Package ‘MANOVA.RM’

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Type  Package
Title  Resampling-Based Analysis of Multivariate Data and Repeated Measures Designs
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Depends  R (>= 3.4.0)
Description  Implemented are various tests for semi-parametric repeated measures and general MANOVA designs that do neither assume multivariate normality nor covariance homogeneity, i.e., the procedures are applicable for a wide range of general multivariate factorial designs. In addition to asymptotic inference methods, novel bootstrap and permutation approaches are implemented as well. These provide more accurate results in case of small to moderate sample sizes. Furthermore, post-hoc comparisons are provided for the multivariate analyses. Friedrich, S., Konietschke, F. and Pauly, M. (2019) <doi:10.32614/RJ-2019-051>.
License  GPL-2 | GPL-3
Imports  plyr (>= 1.8.4), MASS (>= 7.3-51), Matrix (>= 1.2-17), magic (>= 1.5-9), plotrix (>= 3.5-12), parallel, methods, ellipse, multcomp, data.table (>= 1.12.6)
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Encoding  UTF-8
RoxygenNote  7.1.2
VignetteBuilder  knitr, rmarkdown
URL  https://github.com/smn74/MANOVA.RM
BugReports  https://github.com/smn74/MANOVA.RM/issues
NeedsCompilation  no
conf.reg

The conf.reg() function calculates confidence regions for contrasts in multivariate factorial designs. In the two-dimensional case, confidence ellipsoids can be plotted via the generic plot() function.

Description

The conf.reg() function calculates confidence regions for contrasts in multivariate factorial designs. In the two-dimensional case, confidence ellipsoids can be plotted via the generic plot() function.

Usage

conf.reg(object, nullhypo)

Arguments

object A MANOVA object.
nullhypo In scenarios with more than one factor, the null hypothesis, i.e., the contrast of interest must be specified.
**Value**

A `confreg` object containing the following components:

- **center**: The center of the confidence ellipsoid.
- **scale**: The scaling factors for the axis of the confidence ellipsoid calculated as $\sqrt{\lambda * c/N}$, where $\lambda$ are the eigenvalues, $c$ denotes the bootstrap quantile and $N$ is the total sample size. See Friedrich and Pauly (2018) for details.
- **eigenvectors**: The corresponding eigenvectors, which determine the axes of the ellipsoid.

**References**


**Examples**

```r
data(EEG)
EEG_mod <- MANOVA(resp ~ sex * diagnosis,
    data = EEG, subject = "id", resampling = "paramBS",
    alpha = 0.05, iter = 10, CPU = 1)
conf.reg(EEG_mod, nullhypo = "sex")
```

**Description**

At the Department of Neurology, University Clinic of Salzburg, 160 patients were diagnosed with either AD, MCI, or SCC, based on neuropsychological diagnostics. This data set contains z-scores for brain rate and Hjorth complexity, each measured at frontal, temporal and central electrode positions and averaged across hemispheres. In addition to standardization, complexity values were multiplied by -1 in order to make them more easily comparable to brain rate values: For brain rate we know that the values decrease with age and pathology, while Hjorth complexity values are known to increase with age and pathology. The three between-subjects factors considered were sex (men vs. women), diagnosis (AD vs. MCI vs. SCC), and age (< 70 vs. >= 70 years). Additionally, the within-subjects factors region (frontal, temporal, central) and feature (brain rate, complexity) structure the response vector.

