quantile, standard deviation, minimum and maximum of bootstrapped eigenvalues
---------------------	---

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## References

Buja, A. and Eyuboglu, N. (1992). Remarks on parallel analysis. *Multivariate Behavioral Research*, 27(4), 509-540.

Zwick, W. R. and Velicer, W. F. (1986). Comparison of five rules for determining the number of components to retain. *Psychological bulletin*, 99, 432-442.

## See Also

[principalComponents](#), [iterativePrincipalAxis](#), [rRecovery](#)

## Examples

```
# .....
# Example from the iris data
eigenvalues <- eigenComputes(x=iris[, -5])

# Permutation parallel analysis distribution
aparameter <- eigenBootParallel(x=iris[, -5], quantile=0.95)$quantile

# Number of components to retain
results <- nScree(x = eigenvalues, aparameter = aparameter)
results$Components
plotnScree(results)
# .....

# .....
# Bootstrap distributions study of the eigenvalues from iris data
# with different correlation methods
eigenBootParallel(x=iris[, -5], quantile=0.05,
  option="bootstrap", method="pearson")
eigenBootParallel(x=iris[, -5], quantile=0.05,
  option="bootstrap", method="spearman")
eigenBootParallel(x=iris[, -5], quantile=0.05,
  option="bootstrap", method="kendall")
```

---

eigenComputes

---

*Computes Eigenvalues According to the Data Type*


---

## Description

The `eigenComputes` function computes eigenvalues from the identified data type. It is used internally in many functions of the **nFactors** package in order to apply these to a vector of eigenvalues, a matrix of correlations or covariance or a data frame.

## Usage

```
eigenComputes(x, cor=TRUE, model="components", ...)
```

**Arguments**

<code>x</code>	numeric: a vector of eigenvalues, a matrix of correlations or of covariances or a <code>data.frame</code> of data
<code>cor</code>	logical: if TRUE computes eigenvalues from a correlation matrix, else from a covariance matrix
<code>model</code>	character: "components" or "factors"
<code>...</code>	variable: additionnal parameters to give to the <code>cor</code> or <code>cov</code> functions

**Value**

<code>value</code>	numeric: return a vector of eigenvalues
--------------------	---

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**Examples**

```
# .....
# Different data types
# Vector of eigenvalues
data(dFactors)
x1 <- dFactors$Cliff1$eigenvalues
eigenComputes(x1)

# Data from a data.frame
x2 <- data.frame(matrix(20*rnorm(100), ncol=5))
eigenComputes(x2, cor=TRUE, use="everything")
eigenComputes(x2, cor=FALSE, use="everything")
eigenComputes(x2, cor=TRUE, use="everything", method="spearman")
eigenComputes(x2, cor=TRUE, use="everything", method="kendall")

# From a covariance matrix
x3 <- cov(x2)
eigenComputes(x3, cor=TRUE, use="everything")
eigenComputes(x3, cor=FALSE, use="everything")

# From a correlation matrix
x4 <- cor(x2)
eigenComputes(x4, use="everything")
# .....
```

## Description

The `eigenFrom` function identifies the data type from which to obtain the eigenvalues. The function is used internally in many functions of the **nFactors** package to be able to apply these to a vector of eigenvalues, a matrix of correlations or covariance or a `data.frame`.

## Usage

```
eigenFrom(x)
```

## Arguments

`x`                      numeric: a vector of eigenvalues, a matrix of correlations or of covariances or a `data.frame` of data

## Value

`value`                  character: return the data type to obtain the eigenvalues: "eigenvalues", "correlation" or "data"

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## Examples

```
# .....
# Different data types
# Examples of adequate data sources
# Vector of eigenvalues
data(dFactors)
x1 <- dFactors$Cliff1$eigenvalues
eigenFrom(x1)

# Data from a data.frame
x2 <- data.frame(matrix(20*rnorm(100), ncol=5))
eigenFrom(x2)

# From a covariance matrix
x3 <- cov(x2)
eigenFrom(x3)

# From a correlation matrix
x4 <- cor(x2)
eigenFrom(x4)

# Examples of inadequate data sources: not run because of errors generated
# x0 <- c(2,1)                      # Error: not enough eigenvalues
# eigenFrom(x0)
# x2 <- matrix(x1, ncol=5) # Error: non a symetric covariance matrix
# eigenFrom(x2)
# eigenFrom(x3[, (1:2)])            # Error: not enough variables
```

```
# x6 <- table(x5)           # Error: not a valid data class
# eigenFrom(x6)
# .....
```

---

generateStructure    *Generate a Factor Structure Matrix.*

---

## Description

The `generateStructure` function returns a *mjc* factor structure matrix. The number of variables per major factor *pmjc* is equal for each factor. The argument *pmjc* must be divisible by *nVar*. The arguments are strongly inspired from Zick and Velicer (1986, p. 435-436) methodology.

## Usage

```
generateStructure(var, mjc, pmjc, loadings, unique)
```

## Arguments

<code>var</code>	numeric: number of variables
<code>mjc</code>	numeric: number of major factors (factors with practical significance)
<code>pmjc</code>	numeric: number of variables that load significantly on each major factor
<code>loadings</code>	numeric: loadings on the significant variables on each major factor
<code>unique</code>	numeric: loadings on the non significant variables on each major factor

## Value

<code>values</code>	numeric matrix: factor structure
---------------------	----------------------------------

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## References

Zwick, W. R. and Velicer, W. F. (1986). Comparison of five rules for determining the number of components to retain. *Psychological Bulletin*, 99, 432-442.

## See Also

[principalComponents](#), [iterativePrincipalAxis](#), [rRecovery](#)



**Examples**

```

# .....
# Example inspired from Zwick and Velicer (1986, table 2, p. 437)
## .....
unique=0.2; loadings=0.5
zwick1 <- generateStructure(var=36, mjc=6, pmjc= 6, loadings=loadings,
                           unique=unique)
zwick2 <- generateStructure(var=36, mjc=3, pmjc=12, loadings=loadings,
                           unique=unique)
zwick3 <- generateStructure(var=72, mjc=9, pmjc= 8, loadings=loadings,
                           unique=unique)
zwick4 <- generateStructure(var=72, mjc=6, pmjc=12, loadings=loadings,
                           unique=unique)

sat=0.8
## .....
zwick5 <- generateStructure(var=36, mjc=6, pmjc= 6, loadings=loadings,
                           unique=unique)
zwick6 <- generateStructure(var=36, mjc=3, pmjc=12, loadings=loadings,
                           unique=unique)
zwick7 <- generateStructure(var=72, mjc=9, pmjc= 8, loadings=loadings,
                           unique=unique)
zwick8 <- generateStructure(var=72, mjc=6, pmjc=12, loadings=loadings,
                           unique=unique)
## .....

# nsubjects <- c(72, 144, 180, 360)
# require(psych)
# Produce an usual correlation matrix from a congeneric model
nsubjects <- 72
mzwick5 <- sim.structure(fx=as.matrix(zwick5), n=nsubjects)
mzwick5$r

# Factor analysis: recovery of the factor structure
iterativePrincipalAxis(mzwick5$model, nFactors=6,
                       communalities="ginv")$loadings
iterativePrincipalAxis(mzwick5$r, nFactors=6,
                       communalities="ginv")$loadings
factanal(covmat=mzwick5$model, factors=6)
factanal(covmat=mzwick5$r, factors=6)

# Number of components to retain
eigenvalues <- eigen(mzwick5$r)$values
apara11 <- parallel(var = length(eigenvalues),
                   subject = nsubjects,
                   rep = 30,
                   quantile = 0.95,
                   model="components")$eigen$qevpea
results <- nScree(x = eigenvalues,
                 apara11 = apara11)
results$Components
plotnScree(results)

# Number of factors to retain
eigenvalues.fa <- eigen(corFA(mzwick5$r))$values
apara11.fa <- parallel(var = length(eigenvalues.fa),
                     subject = nsubjects,

```

```

                                rep      = 30,
                                quantile = 0.95,
                                model="factors")$eigen$qevpea
results.fa <- nScree(x          = eigenvalues.fa,
                    aparallel = aparallel.fa,
                    model      ="factors")
results.fa$Components
plotnScree(results.fa)
# .....

```

---

iterativePrincipalAxis

*Iterative Principal Axis Analysis*


---

## Description

The `iterativePrincipalAxis` function returns a principal axis analysis with iterated communality estimates. Four different choices of initial communality estimates are given: maximum correlation, multiple correlation (usual and generalized inverse) or estimates based on the sum of the squared principal component analysis loadings. Generally, statistical packages initialize the communalities at the multiple correlation value. Unfortunately, this strategy cannot always deal with singular correlation or covariance matrices. If a generalized inverse, the maximum correlation or the estimated communalities based on the sum of loadings are used instead, then a solution can be computed.

## Usage

```

iterativePrincipalAxis(R,
                        nFactors=2,
                        communalities="component",
                        iterations=20,
                        tolerance=0.001)

```

## Arguments

<code>R</code>	numeric: correlation or covariance matrix
<code>nFactors</code>	numeric: number of factors to retain
<code>communalities</code>	character: initial values for communalities ("component", "maxr", "ginv" or "multiple")
<code>iterations</code>	numeric: maximum number of iterations to obtain a solution
<code>tolerance</code>	numeric: minimal difference in the estimated communalities after a given iteration

## Value

<code>values</code>	numeric: variance of each component
<code>varExplained</code>	numeric: variance explained by each component



```
fMultiple
rRecovery(RU,fMultiple$loadings, diagCommunalities=FALSE)
# .....
```

---

makeCor

*Create a Full Correlation/Covariance Matrix from a Matrix With Lower Part Filled and Upper Part With Zeros*

---

## Description

This function creates a full correlation/covariance matrix from a matrix with lower part filled and upper part with zeros.

