# Package 'onewaytests'

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**Type** Package

**Title** One-Way Tests in Independent Groups Designs

**Version** 2.6

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**Depends** R (>= 3.2.0)

**Imports** stats, moments, car, ggplot2, nortest, graphics, utils

**Suggests** AID, tibble

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**Description** Performs one-way tests in independent groups designs including homoscedastic and heteroscedastic tests. These are one-way analysis of variance (ANOVA), Welch's heteroscedastic F test, Welch's heteroscedastic F test with trimmed means and Winsorized variances, Brown-Forsythe test, Alexander-Govern test, James second order test, Kruskal-Wallis test, Scott-Smith test, Box F test and Johansen F test, Generalized tests equivalent to Parametric Bootstrap and Fiducial tests. The package performs pairwise comparisons and graphical approaches. Also, the package includes Student's t test, Welch's t test and Mann-Whitney U test for two samples. Moreover, it assesses variance homogeneity and normality of data in each group via tests and plots (Dag et al., 2018, <https://journal.r-project.org/archive/2018/RJ-2018-022/RJ-2018-022.pdf>).

**License** GPL (>= 2)

**NeedsCompilation** no

**Repository** CRAN

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## R topics documented:

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`onewaytests-package` *One-Way Tests in Independent Groups Designs*

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## Description

Performs one-way tests in independent groups designs; one-way analysis of variance (ANOVA), Welch's heteroscedastic F test, Welch's heteroscedastic F test with trimmed means and Winsorized variances, Brown-Forsythe test, Alexander-Govern test, James second order test, Kruskal-Wallis test, Scott-Smith test, Box F test and Johansen F test, Generalized tests equivalent to Parametric Bootstrap and Fiducial tests. The package performs pairwise comparisons and graphical approaches. Also, the package includes Student's t test, Welch's t test and Mann-Whitney U test for two samples. Moreover, it assesses variance homogeneity and normality of data in each group via tests and plots (Dag et al., 2018, <https://journal.r-project.org/archive/2018/RJ-2018-022/RJ-2018-022.pdf>).

## Details

| | |
|---|---|
| Package: | onewaytests |
| Type: | Package |
| License: | GPL (>=2) |

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`ag.test` *Alexander-Govern Test*

---

## Description

`ag.test` performs Alexander-Govern test.

## Usage

```
ag.test(formula, data, alpha = 0.05, na.rm = TRUE, verbose = TRUE)
```

## Arguments

| | |
|---|---|
| `formula` | a formula of the form `lhs ~ rhs` where `lhs` gives the sample values and `rhs` the corresponding groups. |
| `data` | a tibble or data frame containing the variables in the formula `formula` |
| `alpha` | the level of significance to assess the statistical difference. Default is set to alpha = 0.05. |
| `na.rm` | a logical value indicating whether NA values should be stripped before the computation proceeds. |
| `verbose` | a logical for printing output to R console. |

## Value

A list with class "owt" containing the following components:

| | |
|---|---|
| `statistic` | the Alexander-Govern test statistic. |
| `parameter` | the parameter(s) of the approximate chi-squared distribution of the test statistic. |
| `p.value` | the p-value of the test. |
| `alpha` | the level of significance to assess the statistical difference. |
| `method` | the character string "Alexander-Govern Test". |
| `data` | a data frame containing the variables in which NA values (if exist) are removed. |
| `formula` | a formula of the form `lhs ~ rhs` where `lhs` gives the sample values and `rhs` the corresponding groups. |

## Note

An R implementation of Alexander-Govern test has been available since 2007 (written by Sven Hartenstein). The website link is here.

## Author(s)

Osman Dag

## References

Dag, O., Dolgun, A., Konar, N.M. (2018). onewaytests: An R Package for One-Way Tests in Independent Groups Designs. *The R Journal*, **10:1**, 175-199.

Schneider, P. J., Penfield, D. A. (1997). Alexander and Govern's Approximation: Providing an Alternative to ANOVA Under Variance Heterogeneity. *The Journal of Experimental Education*, **65:3**, 271-286.