**Usage**

```r
data(EEG)
```
Format

A data frame with 960 rows and 7 variables:

- **resp**: EEG measurements
- **sex**: sex of the patient
- **age**: age of the patient, coded as 0 for less than 70 years and 1 for \( \geq 70 \) years
- **diagnosis**: neuropsychological diagnosis, AD for Alzheimer’s Disease, MCI for mild cognitive impairment or SCC for subjective cognitive complaints without clinically significant deficits
- **region**: brain region of the EEG measurements, one of "temporal", "frontal" and "central"
- **feature**: feature of the EEG measurements, either "brainrate" or "complexity"
- **id**: Subject id

Source


Examples

```r
library(ggplot2)
ggplot(EEG, aes(x=sex, y=resp)) + geom_point(alpha=0.5) + facet_grid(region+feature~diagnosis) +
stat_summary(fun.y = mean, fun.ymin = min, fun.ymax = max, colour = "red")
```

Description

At the Department of Neurology, University Clinic of Salzburg, 160 patients were diagnosed with either AD, MCI, or SCC, based on neuropsychological diagnostics. This data set contains z-scores for brain rate and Hjorth complexity, each measured at frontal, temporal and central electrode positions and averaged across hemispheres. In addition to standardization, complexity values were multiplied by -1 in order to make them more easily comparable to brain rate values: For brain rate we know that the values decrease with age and pathology, while Hjorth complexity values are known to increase with age and pathology. The three between-subjects factors considered were sex (men vs. women), diagnosis (AD vs. MCI vs. SCC), and age (< 70 vs. \( \geq 70 \) years). Additionally, the within-subjects factors region (frontal, temporal, central) and feature (brain rate, complexity) structure the response vector.

Usage

```r
data(EEGwide)
```
Format

A data frame with 160 rows and 9 variables:

- **brainrate_temporal**: EEG measurements for brainrate in temporal regions
- **brainrate_frontal**: EEG measurements for brainrate in frontal regions
- **brainrate_central**: EEG measurements for brainrate in central regions
- **complexity_temporal**: EEG measurements for complexity in temporal regions
- **complexity_frontal**: EEG measurements for complexity in frontal regions
- **complexity_central**: EEG measurements for complexity in central regions
- **sex**: sex of the patient
- **age**: age of the patient
- **diagnosis**: neuropsychological diagnosis, AD for Alzheimer’s Disease, MCI for mild cognitive impairment or SCC for subjective cognitive complaints without clinically significant deficits
- **AgeGroup**: categorized age, coded as 0 for less than 70 years and 1 for >= 70 years

Details

Note that this data set contains exactly the same data as the data set 'EEG’, only the format is different. The transformation between the different formats can be achieved using, e.g., the tidyverse package.

Source


@examples library("ggplot2") qplot(data = EEGwide, diagnosis)

GUI.MANOVA

A graphical user interface for the MANOVA() function

Description

This function provides a graphical user interface for calculating statistical tests for multivariate data.

Usage

GUI.MANOVA()

Details

The function produces a GUI for the calculation of the test statistics. Data can be loaded via the "load data" button. The formula, number of resampling iterations (default: 10,000) and the significance level alpha (default: 0.05) need to be specified. Furthermore, the column name specifying the subjects in the data needs to be provided. For the resampling methods, the user can choose between a parametric bootstrap approach (see e.g. Konietschke et al. (2015)) and a Wild bootstrap using Rademacher weights (see e.g. Bathke et al. (2018)).
Description

This function provides a graphical user interface for calculating statistical tests for multivariate data.

Usage

GUI.MANOVAwide()

Details

The function produces a GUI for the calculation of the test statistics. Data can be loaded via the "load data" button. The formula, number of resampling iterations (default: 10,000) and the significance level alpha (default: 0.05) need to be specified. For the resampling methods, the user can choose between a parametric bootstrap approach (see e.g. Konietschke et al. (2015)) and a Wild bootstrap using Rademacher weights (see e.g. Bathke et al. (2018)).

Description

This function provides a graphical user interface for calculating statistical tests in repeated measures designs.