## Usage

```
makeCor(x)
```

## Arguments

**x**                      numeric: matrix.

## Value

**values**                numeric: full correlation matrix.

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## See Also

[plotuScree](#), [nScree](#), [plotnScree](#), [plotParallel](#)

## Examples

```
## LOWER CORRELATION MATRIX WITH ZEROS ON UPPER PART
## From Gorsuch (table 1.3.1)
gorsuch <- c(
  1,0,0,0,0,0,0,0,0,0,0,
  .6283, 1,0,0,0,0,0,0,0,0,
  .5631, .7353, 1,0,0,0,0,0,0,0,
  .8689, .7055, .8444, 1,0,0,0,0,0,0,
  .9030, .8626, .6890, .8874, 1,0,0,0,0,0,
  .6908, .9028, .9155, .8841, .8816, 1,0,0,0,0,
  .8633, .7495, .7378, .9164, .9109, .8572, 1,0,0,0,
  .7694, .7902, .7872, .8857, .8835, .8884, .7872, 1,0,0,
  .8945, .7929, .7656, .9494, .9546, .8942, .9434, .9000, 1,0,
  .5615, .6850, .8153, .7004, .6583, .7720, .6201, .6141, .6378, 1)
```

```
## UPPER CORRELATION MATRIX FILLED WITH UPPER CORRELATION MATRIX
gorsuch <- makeCor(gorsuch)
gorsuch
```

---

moreStats

*Statistical Summary of a Data Frame*


---

## Description

This function produces another summary of a `data.frame`. This function was proposed in order to apply some functions globally on a `data.frame`: `quantile`, `median`, `min` and `max`. The usual *R* version cannot do so.

## Usage

```
moreStats(x, quantile=0.95, show=FALSE)
```

## Arguments

<code>x</code>	numeric: matrix or <code>data.frame</code> .
<code>quantile</code>	numeric: quantile of the distribution.
<code>show</code>	logical: if <code>TRUE</code> prints the quantile choosen.

## Value

<code>values</code>	numeric: <code>data.frame</code> of statistics: mean, median, quantile, standard deviation, minimum and maximum.
---------------------	--

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## See Also

[plotuScree](#), [nScree](#), [plotnScree](#), [plotParallel](#)

## Examples

```
## GENERATION OF A MATRIX OF 100 OBSERVATIONS AND 10 VARIABLES
x <- matrix(rnorm(1000), ncol=10)

## STATISTICS
res <- moreStats(x, quantile=0.05, show=TRUE)
res
```

---

nBartlett

*Bartlett, Anderson and Lawley Procedures to Determine the Number of Components/Factors*


---

### Description

This function computes the Bartlett, Anderson and Lawley indices for determining the number of components/factors to retain.

### Usage

```
nBartlett(x, N, alpha=0.05, cor=TRUE, details=TRUE, correction=TRUE, ...)
```

### Arguments

x	numeric: a vector of eigenvalues, a matrix of correlations or of covariances or a data.frame of data (eigenFrom)
N	numeric: number of subjects
alpha	numeric: statistical significance level
cor	logical: if TRUE computes eigenvalues from a correlation matrix, else from a covariance matrix
details	logical: if TRUE also returns details about the computation for each eigenvalue
correction	logical: if TRUE uses a correction for the degree of freedom after the first eigenvalue
...	variable: additionnal parameters to give to the cor or cov functions

### Details

The hypothesis tested is:

$$(1) \quad H_k : \lambda_{k+1} = \dots = \lambda_p$$

This hypothesis is verified by the application of different version of a  $\chi^2$  test with different values for the degrees of freedom. Each of these tests shares the computation of a  $V_k$  value:

$$(2) \quad V_k = \prod_{i=k+1}^p \left\{ \frac{\lambda_i}{1/q \sum_{i=k+1}^p \lambda_i} \right\}$$

$p$  is the number of eigenvalues,  $k$  the number of eigenvalues to test, and  $q$  the  $p - k$  remaining eigenvalues.  $n$  is equal to the sample size minus 1 ( $n = N - 1$ ).

The Anderson statistic is distributed as a  $\chi^2$  with  $(q+2)(q-1)/2$  degrees of freedom and is equal to:

$$(3) \quad -n \log(V_k) \sim \chi_{(q+2)(q-1)/2}^2$$

An improvement of this statistic from Bartlett (Bentler, and Yuan, 1996, p. 300; Horn and Engstrom, 1979, equation 8) is distributed as a  $\chi^2$  with  $(q)(q-1)/2$  degrees of freedom and is equal to:

$$(4) \quad - \left[ n - k - \frac{2q^2q+2}{6q} \right] \log(V_k) \sim \chi^2_{(q+2)(q-1)/2}$$

Finally, Anderson (1956) and James (1969) proposed another statistic.

$$(5) \quad - \left[ n - k - \frac{2q^2q+2}{6q} + \sum_{i=1}^k \frac{\bar{\lambda}_q^2}{(\lambda_i - \bar{\lambda}_q)^2} \right] \log(V_k) \sim \chi^2_{(q+2)(q-1)/2}$$

Bartlett (1950, 1951) proposed a correction to the degrees of freedom of these  $\chi^2$  after the first significant test:  $(q+2)(q-1)/2$ .

### Value

nFactors	numeric: vector of the number of factors retained by the Bartlett, Anderson and Lawley procedures.
details	numeric: matrix of the details for each index.

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### References

- Anderson, T. W. (1963). Asymptotic theory for principal component analysis. *Annals of Mathematical Statistics*, 34, 122-148.
- Bartlett, M. S. (1950). Tests of significance in factor analysis. *British Journal of Psychology*, 3, 77-85.
- Bartlett, M. S. (1951). A further note on tests of significance. *British Journal of Psychology*, 4, 1-2.
- Bentler, P. M. and Yuan, K.-H. (1996). Test of linear trend in eigenvalues of a covariance matrix with application to data analysis. *British Journal of Mathematical and Statistical Psychology*, 49, 299-312.
- Bentler, P. M. and Yuan, K.-H. (1998). Test of linear trend in the smallest eigenvalues of the correlation matrix. *Psychometrika*, 63(2), 131-144.
- Horn, J. L. and Engstrom, R. (1979). Cattell's scree test in relation to Bartlett's chi-square test and other observations on the number of factors problem. *Multivariate Behavioral Research*, 14(3), 283-300.
- James, A. T. (1969). Test of equality of the latent roots of the covariance matrix. In P. K. Krishna (Eds): *Multivariate analysis, volume 2*. New-York, NJ: Academic Press.
- Lawley, D. N. (1956). Tests of significance for the latent roots of covariance and correlation matrix. *Biometrika*, 43(1/2), 128-136.

### See Also

[plotuScree](#), [nScree](#), [plotnScree](#), [plotParallel](#)

## Examples

```
## SIMPLE EXAMPLE OF A BARTLETT PROCEDURE

data(dFactors)
eig      <- dFactors$Raiche$eigenvalues

results  <- nBartlett(x=eig, N= 100, alpha=0.05, details=TRUE)
results

plotuScree(eig, main=paste(results$nFactors[1], ", ",
                           results$nFactors[2], " or ",
                           results$nFactors[3],
                           " factors retained by the LRT procedures",
                           sep=""))
```

---

nBentler

*Bentler and Yuan's Procedure to Determine the Number of Components/Factors*


---

## Description

This function computes the Bentler and Yuan's indices for determining the number of components/factors to retain.

## Usage

```
nBentler(x, N, log=TRUE, alpha=0.05, cor=TRUE, details=TRUE,
         minPar=c(min(lambda) - abs(min(lambda)) +.001, 0.001),
         maxPar=c(max(lambda),
                  lm(lambda ~ I(length(lambda):1))$coef[2]), ...)
```

## Arguments

x	numeric: a vector of eigenvalues, a matrix of correlations or of covariances or a data.frame of data
N	numeric: number of subjects.
log	logical: if TRUE does the maximization on the log values.
alpha	numeric: statistical significance level.
cor	logical: if TRUE computes eigenvalues from a correlation matrix, else from a covariance matrix
details	logical: if TRUE also returns details about the computation for each eigenvalue.
minPar	numeric: minimums for the coefficient of the linear trend to maximize.
maxPar	numeric: maximums for the coefficient of the linear trend to maximize.
...	variable: additionnal parameters to give to the cor or cov functions



## Details

The implemented Bentler and Yuan's procedure must be used with care because the minimized function is not always stable, as Bentler and Yan (1996, 1998) already noted. In many cases, constraints must be applied to obtain a solution, as the actual implementation did, but the user can modify these constraints.