Usage

GUI.RM()

Details

The function produces a GUI for the calculation of the test statistics and for plotting. Data can be loaded via the "load data" button. The formula, number of resampling iterations (default: 10,000) and the significance level alpha (default: 0.05) need to be specified. Furthermore, the number of sub-plot factors and the column name specifying the subjects in the data need to be provided. For the resampling methods, the user can choose between a permutation approach (Friedrich et al. (2017)), a parametric bootstrap approach (Konietschke et al. (2015)) and a Wild bootstrap using Rademacher weights (Bathke et al. (2018)). If the plot option is chosen, an additional window opens containing information on the plots.
MANOVA

Tests for Multivariate Data in Semi-Parametric Factorial Designs

Description

The MANOVA function calculates the Wald-type statistic (WTS) and a modified ANOVA-type statistic (MATS) as well as resampling versions of these test statistics for semi-parametric multivariate data.

Usage

MANOVA(
  formula,
  data,
  subject,
  iter = 10000,
  alpha = 0.05,
  resampling = "paramBS",
  para = FALSE,
  CPU,
  seed,
  nested.levels.unique = FALSE,
  dec = 3
)

Arguments

formula A model formula object. The left hand side contains the response variable and the right hand side contains the factor variables of interest.

data A data.frame, list or environment containing the variables in formula. Data must be in long format and must not contain missing values.

subject The column name of the subjects in the data.

iter The number of iterations used for calculating the resampled statistic. The default option is 10,000.

alpha A number specifying the significance level; the default is 0.05.

resampling The resampling method to be used, one of "paramBS" (parametric bootstrap approach) and "WildBS" (wild bootstrap approach with Rademacher weights).

para If parallel computing should be used. Default is FALSE.

CPU The number of cores used for parallel computing. If not specified, cores are detected via detectCores.

seed A random seed for the resampling procedure. If omitted, no reproducible seed is set.
nested.levels.unique
A logical specifying whether the levels of the nested factor(s) are labeled uniquely or not. Default is FALSE, i.e., the levels of the nested factor are the same for each level of the main factor. For an example and more explanations see the GFD package and the corresponding vignette.

dec
Number of decimals the results should be rounded to. Default is 3.

Details
The MANOVA() function provides the Wald-type statistic (WTS) as well as the modified ANOVA-type statistic (MATS) for multivariate designs with metric data as described in Konietschke et al. (2015) and Friedrich and Pauly (2018), respectively. The MATS is invariant under scale transformations of the components and applicable to designs with singular covariance matrices. Both tests are applicable for non-normal error terms, different sample sizes and/or heteroscedastic variances. They are implemented for designs with an arbitrary number of crossed factors or for nested designs. In addition to the asymptotic p-values, the function also provides p-values based on resampling approaches.

Value
A MANOVA object containing the following components:

Descriptive
Some descriptive statistics of the data for all factor level combinations. Displayed are the number of individuals per factor level combination and the vector of means (one column per dimension).

Covariance
The estimated covariance matrix.

WTS
The value of the WTS along with degrees of freedom of the central chi-square distribution and p-value.

MATS
The value of the MATS.

resampling
p-values for the test statistic based on the chosen resampling approach.

NOTE
The number of resampling iterations has been set to 10 in the examples due to run time restrictions on CRAN. Usually it is recommended to use at least 1000 iterations. For more information and detailed examples also refer to the package vignette.

References


See Also
RM

Examples

data(EEG)
EEG_mod <- MANOVA(resp ~ sex * diagnosis,
data = EEG, subject = "id", resampling = "paramBS",
alpha = 0.05, iter = 10)
summary(EEG_mod)

MANOVA.wide  Tests for Multivariate Data in Semi-Parametric Factorial Designs

Description

The MANOVA.wide function calculates the Wald-type statistic (WTS) and a modified ANOVA-type statistic (MATS) as well as resampling versions of these test statistics for semi-parametric multivariate data provided in wide format.