The hypothesis tested (Bentler and Yuan, 1996, equation 10) is:

$$(1) \quad H_k : \lambda_{k+i} = \alpha + \beta x_i, (i = 1, \dots, q)$$

The solution of the following simultaneous equations is needed to find  $(\alpha, \beta) \in$

$$(2) \quad f(x) = \sum_{i=1}^q \frac{[\lambda_{k+i} - N\alpha + \beta x_i]x_i}{(\alpha + \beta x_i)^2} = 0$$

$$\text{and} \quad g(x) = \sum_{i=1}^q \frac{\lambda_{k+i} - N\alpha + \beta x_i x_i}{(\alpha + \beta x_i)^2} = 0$$

The solution to this system of equations was implemented by minimizing the following equation:

$$(3) \quad (\alpha, \beta) \in \inf [h(x)] = \inf \log [f(x)^2 + g(x)^2]$$

The likelihood ratio test  $LRT$  proposed by Bentler and Yuan (1996, equation 7) follows a  $\chi^2$  probability distribution with  $q - 2$  degrees of freedom and is equal to:

$$(4) \quad LRT = N(k - p) \left\{ \ln \left( \frac{n}{N} \right) + 1 \right\} - N \sum_{j=k+1}^p \ln \left\{ \frac{\lambda_j}{\alpha + \beta x_j} \right\} + n \sum_{j=k+1}^p \left\{ \frac{\lambda_j}{\alpha + \beta x_j} \right\}$$

With  $p$  being the number of eigenvalues,  $k$  the number of eigenvalues to test,  $q$  the  $p - k$  remaining eigenvalues,  $N$  the sample size, and  $n = N - 1$ . Note that there is an error in the Bentler and Yuan equation, the variables  $N$  and  $n$  being inverted in the preceding equation 4.

A better strategy proposed by Bentler and Yuan (1998) is to use a minimized  $\chi^2$  solution. This strategy will be implemented in a future version of the **nFactors** package.

## Value

nFactors	numeric: vector of the number of factors retained by the Bentler and Yuan's procedure.
details	numeric: matrix of the details of the computation.

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## References

Bentler, P. M. and Yuan, K.-H. (1996). Test of linear trend in eigenvalues of a covariance matrix with application to data analysis. *British Journal of Mathematical and Statistical Psychology*, 49, 299-312.

Bentler, P. M. and Yuan, K.-H. (1998). Test of linear trend in the smallest eigenvalues of the correlation matrix. *Psychometrika*, 63(2), 131-144.

## See Also

[nBartlett](#), [bentlerParameters](#)

## Examples

```
## .....
## SIMPLE EXAMPLE OF THE BENTLER AND YUAN PROCEDURE

# Bentler (1996, p. 309) Table 2 - Example 2 .....
n=649
bentler2<-c(5.785, 3.088, 1.505, 0.582, 0.424, 0.386, 0.360, 0.337, 0.303,
            0.281, 0.246, 0.238, 0.200, 0.160, 0.130)

results <- nBentler(x=bentler2, N=n)
results

plotuScree(x=bentler2, model="components",
           main=paste(results$nFactors,
                      " factors retained by the Bentler and Yuan's procedure (1996, p. 309)",
                      sep=""))
# .....

# Bentler (1998, p. 140) Table 3 - Example 1 .....
n <- 145
example1 <- c(8.135, 2.096, 1.693, 1.502, 1.025, 0.943, 0.901, 0.816, 0.790,
              0.707, 0.639, 0.543,
              0.533, 0.509, 0.478, 0.390, 0.382, 0.340, 0.334, 0.316, 0.297,
              0.268, 0.190, 0.173)

results <- nBentler(x=example1, N=n)
results

plotuScree(x=example1, model="components",
           main=paste(results$nFactors,
                      " factors retained by the Bentler and Yuan's procedure (1998, p. 140)",
                      sep=""))
# .....
```

## Description

This function computes the *CNG* indices for the eigenvalues of a correlation/covariance matrix (Gorsuch and Nelson, 1981; Nasser, 2002, p. 400; Zoski and Jurs, 1993, p. 6).

**Usage**

```
nCng(x, cor=TRUE, model="components", details=TRUE, ...)
```

**Arguments**

<code>x</code>	numeric: a vector of eigenvalues, a matrix of correlations or of covariances or a <code>data.frame</code> of data
<code>cor</code>	logical: if <code>TRUE</code> computes eigenvalues from a correlation matrix, else from a covariance matrix
<code>model</code>	character: "components" or "factors"
<code>details</code>	logical: if <code>TRUE</code> also returns details about the computation for each eigenvalue.
<code>...</code>	variable: additionnal parameters to give to the <code>eigenComputes</code> function

**Details**

Note that the `nCng` function is only valid when more than six eigenvalues are used and that these are obtained in the context of a principal component analysis. For a factor analysis, some eigenvalues could be negative and the function will stop and give an error message.

The slope of all possible sets of three adjacent eigenvalues are compared, so *CNG* indices can be applied only when more than six eigenvalues are used. The eigenvalue at which the greatest difference between two successive slopes occurs is the indicator of the number of components/factors to retain.

**Value**

<code>nFactors</code>	numeric: number of factors retained by the CNG procedure.
<code>details</code>	numeric: matrix of the details for each index.

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**References**

- Gorsuch, R. L. and Nelson, J. (1981). *CNG scree test: an objective procedure for determining the number of factors*. Presented at the annual meeting of the Society for multivariate experimental psychology.
- Nasser, F. (2002). The performance of regression-based variations of the visual scree for determining the number of common factors. *Educational and Psychological Measurement*, 62(3), 397-419.
- Zoski, K. and Jurs, S. (1993). Using multiple regression to determine the number of factors to retain in factor analysis. *Multiple Linear Regression Viewpoints*, 20(1), 5-9.

**See Also**

[plotuScree](#), [nScree](#), [plotnScree](#), [plotParallel](#)

## Examples

```
## SIMPLE EXAMPLE OF A CNG ANALYSIS

data(dFactors)
eig      <- dFactors$Raiche$eigenvalues

results  <- nCng(eig, details=TRUE)
results

plotuScree(eig, main=paste(results$nFactors,
                           " factors retained by the CNG procedure",
                           sep=""))
```

---

nFactors-parameters

*Argument and Value Parameters Common to the Different Functions  
Available in Package nFactors*

---

## Description

This help file describes the argument and value parameters used in the different functions available in package **nFactors**.

### Arguments:

1. *adequacy*: logical: if TRUE prints the recovered population matrix from the factor structure (structureSim)
2. *all*: logical: if TRUE computes the Bentler and Yuan index (very long computing time to consider) (structureSim, studySim)
3. *alpha*: numeric: statistical significance level (nBartlett, nBentler)
4. *apara*: numeric: results of a parallel analysis (nScree)
5. *cent*: deprecated numeric (use quantile instead): quantile of the distribution (moreStats, parallel)
6. *communalities*: character: initial values for communalities ("component", "ginv", "maxr", or "multiple") (iterativePrincipalAxis, principalAxis)
7. *cor*: logical: if TRUE computes eigenvalues from a correlation matrix, else from a covariance matrix (eigenComputes, nBartlett, nBentler, nCng, nMreg, nScree, nSeScree)
8. *correction*: logical: if TRUE uses a correction for the degree of freedom after the first eigenvalue (nBartlett)
9. *criteria*: numeric: by default fixed at  $\hat{\lambda}$ . When the  $\lambda$ s are computed from a principal components analysis on a correlation matrix, it corresponds to the usual Kaiser  $\lambda \geq 1$  rule. On a covariance matrix or from a factor analysis, it is simply the mean. To apply the  $\lambda \geq 0$  sometimes used with factor analysis, fixed the criteria to 0 (nScree)
10. *details*: logical: if TRUE also returns details about the computation for each eigenvalues (nBartlett, nBentler, nCng, nMreg, structureSim)
11. *diagCommunalities*: logical: if TRUE, the correlation between the initial solution and the estimated one will use a correlation of one in the diagonal. If FALSE (default) the diagonal is not used in the computation of this correlation or covariance matrix (rRecovery)

12. *dir*: character: directory where to save output (studySim)
13. *eig*: depreciated parameter (use x instead): eigenvalues to analyse (nScree, plotParallel)
14. *Eigenvalue*: depreciated parameter (use x instead): eigenvalues to analyse (plotnScree)
15. *fload*: matrix: loadings of the factor structure (structureSim)
16. *graphic*: logical: specific plot (bentlerParameters, structureSim)
17. *index*: numeric: vector of the index of the selected indices (plot.structureSim, print.structureSim, summary.structureSim)
18. *iterations*: numeric: maximum number of iterations to obtain a solution (iterativePrincipalAxis)
19. *legend*: logical indicator of the presence of a legend (plotnScree, plotParallel)
20. *loadings*: numeric: loadings from a factor analysis solution (rRecovery, generateStructure, studySim)
21. *log*: logical: if TRUE does the minimization on the log values (bentlerParameters, nBentler)
22. *main*: character: main title (plotnScree, plotParallel, plotuScree, boxplot.structureSim, plot.structureSim)
23. *maxPar*: numeric: maximums for the coefficient of the linear trend (bentlerParameters, nBentler)
24. *minPar*: numeric: minimums for the coefficient of the linear trend (bentlerParameters, nBentler)
25. *method*: character: actually only "giv" is supplied to compute the approximation of the communalities by maximum correlation (corFA, nCng, nMreg, nScree, nSeScree)
26. *mjc*: numeric: number of major factors (factors with practical significance) (generateStructure)
27. *pmjc*: numeric: number of variables that load significantly on each major factor (generateStructure)
28. *model*: character: "components" or "factors" (nScree, parallel, plotParallel, plotuScree, structureSim, eigenBootParallel, eigenBootParallel, studySim)
29. *N*: numeric: number of subjects (nBartlett, bentlerParameters, nBentler, studySim)
30. *nboot*: numeric: number of bootstrap samples (eigenBootParallel)
31. *nFactors*: numeric: number of components/factors to retained (componentAxis, iterativePrincipalAxis, principalAxis, bentlerParameters, boxplot.structureSim, studySim)
32. *nScree*: results of a previous nScree analysis (plotnScree)
33. *option*: character: "permutation" or "bootstrap" (eigenBootParallel)
34. *object*: nScree: an object of the class nScree is.nScree, summary.nScree
35. *object*: structureSim: an object of the class structureSim (is.structureSim, summary.structureSim)
36. *parallel*: numeric: vector of the result of a previous parallel analysis (plotParallel)
37. *pmjc*: numeric: number of major loadings on each factor factors (generateStructure, studySim)
38. *quantile*: numeric: quantile that will be reported (parallel, moreStats, eigenBootParallel, structureSim, studySim)
39. *R*: numeric: correlation or covariance matrix (componentAxis, iterativePrincipalAxis, principalAxis, principalComponents, rRecovery, corFA)
40. *r2limen*: numeric: R2 limen value for the R2 Nelson index (structureSim, nSeScree, studySim)

41. *rep*: numeric: number of replications of the correlation or the covariance matrix (default is 100) (*parallel*)
42. *reppar*: numeric: number of replications for the parallel analysis (*structureSim*, *studySim*)
43. *repsim*: numeric: number of replications of the matrix correlation simulation (*structureSim*, *studySim*)
44. *resParx*: numeric: restriction on the  $\alpha$  coefficient (x) to graph the function to minimize (*bentlerParameters*)
45. *resolution*: numeric: resolution of the 3D graph (number of points from  $\alpha$  and from  $\beta$ ).
46. *resPary*: numeric: restriction on the  $\beta$  coefficient (y) to graph the function to minimize (*bentlerParameters*)
47. *sd*: numeric: vector of standard deviations of the simulated variables (for a parallel analysis on a covariance matrix) (*parallel*)
48. *show*: logical: if TRUE prints the quantile chosen (*moreStats*)
49. *stats*: numeric: vector of the statistics to return: mean(1), median(2), sd(3), quantile(4), min(5), max(6) (*studySim*)
50. *subject*: numeric: number of subjects (default is 100) (*parallel*)
51. *tolerance*: numeric: minimal difference in the estimated communalities after a given iteration (*iterativePrincipalAxis*)
52. *trace*: logical: if TRUE gives details of the status of the simulations (*studySim*)
53. *typePlot*: character: plots the minimized function according to a 3D plot: "wireframe", "contourplot" or "levelplot" (*bentlerParameters*)
54. *unique*: numeric: loadings on the non significant variables on each major factor (*generateStructure*, *studySim*)
55. *upper*: logical: if TRUE upper diagonal is replaced with lower diagonal. If FALSE, lower diagonal is replaced with upper diagonal (*diagReplace*)
56. *use*: character: how to deal with missing values, same as the parameter from the *corr* function (*eigenBootParallel*)
57. *var*: numeric: number of variables (default is 10) (*parallel*, *generateStructure*, *studySim*)
58. *vLine*: character: color of the vertical indicator line in the eigen boxplot (*boxplot.structureSim*)
59. *x*: numeric: a vector of eigenvalues, a matrix of correlations or of covariances or a data.frame of data (*eigenFrom*, *nBartlett*, *nCng*, *nMreg*)
60. *xlab*: character: label of the x axis (*plotnScree*, *plotParallel*, *plotuScree*, *boxplot.structureSim*)
61. *x*: data.frame: data from which a correlation or covariance matrix will be obtained (*eigenBootParallel*)
62. *x*: depreciated: (*plotParallel*)
63. *x*: nScree: an object of the class nScree (*plot.nScree*, *print.nScree*)
64. *x*: numeric: matrix (*makeCor*)
65. *x*: numeric: matrix or data.frame (*moreStats*)
66. *x*: structureSim: an object of the class structureSim (*boxplot.structureSim*, *plot.structureSim*, *print.structureSim*)
67. *ylab*: character: label of the y axis (*plotnScree*, *plotParallel*, *plotuScree*, *boxplot.structureSim*)

Values:

1. *cor*: numeric: Pearson correlation between initial and recovered estimated correlation or covariance matrix. Computation depend on the logical value of the `communalities` argument (`rRecovery`)
2. *details*: numeric: matrix of the details for each index (`nBartlett`, `bentlerParameters`, `nCng`, `nMreg`)
3. *difference*: numeric: difference between initial and recovered estimated correlation or covariance matrix (`rRecovery`)
4. *iterations*: numeric: maximum number of iterations to obtain a solution (`iterativePrincipalAxis`)
5. *loadings*: numeric: loadings of each variable on each component or factor retained (`componentAxis`, `iterativePrincipalAxis`, `principalAxis`, `principalComponents`)
6. *nFactors*: numeric: vector of the number of components or factors retained by the Bartlett, Anderson and Lawley procedures (`nBartlett`, `bentlerParameters`, `nCng`, `nMreg`)
7. *R*: numeric: correlation or covariance matrix (`diagReplace`, `rRecovery`)
8. *recoveredR*: numeric: recovered estimated correlation or covariance matrix (`rRecovery`)
9. *tolerance*: numeric: minimal difference in the estimated communalities after a given iteration (`iterativePrincipalAxis`)
10. *values*: numeric: data.frame of information (`nScree`, `parallel`, `plotnScree`, `plotParallel`, `plotuScree`, `structureSim`)
11. *values*: numeric: data.frame of statistics (`moreStats`)
12. *values*: numeric: full matrix of correlation or covariance (`makeCor`)
13. *values*: numeric: variance of each component or factor (`iterativePrincipalAxis`, `principalComponents`)
14. *values*: data.frame: mean, median, quantile, standard deviation, minimum and maximum of bootstrapped eigenvalues (`eigenBootParallel`)
15. *values*: numeric: matrix of correlation or covariance with communalities in the diagonal (`corFA`)
16. *values*: numeric: variance of each component or factor retained (`componentAxis`, `principalAxis`)
17. *values*: numeric: matrix factor structure (`generateStructure`)
18. *varExplained*: numeric: variance explained by each component or factor retained (`componentAxis`, `iterativePrincipalAxis`, `principalAxis`, `principalComponents`)
19. *varExplained*: numeric: cumulative variance explained by each component or factor retained (`componentAxis`, `iterativePrincipalAxis`, `principalAxis`, `principalComponents`)

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## References

Raiche, G., Riopel, M. and Blais, J.-G. (2006). *Non graphical solutions for the Cattell's scree test*. Paper presented at the International Annual meeting of the Psychometric Society, Montreal. [<http://www.er.uqam.ca/nobel/r17165/RECHERCHE/COMMUNICATIONS/>]

## See Also

Other packages are also very useful for principal component and factor analysis. The *R* psychometric view is instructive at this point. See <http://cran.stat.sfu.ca/web/views/Psychometrics.html> for further details.

---

nFactorsObjectMethods

*Utility Functions for nFactors Class Objects*

---

## Description

Utility functions for nFactors class objects.

## Usage

```
## S3 method for class 'nFactors':
is      (object)
## S3 method for class 'nFactors':
print   (x, ...)
## S3 method for class 'nFactors':
summary(object, ...)
```

## Arguments

x	nFactors: an object of the class nFactors
object	nFactors: an object of the class nFactors
...	variable: additionnal parameters to give to the print function with print.nFactors or to the summary function with summary.nFactors

## Value

Generic functions for the nFactors class:

is.nFactors	logical: is the object of the class nFactors?
print.nFactors	numeric: vector of the number of components/factors to retain: same as the nFactors vector from the nFactors object
summary.nFactors	data.frame: details of the results from a nFactors object: same as the details data.frame from the nFactors object, but with easier control of the number of decimals with the digits parameter



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**References**

Raiche, G., Riopel, M. and Blais, J.-G. (2006). *Non graphical solutions for the Cattell's scree test*. Paper presented at the International Annual meeting of the Psychometric Society, Montreal. [<http://www.er.uqam.ca/nobel/r17165/RECHERCHE/COMMUNICATIONS/>]

**See Also**

[nBentler](#), [nBartlett](#), [nCng](#), [nMreg](#), [nSeScree](#)

**Examples**

```
## SIMPLE EXAMPLE
data(dFactors)
eig      <- dFactors$Raiche$eigenvalues
N        <- dFactors$Raiche$nsubjects

res <- nBartlett(eig,N); res; is.nFactors(res); summary(res, digits=2)
res <- nBentler(eig,N); res; is.nFactors(res); summary(res, digits=2)
res <- nCng(eig);      res; is.nFactors(res); summary(res, digits=2)
res <- nMreg(eig);      res; is.nFactors(res); summary(res, digits=2)
res <- nSeScree(eig);   res; is.nFactors(res); summary(res, digits=2)

## SIMILAR RESULTS, BUT NOT A nFactors OBJECT
res <- nScree(eig);      res; is.nFactors(res); summary(res, digits=2)
```

---

nMreg

---

*Multiple Regression Procedure to Determine the Number of Components/Factors*


---

**Description**

This function computes the  $\beta$  indices, like their associated Student  $t$  and probability (Zoski and Jurs, 1993, 1996, p. 445). These three values can be used as three different indices for determining the number of components/factors to retain.