Usage

MANOVA.wide(
  formula,
data,
  iter = 10000,
  alpha = 0.05,
  resampling = "paramBS",
  para = FALSE,
  CPU,
  seed,
  nested.levels.unique = FALSE,
  dec = 3,
  ...
)
Arguments

formula A model formula object. The left hand side contains the matrix of response variables and the right hand side contains the factor variables of interest.

data A data.frame, list or environment containing the variables in formula. Data must be in wide format. Note: Lines containing missing values will be removed.

iter The number of iterations used for calculating the resampled statistic. The default option is 10,000.

alpha A number specifying the significance level; the default is 0.05.

resampling The resampling method to be used, one of "paramBS" (parametric bootstrap approach) and "WildBS" (wild bootstrap approach with Rademacher weights). The Wild Bootstrap is calculated for all test statistics.

para If parallel computing should be used. Default is FALSE.

CPU The number of cores used for parallel computing. If not specified, cores are detected via detectCores.

seed A random seed for the resampling procedure. If omitted, no reproducible seed is set.

dec Number of decimals the results should be rounded to. Default is 3.

Value

See MANOVA

NOTE

The number of resampling iterations has been set to 100 in the examples due to run time restrictions on CRAN. Usually it is recommended to use at least 1000 iterations.

See Also

MANOVA

Examples

#Example on producing plastic film from Krzanowski (1998, p. 381), see \code{\link{manova.summary}}
tear <- c(6.5, 6.2, 5.8, 6.5, 6.5, 6.9, 7.2, 6.9, 6.1, 6.3,
          6.7, 6.6, 7.2, 7.1, 6.8, 7.1, 7.0, 7.2, 7.5, 7.6)
gloss <- c(9.5, 9.9, 9.6, 9.6, 9.2, 9.1, 10.8, 9.9, 9.5, 9.4,
          9.1, 9.3, 8.3, 8.4, 8.5, 9.2, 8.8, 9.7, 10.1, 9.2)
opacity <- c(4.4, 6.4, 3.0, 4.1, 0.8, 5.7, 2.0, 3.9, 1.9, 5.7,
             2.8, 4.1, 3.8, 1.6, 3.4, 8.4, 5.2, 6.9, 2.7, 1.9)
rate <- gl(2,10, labels = c("Low", "High"))
additive <- gl(2, 5, length = 20, labels = c("Low", "High"))
example <- data.frame(tear, gloss, opacity, rate, additive)
fit <- MANOVA.wide(cbind(tear, gloss, opacity) ~ rate * additive,
data = example, iter = 1000)
summary(fit)

MANOVARM

MANOVA.RM: A package for calculating test statistics and their re-
sampling versions for heteroscedastic semi-parametric multivariate
data or repeated measures designs.

Description

The MANOVA.RM package provides three important functions: MANOVA(), RM() and multRM() which will be explained in detail below.

MANOVA and MANOVA.wide function

The MANOVA() and MANOVA.wide() functions provide the Wald-type statistic (WTS) as well as a modified ANOVA-type statistic (MATS) as in Friedrich and Pauly (2018) for multivariate designs with metric data as described in Konietschke et al. (2015). These are applicable for non-normal error terms, different sample sizes and/or heteroscedastic variances. The MATS can even handle designs involving singular covariance matrices. The tests are implemented for designs with an arbitrary number of crossed factors or for nested designs. In addition to the asymptotic p-values, they also provide p-values based on resampling approaches (parametric or wild bootstrap). The difference between the two functions is the format of the data: For MANOVA(), the data needs to be in long format, while MANOVA.wide() is for data in wide format. For further details, see MANOVA and MANOVA.wide.

RM function

The RM() function provides the Wald-type statistic (WTS) as well as the ANOVA-type statistic (ATS) for repeated measures designs with metric data as described in Friedrich et al. (2017). These are even applicable for non-normal error terms and/or heteroscedastic variances. It is implemented for designs with an arbitrary number of whole-plot and sub-plot factors and allows for different sample sizes. In addition to the asymptotic p-values, it also provides p-values based on resampling approaches (Permutation, parametric bootstrap, Wild bootstrap). For further details, see RM.

multRM function

The multRM() function is a combination of the procedures above suited for multivariate repeated measures designs. It provides the WTS and the MATS along with p-values based on a parametric or a wild bootstrap approach.
References


multRM

Tests for Repeated Measures in Multivariate Semi-Parametric Factorial Designs

Description

The multRM() function calculates the Wald-type statistic (WTS) and the modified ANOVA-type statistic (MATS) as well as resampling versions of these test statistics for multivariate semi-parametric repeated measures designs.

Usage

multRM(
  formula,
  data,
  subject,
  within,
  iter = 10000,
  alpha = 0.05,
  resampling = "paramBS",
  para = FALSE,
  CPU,
  seed,
  dec = 3
)
Arguments

formula  A model `formula` object. The left hand side contains the matrix of response variables (using `cbind()`) and the right hand side contains the factor variables of interest. The within-subject factors must be specified last in the formula, e.g. `cbind(outcome1, outcome2) ~ between1 * between2 * within1 * within2`.

data  A `data.frame`, list or environment containing the variables in `formula`. Data must be in long format and must not contain missing values.

subject  The column name of the subjects in the data. NOTE: Subjects within different groups of between-subject factors must have individual labels, see Details for more explanation.

within  Specifies the within-subject factor(s) in the formula.

iter  The number of iterations used for calculating the resampled statistic. The default option is 10,000.

alpha  A number specifying the significance level; the default is 0.05.

resampling  The resampling method to be used, one of "paramBS" (parametric bootstrap approach) and "WildBS" (wild bootstrap approach with Rademacher weights).

para  If parallel computing should be used. Default is FALSE.

CPU  The number of cores used for parallel computing. If not specified, cores are detected via `detectCores`.

seed  A random seed for the resampling procedure. If omitted, no reproducible seed is set.

dec  Number of decimals the results should be rounded to. Default is 3.

Details

The `multRM()` function provides the Wald-type statistic as well as the modified ANOVA-type statistic (Friedrich and Pauly, 2018) for repeated measures designs with multivariate metric outcomes. These methods are even applicable for non-normal error terms and/or heteroscedastic variances. Implemented are designs with an arbitrary number of between-subject (whole-plot) and within-subject (sub-plot) factors and the methods allow for different sample sizes. In addition to the asymptotic p-values, p-values based on resampling approaches are provided. NOTE: The within-subject factors need to be specified in the function call (`within =`).

If subjects in different groups of the between-subject factor have the same id, they will not be identified as different subjects and thus it is erroneously assumed that their measurements belong to one subject. See `RM` for more explanations and an example.

Value

A `MANOVA` object containing the following components:

Descriptive  Some descriptive statistics of the data for all factor level combinations. Displayed are the number of individuals per factor level combination and the vector of means (one column per dimension).

Covariance  The estimated covariance matrix.
WTS  The value of the WTS along with degrees of freedom of the central chi-square distribution and p-value.
MATS  The value of the MATS.
resampling  p-values for the test statistic based on the chosen resampling approach.

References


See Also  
RM, MANOVA

Examples

```r
## Not run:
data(EEG)
library(tidyr)
eeg <- spread(EEG, feature, resp)
fit <- multRM(cbind(brainrate, complexity) ~ sex * region, data = eeg, subject = "id", within = "region")
summary(fit)
## End(Not run)
```

o2cons  Oxygen Consumption of Leukocytes

Description

A dataset containing measurements on the oxygen consumption of leukocytes in the presence and absence of inactivated staphylococci.

Usage

data(o2cons)
Format

A data frame with 144 rows and 5 variables:

- **O2**: oxygen consumption of leukocytes in µl
- **Staphylococci**: whether or not inactivated staphylococci were added, 1 denotes yes, 0 no
- **Time**: the measurements were taken after 6, 12 and 18 minutes
- **Group**: the treatment group, either P for Placebo or V for Verum
- **Subject**: the subject id

Source


Examples

```r
library(ggplot2)
ggplot(o2cons, aes(x=Group, y=O2)) + geom_point(alpha=0.5) + facet_grid(Staphylococci~Time) + 
stat_summary(fun.y = mean, fun.ymin = min, fun.ymax = max, colour = "red")
```

---

plot.RM

*Plot function for an RM object*

Description

Generic plot function for RM objects: Returns a plot of the mean values along with confidence intervals for a specified RM-model.