**Usage**

```
nMreg(x, cor=TRUE, model="components", details=TRUE, ...)
```



```
results$nFactors[3],
" factors retained by the MREG procedures",
sep="") )
```

nSree

*Non Graphical Cattell's Scree Test*

## Description

The `nSree` function returns an analysis of the number of component or factors to retain in an exploratory principal component or factor analysis. The function also returns information about the number of components/factors to retain with the Kaiser rule and the parallel analysis.

## Usage

```
nSree(eig=NULL, x=eig, aparallel=NULL, cor=TRUE, model="components",
      criteria=NULL, ...)
```

## Arguments

<code>eig</code>	depreciated parameter (use <code>x</code> instead): eigenvalues to analyse
<code>x</code>	numeric: a vector of eigenvalues, a matrix of correlations or of covariances or a <code>data.frame</code> of data
<code>aparallel</code>	numeric: results of a parallel analysis. Defaults eigenvalues fixed at $\lambda \geq \bar{\lambda}$ (Kaiser and related rule) or $\lambda \geq 0$ (CFA analysis)
<code>cor</code>	logical: if <code>TRUE</code> computes eigenvalues from a correlation matrix, else from a covariance matrix
<code>model</code>	character: "components" or "factors"
<code>criteria</code>	numeric: by default fixed at $\bar{\lambda}$ . When the $\lambda$ s are computed from a principal component analysis on a correlation matrix, it corresponds to the usual Kaiser $\lambda \geq 1$ rule. On a covariance matrix or from a factor analysis, it is simply the mean. To apply $\lambda \geq 0$ , sometimes used with factor analysis, fix the criteria to 0.
<code>...</code>	variable: additionnal parameters to give to the <code>cor</code> or <code>cov</code> functions

## Details

The `nSree` function returns an analysis of the number of components/factors to retain in an exploratory principal component or factor analysis. Different solutions are given. The classical ones are the Kaiser rule, the parallel analysis, and the usual scree test ([plotuSree](#)). Non graphical solutions to the Cattell subjective scree test are also proposed: an acceleration factor (*af*) and the optimal coordinates index *oc*. The acceleration factor indicates where the elbow of the scree plot appears. It corresponds to the acceleration of the curve, i.e. the second derivative. The optimal coordinates are the extrapolated coordinates of the previous eigenvalue that allow the observed eigenvalue to go beyond this extrapolation. The extrapolation is made by a linear regression using the last eigenvalue coordinates and the  $k+1$  eigenvalue coordinates. There are  $k-2$  regression lines like this. The Kaiser rule or a parallel analysis criterion ([parallel](#)) must also be simultaneously

satisfied to retain the components/factors, whether for the acceleration factor, or for the optimal coordinates.

If  $\lambda_i$  is the  $i^{th}$  eigenvalue, and  $LS_i$  is a location statistics like the mean or a centile (generally the followings: 1<sup>st</sup>, 5<sup>th</sup>, 95<sup>th</sup>, or 99<sup>th</sup>).

The Kaiser rule is computed as:

$$n_{Kaiser} = \sum_i (\lambda_i \geq \bar{\lambda}).$$

Note that  $\bar{\lambda}$  is equal to 1 when a correlation matrix is used.

The parallel analysis is computed as:

$$n_{parallel} = \sum_i (\lambda_i \geq LS_i).$$

The acceleration factor ( $AF$ ) corresponds to a numerical solution to the elbow of the scree plot:

$$n_{AF} \equiv \text{If } [(\lambda_i \geq LS_i) \text{ and } \max(AF_i)].$$

The optimal coordinates ( $OC$ ) corresponds to an extrapolation of the preceeding eigenvalue by a regression line between the eigenvalue coordinates and the last eigenvalue coordinates:

$$n_{OC} = \sum_i [(\lambda_i \geq LS_i) \cap (\lambda_i \geq (\lambda_i \text{ predicted}))].$$

## Value

Components	Data frame for the number of components/factors according to different rules
Components\$noc	Number of components/factors to retain according to optimal coordinates <i>oc</i>
Components\$naf	Number of components/factors to retain according to the acceleration factor <i>af</i>
Components\$npar.analysis	Number of components/factors to retain according to parallel analysis
Components\$nkaiser	Number of components/factors to retain according to the Kaiser rule
Analysis	Data frame of vectors linked to the different rules
Analysis\$Eigenvalues	Eigenvalues
Analysis\$Prop	Proportion of variance accounted by eigenvalues
Analysis\$Cumulative	Cumulative proportion of variance accounted by eigenvalues
Analysis\$Par.analysis	Centiles of the random eigenvalues generated by the parallel analysis.
Analysis\$Pred.eig	Predicted eigenvalues by each optimal coordinate regression line
Analysis\$OC	Critical optimal coordinates <i>oc</i>
Analysis\$Acc.factor	Acceleration factor <i>af</i>
Analysis\$AF	Critical acceleration factor <i>af</i>

Otherwise, returns a summary of the analysis.

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[\[http://www.er.uqam.ca/nobel/r17165/RECHERCHE/COMMUNICATIONS/\]](http://www.er.uqam.ca/nobel/r17165/RECHERCHE/COMMUNICATIONS/)

**See Also**

[plotuScree](#), [plotnScree](#), [parallel](#), [plotParallel](#),

**Examples**

```
## INITIALISATION
data(dFactors)                # Load the nFactors dataset
attach(dFactors)
vect      <- Raiche           # Uses the example from Raiche
eigenvalues <- vect$eigenvalues # Extracts the observed eigenvalues
nsubjects  <- vect$nsubjects   # Extracts the number of subjects
variables  <- length(eigenvalues) # Computes the number of variables
rep        <- 100              # Number of replications for PA analysis
cent       <- 0.95             # Centile value of PA analysis

## PARALLEL ANALYSIS (qevpea for the centile criterion, mevpea for the
## mean criterion)
aparameter <- parallel(var      = variables,
                        subject = nsubjects,
                        rep      = rep,
                        cent     = cent
                        )$eigen$qevpea # The 95 centile

## NUMBER OF FACTORS RETAINED ACCORDING TO DIFFERENT RULES
results    <- nScre(x=eigenvalues, aparameter=aparameter)
results
summary(results)

## PLOT ACCORDING TO THE nScre CLASS
```

```
plotnScrees(results)
```

---

```
nScreesObjectMethods
```

*Utility Functions for nScrees Class Objects*

---

## Description

Utility functions for nScrees class objects. Some of these functions are already implemented in the nFactors package, but are easier to use with generic functions like these.

## Usage

```
## S3 method for class 'nScrees':
is      (object)
## S3 method for class 'nScrees':
plot    (x, ...)
## S3 method for class 'nScrees':
print   (x, ...)
## S3 method for class 'nScrees':
summary(object, ...)
```

## Arguments

x	nScrees: an object of the class nScrees
object	nScrees: an object of the class nScrees
...	variable: additional parameters to give to the print function with print.nScrees, the plotnScrees with plot.nScrees or to the summary function with summary.nScrees

## Value

Generic functions for the nScrees class:

is.nScrees	logical: is the object of the class nScrees?
plot.nScrees	graphic: plots a figure according to the plotnScrees function
print.nScrees	numeric: vector of the number of components/factors to retain: same as the Components vector from the nScrees object
summary.nScrees	data.frame: details of the results from a nScrees analysis: same as the Analysis data.frame from the nScrees object, but with easier control of the number of decimals with the digits parameter

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## References

Raiche, G., Riopel, M. and Blais, J.-G. (2006). *Non graphical solutions for the Cattell's scree test*. Paper presented at the International Annual meeting of the Psychometric Society, Montreal. [<http://www.er.uqam.ca/nobel/r17165/RECHERCHE/COMMUNICATIONS/>]

## See Also

[plotuScree](#), [plotnScree](#), [parallel](#), [plotParallel](#),

## Examples

```
## INITIALISATION
data(dFactors)                    # Load the nFactors dataset
attach(dFactors)
vect      <- Raiche                # Use the example from Raiche
eigenvalues <- vect$eigenvalues    # Extract the observed eigenvalues
nsubjects  <- vect$nsubjects      # Extract the number of subjects
variables  <- length(eigenvalues) # Compute the number of variables
rep        <- 100                 # Number of replications for the parallel analysis
cent       <- 0.95                # Centile value of the parallel analysis

## PARALLEL ANALYSIS (gevpea for the centile criterion, mevpea for the mean criterion)
aparameter <- parallel(var      = variables,
                      subject = nsubjects,
                      rep      = rep,
                      cent     = cent
                      )$eigen$gevpea # The 95 centile

## NUMBER OF FACTORS RETAINED ACCORDING TO DIFFERENT RULES
results    <- nScree(x=eigenvalues, aparameter=aparameter)

is.nScree(results)
results
summary(results)

## PLOT ACCORDING TO THE nScree CLASS
plot(results)
```

---

nSeScree

*Standard Error Scree and Coefficient of Determination Procedures to Determine the Number of Components/Factors*

---

## Description

This function computes the *seScree* ( $S_{Y \bullet X}$ ) indices (Zoski and Jurs, 1996) and the coefficient of determination indices of Nelson (2005)  $R^2$  for determining the number of components/factors to retain.