Usage

```r
## S3 method for class 'RM'
plot(x, leg = TRUE, ...)
```

Arguments

- **x**: An object of class RM
- **leg**: Logical: Should a legend be plotted?
- **...**: Additional parameters to be passed to plot()
print.MANOVA

Display MANOVA object

Description

Returns a short summary of the results (test statistics with p-values)

Usage

```r
## S3 method for class 'MANOVA'
print(x, ...)
```

Arguments

- `x` A MANOVA object
- `...` Additional parameters (currently not used)

print.RM

Display an RM object

Description

Returns a short summary of the results (test statistics with p-values)

Usage

```r
## S3 method for class 'RM'
print(x, ...)
```

Arguments

- `x` An RM object
- `...` Additional parameters (currently not used)
Description

The `RM()` function calculates the Wald-type statistic (WTS), the ANOVA-type statistic (ATS) as well as resampling versions of these test statistics for semi-parametric repeated measures designs.

Usage

```r
RM(
    formula, 
    data, 
    subject, 
    within, 
    no.subf, 
    iter = 10000, 
    alpha = 0.05, 
    resampling = "Perm", 
    para = FALSE, 
    CPU, 
    seed, 
    CI.method = "t-quantile", 
    dec = 3
)
```

Arguments

- **formula**: A model `formula` object. The left hand side contains the response variable and the right hand side contains the factor variables of interest. The within-subject factor(s) must be the last factor(s) in the formula, e.g. `outcome ~ between1 * between2 * within1 * within2`.
- **data**: A data.frame, list or environment containing the variables in formula. Data must be in long format and must not contain missing values.
- **subject**: The column name of the subjects in the data. NOTE: Subjects within different groups of between-subject factors must have individual labels, see Details for more explanation.
- **within**: Specifies the within-subject factor(s) in the formula. Either this or `no.subf` must be specified.
- **no.subf**: The number of within-subject factors in the data. Must be specified if `within` is omitted.
- **iter**: The number of iterations used for calculating the resampled statistic. The default option is 10,000.
- **alpha**: A number specifying the significance level; the default is 0.05.
The resampling method to be used, one of "Perm" (randomly permute all observations), "paramBS" (parametric bootstrap approach) and "WildBS" (wild bootstrap approach with Rademacher weights). Except for the Wild Bootstrap, all methods are applied to the WTS only.

If parallel computing should be used. Default is FALSE.

The number of cores used for parallel computing. If not specified, cores are detected via `detectCores`.

A random seed for the resampling procedure. If omitted, no reproducible seed is set.

The method for calculating the quantiles used for the confidence intervals, either "t-quantile" (the default) or "resampling" (the quantile of the resampled WTS).

Number of decimals the results should be rounded to. Default is 3.

The `RM()` function provides the Wald-type statistic as well as the ANOVA-type statistic for repeated measures designs with metric data as described in Friedrich et al. (2017). These are even applicable for non-normal error terms and/or heteroscedastic variances. It is implemented for designs with an arbitrary number of between-subject (whole-plot) and within-subject (sub-plot) factors and allows for different sample sizes. In addition to the asymptotic p-values, it also provides p-values based on resampling approaches. NOTE: The number of within-subject factors or their labels need to be specified in the function call. If only one factor is present, it is assumed that this is a within-subject factor (e.g. time).