## Usage

```
nSeScree(x, cor=TRUE, model="components", details=TRUE, r2limen=0.75, ...)
```

## Arguments

<code>x</code>	numeric: eigenvalues.
<code>cor</code>	logical: if TRUE computes eigenvalues from a correlation matrix, else from a covariance matrix
<code>model</code>	character: "components" or "factors"
<code>details</code>	logical: if TRUE also returns details about the computation for each eigenvalue.
<code>r2limen</code>	numeric: criterion value retained for the coefficient of determination indices.
<code>...</code>	variable: additional parameters to give to the <code>eigenComputes</code> and <code>cor</code> or <code>cov</code> functions

## Details

The Zoski and Jurs  $S_{Y \bullet X}$  index is the standard error of the estimate (predicted) eigenvalues by the regression from the  $(k + 1, \dots, p)$  subsequent ranks of the eigenvalues. The standard error is computed as:

$$(1) \quad S_{Y \bullet X} = \sqrt{\frac{(\lambda_k - \hat{\lambda}_k)^2}{p-2}}$$

A value of  $1/p$  is chosen as the criteria to determine the number of components or factors to retain,  $p$  corresponding to the number of variables.

The Nelson  $R^2$  index is simply the multiple regression coefficient of determination for the  $k + 1, \dots, p$  eigenvalues. Note that Nelson didn't give formal prescriptions for the criteria for this index. He only suggested that a value of 0.75 or more must be considered. More is to be done to explore adequate values.

## Value

<code>nFactors</code>	numeric: number of components/factors retained by the seScree procedure.
<code>details</code>	numeric: matrix of the details for each index.

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## References

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**See Also**

[plotuScree](#), [nScree](#), [plotnScree](#), [plotParallel](#)

**Examples**

```
## SIMPLE EXAMPLE OF SESCREE AND R2 ANALYSIS

data(dFactors)
eig      <- dFactors$Raiche$eigenvalues

results  <- nSeScree(eig)
results

plotuScree(eig, main=paste(results$nFactors[1], " or ", results$nFactors[2],
                           " factors retained by the sescree and R2 procedures",
                           sep=""))
```

---

parallel

---

*Parallel Analysis of a Correlation or Covariance Matrix*


---

**Description**

This function gives the distribution of the eigenvalues of correlation or a covariance matrices of random uncorrelated standardized normal variables. The mean and a selected quantile of this distribution are returned.

**Usage**

```
parallel(subject = 100,
         var      = 10,
         rep      = 100,
         cent     = 0.05,
         quantile = cent,
         model     = "components",
         sd       = diag(1, var),
         ...)
```

**Arguments**

subject	numeric: number of subjects (default is 100)
var	numeric: number of variables (default is 10)
rep	numeric: number of replications of the correlation matrix (default is 100)
cent	depreciated numeric (use quantile instead): quantile of the distribution on which the decision is made (default is 0.05)
quantile	numeric: quantile of the distribution on which the decision is made (default is 0.05)
model	character: "components" or "factors"
sd	numeric: vector of standard deviations of the simulated variables (for a parallel analysis on a covariance matrix)
...	variable: other parameters for the "mvrnorm", <code>corr</code> or <code>cov</code> functions

## Details

Note that if the decision is based on a quantile value rather than on the mean, care must be taken with the number of replications (`rep`). In fact, the smaller the quantile (`cent`), the bigger the number of necessary replications.

## Value

`eigen` Data frame consisting of the mean and the quantile of the eigenvalues distribution

`eigen$mevpea` Mean of the eigenvalues distribution

`eigen$sevpea` Standard deviation of the eigenvalues distribution

`eigen$qevpea` quantile of the eigenvalues distribution

`eigen$$sevpea` Standard error of the quantile of the eigenvalues distribution

`subject` Number of subjects

`variables` Number of variables

`centile` Selected quantile

Otherwise, returns a summary of the parallel analysis.

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## See Also

[plotUScree](#), [nScree](#), [plotnScree](#), [plotParallel](#)

## Examples

```
## SIMPLE EXAMPLE OF A PARALLEL ANALYSIS
## OF A CORRELATION MATRIX WITH ITS PLOT
data(dFactors)
eig      <- dFactors$Raiche$eigenvalues
subject  <- dFactors$Raiche$nsubjects
var      <- length(eig)
rep      <- 100
quantile <- 0.95
```

```

results <- parallel(subject, var, rep, quantile)

results

## IF THE DECISION IS BASED ON THE CENTILE USE qevpea INSTEAD
## OF mevpea ON THE FIRST LINE OF THE FOLLOWING CALL
plotuScree(x      = eig,
           main = "Parallel Analysis"
          )

lines(1:var,
      results$eigen$qevpea,
      type="b",
      col="green"
     )

## ANOTHER SOLUTION IS SIMPLY TO
plotParallel(results)

```

---

plotnScree

*Scree Plot According to a nScree Object Class*


---

## Description

Plot a scree plot adding information about a non graphical nScree analysis.

## Usage

```

plotnScree(nScree,
           legend = TRUE,
           ylab   = "Eigenvalues",
           xlab   = "Components",
           main    = "Non Graphical Solutions to Scree Test"
          )

```

## Arguments

nScree	Results of a previous nScree analysis
legend	Logical indicator of the presence or not of a legend
xlab	Label of the x axis (default to "Component")
ylab	Label of the y axis (default to "Eigenvalue")
main	Main title (default to "Non Graphical Solutions to the Scree Test")

## Value

Nothing returned.

**Author(s)**

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**References**

Raiche, G., Riopel, M. and Blais, J.-G. (2006). *Non graphical solutions for the Cattell's scree test*. Paper presented at the International Annual meeting of the Psychometric Society, Montreal.  
[\[http://www.er.uqam.ca/nobel/r17165/RECHERCHE/COMMUNICATIONS/\]](http://www.er.uqam.ca/nobel/r17165/RECHERCHE/COMMUNICATIONS/)

**See Also**

[plotuScree](#), [nScree](#), [plotParallel](#), [parallel](#)

**Examples**

```
## INITIALISATION
data(dFactors)                # Load the nFactors dataset
attach(dFactors)
vect      <- Raiche           # Use the second example from Buja and Eyuboglu
                                # (1992, p. 519, nsubjects not specified by them)
eigenvalues <- vect$eigenvalues # Extract the observed eigenvalues
nsubjects  <- vect$nsubjects   # Extract the number of subjects
variables  <- length(eigenvalues) # Compute the number of variables
rep        <- 100              # Number of replications for the parallel analysis
cent       <- 0.95             # Centile value of the parallel analysis

## PARALLEL ANALYSIS (qevpea for the centile criterion, mevpea for the mean criterion)
aparaallel <- parallel(var      = variables,
                      subject = nsubjects,
                      rep      = rep,
                      cent     = cent)$eigen$qevpea # The 95 centile

## NUMBER OF FACTORS RETAINED ACCORDING TO DIFFERENT RULES
results <- nScree(eig      = eigenvalues,
                 paraallel = aparaallel
                 )

results

## PLOT ACCORDING TO THE nScree CLASS
plotnScree(results)
```

---

plotParallel

---

*Plot a Parallel Analysis Class Object*


---

**Description**

Plot a scree plot adding information about a parallel analysis.

**Usage**

```
plotParallel(parallel,
             eig     = NA,
             x       = eig,
             model    = "components",
             legend   = TRUE,
             ylab     = "Eigenvalues",
             xlab     = "Components",
             main     = "Parallel Analysis",
             ...
            )
```

**Arguments**

<code>parallel</code>	numeric: vector of the results of a previous parallel analysis
<code>eig</code>	depreciated parameter: eigenvalues to analyse (not used if <code>x</code> is used, recommended)
<code>x</code>	numeric: a vector of eigenvalues, a matrix of correlations or of covariances or a <code>data.frame</code> of data
<code>model</code>	character: "components" or "factors"
<code>main</code>	character: title of the plot
<code>xlab</code>	character: label of the x axis
<code>ylab</code>	character: label of the y axis
<code>legend</code>	logical: indicator of the presence or not of a legend
<code>...</code>	variable: additionnal parameters to give to the <code>cor</code> or <code>cov</code> functions

**Details**

If `eig` is `FALSE` the plot shows only the parallel analysis without eigenvalues.

**Value**

Nothing returned.

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**References**

Raiche, G., Riopel, M. and Blais, J.-G. (2006). *Non graphical solutions for the Cattell's scree test*. Paper presented at the International Annual meeting of the Psychometric Society, Montreal. [<http://www.er.uqam.ca/nobel/r17165/RECHERCHE/COMMUNICATIONS/>]

**See Also**

[plotuScree](#), [nScree](#), [plotnScree](#), [parallel](#)

**Examples**

```
## SIMPLE EXAMPLE OF A PARALLEL ANALYSIS
## OF A CORRELATION MATRIX WITH ITS PLOT
data(dFactors)
eig      <- dFactors$Raiche$eigenvalues
subject  <- dFactors$Raiche$nsubjects
var      <- length(eig)
rep      <- 100
cent     <- 0.95
results  <- parallel(subject, var, rep, cent)

results

## PARALLEL ANALYSIS SCREE PLOT
plotParallel(results, x=eig)
plotParallel(results)
```

---

plotuScree

*Plot of the Usual Cattell's Scree Test*


---

**Description**

uScree plot a usual scree test of the eigenvalues of a correlation matrix.

**Usage**

```
plotuScree(Eigenvalue,
           x      = Eigenvalue,
           model  = "components",
           ylab   = "Eigenvalues",
           xlab   = "Components",
           main   = "Scree Plot",
           ...
           )
```

**Arguments**

Eigenvalue	depreciated parameter: eigenvalues to analyse (not used if x is used, recommended)
x	numeric: a vector of eigenvalues, a matrix of correlations or of covariances or a data.frame of data
model	character: "components" or "factors"
main	character: title of the plot (default is Scree Plot)
xlab	character: label of the x axis (default is Component)
ylab	character: label of the y axis (default is Eigenvalue)
...	variable: additionnal parameters to give to the eigenComputes function

**Value**

Nothing returned with this function.

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**References**

Cattell, R. B. (1966). The scree test for the number of factors. *Multivariate Behavioral Research*, 1, 245-276.

**See Also**

[nScree](#), [parallel](#)

**Examples**

```
## SCREE PLOT
data(dFactors)
attach(dFactors)
eig = Cliff1$eigenvalues
plotuScree(x=eig)
```

---

principalAxis	<i>Principal Axis Analysis</i>
---------------	--------------------------------

---

**Description**

The `PrincipalAxis` function returns a principal axis analysis without iterated communalities estimates. Three different choices of communalities estimates are given: maximum correlation, multiple correlation or estimates based on the sum of the squared principal component analysis loadings. Generally statistical packages initialize the communalities at the multiple correlation value (usual inverse or generalized inverse). Unfortunately, this strategy cannot deal with singular correlation or covariance matrices. If a generalized inverse, the maximum correlation or the estimated communalities based on the sum of loading are used instead, then a solution can be computed.

**Usage**

```
principalAxis(R,
              nFactors=2,
              communalities="component")
```

**Arguments**

R                      numeric: correlation or covariance matrix

nFactors              numeric: number of factors to retain

communalities              character: initial values for communalities ("component", "maxr", "ginv" or "multiple")

**Value**

values                  numeric: variance of each component/factor

varExplained          numeric: variance explained by each component/factor

varExplained          numeric: cumulative variance explained by each component/factor

loadings                numeric: loadings of each variable on each component/factor

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**References**

Kim, J.-O. and Mueller, C. W. (1978). *Introduction to factor analysis. What it is and how to do it.* Beverly Hills, CA: Sage.

Kim, J.-O. and Mueller, C. W. (1987). *Factor analysis. Statistical methods and practical issues.* Beverly Hills, CA: Sage.

**See Also**

[componentAxis](#), [iterativePrincipalAxis](#), [rRecovery](#)

**Examples**

```
# .....
# Example from Kim and Mueller (1978, p. 10)
# Population: upper diagonal
# Simulated sample: lower diagonal
R <- matrix(c( 1.000, .6008, .4984, .1920, .1959, .3466,
               .5600, 1.000, .4749, .2196, .1912, .2979,
               .4800, .4200, 1.000, .2079, .2010, .2445,
               .2240, .1960, .1680, 1.000, .4334, .3197,
               .1920, .1680, .1440, .4200, 1.000, .4207,
               .1600, .1400, .1200, .3500, .3000, 1.000),
            nrow=6, byrow=TRUE)

# Factor analysis: Principal axis factoring
# without iterated communalities -
# Kim and Mueller (1978, p. 21)
# Replace upper diagonal with lower diagonal
RU <- diagReplace(R, upper=TRUE)
principalAxis(RU, nFactors=2, communalities="component")
principalAxis(RU, nFactors=2, communalities="maxr")
```



```

principalAxis(RU, nFactors=2, communalities="multiple")
# Replace lower diagonal with upper diagonal
RL <- diagReplace(R, upper=FALSE)
principalAxis(RL, nFactors=2, communalities="component")
principalAxis(RL, nFactors=2, communalities="maxr")
principalAxis(RL, nFactors=2, communalities="multiple")
# .....

```

---

principalComponents

*Principal Component Analysis*


---

## Description

The `principalComponents` function returns a principal component analysis. Other R functions give the same results, but `principalComponents` is customized mainly for the other factor analysis functions available in the **nfactors** package. In order to retain only a small number of components the `componentAxis` function has to be used.

## Usage

```
principalComponents(R)
```

## Arguments

R                      numeric: correlation or covariance matrix

## Value

values                numeric: variance of each component  
varExplained        numeric: variance explained by each component  
varExplained        numeric: cumulative variance explained by each component  
loadings             numeric: loadings of each variable on each component

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## References

Joliffe, I. T. (2002). *Principal components analysis* (2th Edition). New York, NJ: Springer-Verlag.  
Kim, J.-O. and Mueller, C. W. (1978). *Introduction to factor analysis. What it is and how to do it*. Beverly Hills, CA: Sage.  
Kim, J.-O. and Mueller, C. W. (1987). *Factor analysis. Statistical methods and practical issues*. Beverly Hills, CA: Sage.

See Also

[componentAxis](#), [iterativePrincipalAxis](#), [rRecovery](#)

Examples

```
# .....  
# Example from Kim and Mueller (1978, p. 10)  
# Population: upper diagonal  
# Simulated sample: lower diagonal  
R <- matrix(c( 1.000, .6008, .4984, .1920, .1959, .3466,  
              .5600, 1.000, .4749, .2196, .1912, .2979,  
              .4800, .4200, 1.000, .2079, .2010, .2445,  
              .2240, .1960, .1680, 1.000, .4334, .3197,  
              .1920, .1680, .1440, .4200, 1.000, .4207,  
              .1600, .1400, .1200, .3500, .3000, 1.000),  
            nrow=6, byrow=TRUE)  
  
# Factor analysis: Principal component -  
# Kim et Mueller (1978, p. 21)  
# Replace upper diagonal with lower diagonal  
RU <- diagReplace(R, upper=TRUE)  
principalComponents(RU)  
  
# Replace lower diagonal with upper diagonal  
RL <- diagReplace(R, upper=FALSE)  
principalComponents(RL)  
# .....
```

---

rRecovery	<i>Test of Recovery of a Correlation or a Covariance matrix from a Factor Analysis Solution</i>
-----------	---

---

Description

The `rRecovery` function returns a verification of the quality of the recovery of the initial correlation or covariance matrix by the factor solution.

Usage

```
rRecovery(R, loadings, diagCommunalities=FALSE)
```

Arguments

- R                    numeric: initial correlation or covariance matrix
- loadings            numeric: loadings from a factor analysis solution
- diagCommunalities   logical: if TRUE, the correlation between the initial solution and the estimated one will use a correlation of one in the diagonal. If FALSE (default) the diagonal is not used in the computation of this correlation.

**Value**

R	numeric: initial correlation or covariance matrix
recoveredR	numeric: recovered estimated correlation or covariance matrix
difference	numeric: difference between initial and recovered estimated correlation or covariance matrix
cor	numeric: Pearson correlation between initial and recovered estimated correlation or covariance matrix. Computations depend on the logical value of the <code>communalities</code> argument.

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**See Also**

[componentAxis](#), [iterativePrincipalAxis](#), [principalAxis](#)

**Examples**

```
# .....
# Example from Kim and Mueller (1978, p. 10)
# Population: upper diagonal
# Simulated sample: lower diagonal
R <- matrix(c( 1.000, .6008, .4984, .1920, .1959, .3466,
               .5600, 1.000, .4749, .2196, .1912, .2979,
               .4800, .4200, 1.000, .2079, .2010, .2445,
               .2240, .1960, .1680, 1.000, .4334, .3197,
               .1920, .1680, .1440, .4200, 1.000, .4207,
               .1600, .1400, .1200, .3500, .3000, 1.000),
            nrow=6, byrow=TRUE)

# Replace upper diagonal with lower diagonal
RU <- diagReplace(R, upper=TRUE)
nFactors <- 2
loadings <- principalAxis(RU, nFactors=nFactors,
                          communalities="component")$loadings
rComponent <- rRecovery(RU, loadings, diagCommunalities=FALSE)$cor

loadings <- principalAxis(RU, nFactors=nFactors,
                          communalities="maxr")$loadings
rMaxr <- rRecovery(RU, loadings, diagCommunalities=FALSE)$cor

loadings <- principalAxis(RU, nFactors=nFactors,
                          communalities="multiple")$loadings
rMultiple <- rRecovery(RU, loadings, diagCommunalities=FALSE)$cor

round(c(rComponent = rComponent,
        rMaxr      = rMaxr,
        rMultiple  = rMultiple), 3)
# .....
```

---

structureSim	<i>Population or Simulated Sample Correlation Matrix from a Given Factor Structure Matrix</i>
--------------	---

---

### Description

The `structureSim` function returns a population and a sample correlation matrices from a pre-defined congeneric factor structure.