If subjects in different groups of the between-subject factor have the same id, they will not be identified as different subjects and thus it is erroneously assumed that their measurements belong to one subject. Example: Consider a study with one between-subject factor "treatment" with levels verum and placebo and one within-subject factor "time" (4 measurements). If subjects in the placebo group are labeled 1-20 and subjects in the verum group have the same labels, the program erroneously assumes 20 individuals with 8 measurements each instead of 40 individuals with 4 measurements each.

An `RM` object containing the following components:

- **Descriptive**: Some descriptive statistics of the data for all factor level combinations. Displayed are the number of individuals per factor level combination, the mean and 100*(1-alpha)% confidence intervals (based on t-quantiles).
- **Covariance**: The estimated covariance matrix.
- **WTS**: The value of the WTS along with degrees of freedom of the central chi-square distribution and corresponding p-value.
- **ATS**: The value of the ATS, degrees of freedom of the central F distribution and the corresponding p-value.
- **resampling**: p-values for the test statistics based on the chosen resampling approach.
References


See Also

GFD, nparLD, MANOVA

Examples

data(o2cons)
### Not run:
oxy <- RM(O2 ~ Group * Staphylococci * Time, data = o2cons,
subject = "Subject", no.subf = 2, iter = 1000,
resampling = "Perm")
summary(oxy)
plot(oxy, factor = "Group")

# For more details including the output of the examples also refer to the # package vignette.

# using the EEG data, consider additional within-subjects factors 'brain region' # and 'feature'
data(EEG)
EEG_model <- RM(resp ~ sex * diagnosis * feature * region,
data = EEG, subject = "id", within = c("feature", "region"),
resampling = "WildBS",
iter = 1000, alpha = 0.01, seed = 987, dec = 2)
summary(EEG_model)

### End(Not run)
Usage

```r
simCI(
    object,
    contrast,
    contmat = NULL,
    type = NULL,
    base = 1,
    interaction = TRUE,
    factor = NA,
    silent = FALSE,
    ...
)
```

Arguments

- **object**: A MANOVA object.
- **contrast**: The contrast matrix of interest, can either be "pairwise" or "user-defined".
- **contmat**: If contrast = "user-defined", the contrast matrix must be specified here. Note that its rows must sum to zero.
- **type**: If contrast is "pairwise", the type of the pairwise comparison must be specified here. Calculation is based on the contrMat function in package multcomp, see the corresponding help page for details on the types of contrasts available.
- **base**: An integer specifying which group is considered the baseline group for Dunnett contrasts, see `contrMat`.
- **interaction**: Logical. If interaction = FALSE in models with more than one factor, the factor of interest for the post-hoc analysis must be specified. Default is TRUE, which means post-hoc tests are performed for all factor level combinations.
- **factor**: Only needed if interaction = FALSE. Specifies the factor for which post-hoc analysis are requested.
- **silent**: Set to TRUE to suppress output.
- **...**: Not used yet.

Details

The `simCI()` function computes the multivariate p-values for the chosen contrast of the multivariate mean vector based on the bootstrap version of the sum statistic. Details on this test can be found in Friedrich and Pauly (2018). Furthermore, confidence intervals for summary effects (i.e., averaged over each dimension), also based on the bootstrap version of the sum statistic, are returned as well.

Value

Multivariate p-values and simultaneous confidence intervals for the chosen contrasts.

References

**summary.MANOVA**

See Also

contrMat

summary.MANOVA  
*Summarizing a MANOVA object*

Description

Returns a summary of the results including mean vectors and sample sizes for all groups as well as test statistics with degrees of freedom and p-values

Usage

```r
## S3 method for class 'MANOVA'
summary(object, ...)
```

Arguments

- `object`  
  A MANOVA object
- `...`  
  Additional parameters (currently not used)

**summary.RM**  
*Summarizing an RM object*

Description

Returns a summary of the results including mean values, variances and sample sizes for all groups as well as test statistics with degrees of freedom and p-values

Usage

```r
## S3 method for class 'RM'
summary(object, ...)
```

Arguments

- `object`  
  An RM object
- `...`  
  Additional parameters (currently not used)
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