### Usage

```
structureSim(fload, reppar=30, repsim=100, N, quantile=0.95,
             model="components", adequacy=FALSE, details=TRUE,
             r2limen=0.75, all=FALSE)
```

### Arguments

<code>fload</code>	matrix: loadings of the factor structure
<code>reppar</code>	numeric: number of replications for the parallel analysis
<code>repsim</code>	numeric: number of replications of the matrix correlation simulation
<code>N</code>	numeric: number of subjects
<code>quantile</code>	numeric: quantile for the parallel analysis
<code>model</code>	character: "components" or "factors"
<code>adequacy</code>	logical: if TRUE prints the recovered population matrix from the factor structure
<code>details</code>	logical: if TRUE outputs details of the <code>repsim</code> simulations
<code>r2limen</code>	numeric: R2 limen value for the R2 Nelson index
<code>all</code>	logical: if TRUE computes the Bentler and Yuan index (very long computing time to consider)

### Value

<code>values</code>	the output depends of the logical value of <code>details</code> . If FALSE, returns only statistics about the eigenvalues: mean, median, quantile, standard deviation, minimum and maximum. If TRUE, returns also details about the <code>repsim</code> simulations. If <code>adequacy = TRUE</code> returns the recovered factor structure
---------------------	---

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## References

Zwick, W. R. and Velicer, W. F. (1986). Comparison of five rules for determining the number of components to retain. *Psychological Bulletin*, 99, 432-442.

## See Also

[principalComponents](#), [iterativePrincipalAxis](#), [rRecovery](#)

## Examples

```
## Not run:
# .....
# Example inspired from Zwick and Velicer (1986, table 2, p. 437)
# .....
nFactors <- 3
unique <- 0.2
loadings <- 0.5
nsubjects <- 180
repsim <- 30
zwick <- generateStructure(var=36, mjc=nFactors, pmjc=12,
                          loadings=loadings,
                          unique=unique)
# .....

# Produce statistics about a replication of a parallel analysis on
# 30 sampled correlation matrices

mzwick.fa <- structureSim(fload=as.matrix(zwick), reppar=30,
                        repsim=repsim, N=nsubjects, quantile=0.5,
                        model="factors")

mzwick <- structureSim(fload=as.matrix(zwick), reppar=30,
                      repsim=repsim, N=nsubjects, quantile=0.5, all=TRUE)

# Very long execution time that could be used only with model="components"
# mzwick <- structureSim(fload=as.matrix(zwick), reppar=30,
#                       repsim=repsim, N=nsubjects, quantile=0.5, all=TRUE)
#

par(mfrow=c(2,1))
plot(x=mzwick, nFactors=nFactors, index=c(1:14), cex.axis=0.7, col="red")
plot(x=mzwick.fa, nFactors=nFactors, index=c(1:11), cex.axis=0.7, col="red")
par(mfrow=c(1,1))

par(mfrow=c(2,1))
boxplot(x=mzwick, nFactors=3, cex.axis=0.8, vLine="blue", col="red")
boxplot(x=mzwick.fa, nFactors=3, cex.axis=0.8, vLine="blue", col="red",
        xlab="Components")
par(mfrow=c(1,1))
# .....

## End(Not run)
```

---

structureSimObjectMethods

*Utility Functions for nScree Class Objects*


---

## Description

Utility functions for `structureSim` class objects. Note that with the `plot.structureSim` a dotted black vertical line shows the median number of factors retained by all the different indices.

## Usage

```
## S3 method for class 'structureSim':
boxplot (x, nFactors=NULL, eigenSelect=NULL,
         vLine="green", xlab="Factors",
         ylab="Eigenvalues", main="Eigen Box Plot", ...)

## S3 method for class 'structureSim':
is      (object)

## S3 method for class 'structureSim':
plot    (x, nFactors=NULL, index=NULL,
         main="Index Acuracy Plot", ...)

## S3 method for class 'structureSim':
print   (x, index=NULL, ...)

## S3 method for class 'structureSim':
summary (object, index=c(1:15), eigenSelect=NULL, ...)
```

## Arguments

<code>eigenSelect</code>	numeric: vector of the index of the selected eigenvalues
<code>index</code>	numeric: vector of the index of the selected indices
<code>main</code>	character: main title
<code>nFactors</code>	numeric: if known, number of factors
<code>object</code>	structureSim: an object of the class <code>structureSim</code>
<code>vLine</code>	character: color of the vertical indicator line of the initial number of factors in the eigen boxplot
<code>x</code>	structureSim: an object of the class <code>structureSim</code>
<code>xlab</code>	character: x axis label
<code>ylab</code>	character: y axis label
<code>...</code>	variable: additionnal parameters to give to the <code>boxplot</code> , <code>plot</code> , <code>print</code> and <code>summary</code> functions.

## Value

Generic functions for the `structureSim` class:

`boxplot.structureSim`

graphic: plots an eigen boxplot

`is.structureSim`

logical: is the object of the class `structureSim`?

```

plot.structureSim
    graphic: plots an index accuracy plot
print.structureSim
    numeric: data.frame of statistics about the number of components/factors to
            retain according to different indices following a structureSim simulation
summary.structureSim
    list: two data.frame, the first with the details of the simulated eigenvalues, the
         second with the details of the simulated indices

```

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### References

Raiche, G., Riopel, M. and Blais, J.-G. (2006). *Non graphical solutions for the Cattell's scree test*. Paper presented at the International Annual meeting of the Psychometric Society, Montreal.  
[\[http://www.er.uqam.ca/nobel/r17165/RECHERCHE/COMMUNICATIONS/\]](http://www.er.uqam.ca/nobel/r17165/RECHERCHE/COMMUNICATIONS/)

### See Also

[nFactors-package](#)

### Examples

```

## Not run:
## INITIALISATION
library(xtable)
library(nFactors)
nFactors <- 3
unique <- 0.2
loadings <- 0.5
nsubjects <- 180
repsim <- 10
var <- 36
pmjc <- 12
reppar <- 10
zwick <- generateStructure(var=var, mjc=nFactors, pmjc=pmjc,
                           loadings=loadings,
                           unique=unique)

## SIMULATIONS
mzwick <- structureSim(fload=as.matrix(zwick), reppar=reppar,
                      repsim=repsim, details=TRUE,
                      N=nsubjects, quantile=0.5)

## TEST OF structureSim METHODS
is(mzwick)
summary(mzwick, index=1:5, eigenSelect=1:10, digits=3)
print(mzwick, index=1:10)
plot(x=mzwick, index=c(1:10), cex.axis=0.7, col="red")
boxplot(x=mzwick, nFactors=3, vLine="blue", col="red")

```

```
## End (Not run)
```

---

studySim	<i>Simulation Study from Given Factor Structure Matrices and Conditions</i>
----------	---

---

## Description

The `structureSim` function returns statistical results from simulations from predefined congeneric factor structures. The main ideas come from the methodology applied by Zwick and Velicer (1986).

## Usage

```
studySim(var, nFactors, pmjc, loadings, unique, N, repsim, reppar,
          stats=1, quantile=0.5, model="components", r2limen=0.75,
          all=FALSE, dir=NA, trace=TRUE)
```

## Arguments

<code>var</code>	numeric: vector of the number of variables
<code>nFactors</code>	numeric: vector of the number of components/factors
<code>pmjc</code>	numeric: vector of the number of major loadings on each component/factor
<code>loadings</code>	numeric: vector of the major loadings on each component/factor
<code>unique</code>	numeric: vector of the unique loadings on each component/factor
<code>N</code>	numeric: vector of the number of subjects/observations
<code>repsim</code>	numeric: number of replications of the matrix correlation simulation
<code>reppar</code>	numeric: number of replications for the parallel and permutation analysis
<code>stats</code>	numeric: vector of the statistics to return: mean(1), median(2), sd(3), quantile(4), min(5), max(6)
<code>quantile</code>	numeric: quantile for the parallel and permutation analysis
<code>model</code>	character: "components" or "factors"
<code>r2limen</code>	numeric: R2 limen value for the R2 Nelson index
<code>all</code>	logical: if TRUE computes the Bentler and Yuan index (very long computing time to consider)
<code>dir</code>	character: directory where to save output. Default to NA
<code>trace</code>	logical: if TRUE outputs details of the status of the simulations

## Value

<code>values</code>	Returns selected statistics about the number of components/factors to retain: mean, median, quantile, standard deviation, minimum and maximum.
---------------------	--



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**References**

Zwick, W. R. and Velicer, W. F. (1986). Comparison of five rules for determining the number of components to retain. *Psychological Bulletin*, 99, 432-442.

**See Also**

[generateStructure](#), [structureSim](#)

**Examples**

```
## Not run:
# .....
# Example inspired from Zwick and Velicer (1986)
# Very long computing time
# .....

# 1. Initialisation
# reppar      <- 30
# repsim      <- 5
# quantile    <- 0.50

# 2. Simulations
# X           <- studySim(var=36,nFactors=3, pmjc=c(6,12), loadings=c(0.5,0.8),
#                        unique=c(0,0.2), quantile=quantile,
#                        N=c(72,180), repsim=repsim, reppar=reppar,
#                        stats=c(1:6))

# 3. Results (first 10 results)
# print(X[1:10,1:14],2)
# names(X)

# 4. Study of the error done in the determination of the number
#    of components/factors. A positive value is associated to over
#    determination.
# results      <- X[X$stats=="mean",]
# residuals    <- results[,c(11:25)] - X$nfactors
# BY           <- c("nsubjects","var","loadings")
# round(aggregate(residuals, by=results[BY], mean),0)

## End(Not run)
```

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