## Examples

```
######

library(onewaytests)

ag.test(Sepal.Length ~ Species, data = iris)

out <- ag.test(Sepal.Length ~ Species, data = iris)
paircomp(out)

######

library(onewaytests)
library(tibble)

iris <- as_tibble(iris)
ag.test(Sepal.Length ~ Species, data = iris)

out <- ag.test(Sepal.Length ~ Species, data = iris)
paircomp(out)

######
```

---

`aov.test` *One-Way Analysis of Variance*

---

## Description

`aov.test` performs one-way analysis of variance (ANOVA).

## Usage

```
aov.test(formula, data, alpha = 0.05, na.rm = TRUE, verbose = TRUE)
```

## Arguments

| | |
|---|---|
| `formula` | a formula of the form `lhs ~ rhs` where `lhs` gives the sample values and `rhs` the corresponding groups. |
| `data` | a tibble or data frame containing the variables in the formula `formula` |
| `alpha` | the level of significance to assess the statistical difference. Default is set to alpha = 0.05. |
| `na.rm` | a logical value indicating whether NA values should be stripped before the computation proceeds. |
| `verbose` | a logical for printing output to R console. |

## Value

A list with class "owt" containing the following components:

| | |
|---|---|
| `statistic` | the analysis of variance test statistic. |
| `parameter` | the parameter(s) of the approximate F distribution of the test statistic. |
| `p.value` | the p-value of the test. |
| `alpha` | the level of significance to assess the statistical difference. |
| `method` | the character string "One-Way Analysis of Variance". |
| `data` | a data frame containing the variables in which NA values (if exist) are removed. |
| `formula` | a formula of the form `lhs ~ rhs` where `lhs` gives the sample values and `rhs` the corresponding groups. |

## Author(s)

Osman Dag

## References

Dag, O., Dolgun, A., Konar, N.M. (2018). onewaytests: An R Package for One-Way Tests in Independent Groups Designs. *The R Journal*, **10:1**, 175-199.

Sheskin, D. J. (2004). *Handbook of Parametric and Nonparametric Statistical Procedures*. 3rd Edition. Chapman and Hall CRC. Florida: Boca Raton.

## Examples

```
library(onewaytests)

aov.test(Sepal.Length ~ Species, data = iris)

out <- aov.test(Sepal.Length ~ Species, data = iris)
paircomp(out)
```

---

# bf.test *Brown-Forsythe Test*

---

## Description

`bf.test` performs Brown-Forsythe test.

## Usage

```
bf.test(formula, data, alpha = 0.05, na.rm = TRUE, verbose = TRUE)
```

## Arguments

| | |
|---|---|
| formula | a formula of the form lhs ~ rhs where lhs gives the sample values and rhs the corresponding groups. |
| data | a tibble or data frame containing the variables in the formula formula |
| alpha | the level of significance to assess the statistical difference. Default is set to alpha = 0.05. |
| na.rm | a logical value indicating whether NA values should be stripped before the computation proceeds. |
| verbose | a logical for printing output to R console. |

## Value

A list with class "owt" containing the following components:

| | |
|---|---|
| statistic | the Brown-Forsythe test statistic. |
| parameter | the parameter(s) of the approximate F distribution of the test statistic. |
| p.value | the p-value of the test. |
| alpha | the level of significance to assess the statistical difference. |
| method | the character string "Brown-Forsythe Test". |
| data | a data frame containing the variables in which NA values (if exist) are removed. |
| formula | a formula of the form lhs ~ rhs where lhs gives the sample values and rhs the corresponding groups. |

## Author(s)

Osman Dag

## References

Brown, M. B., Forsythe. A. B. (1974a). The small sample behavior of some statistics which test the equality of several means. *Technometrics*, **16**, 129-132.

Dag, O., Dolgun, A., Konar, N.M. (2018). onewaytests: An R Package for One-Way Tests in Independent Groups Designs. *The R Journal*, **10:1**, 175-199.

## Examples

```
library(onewaytests)

bf.test(Sepal.Length ~ Species, data = iris)

out <- bf.test(Sepal.Length ~ Species, data = iris)
paircomp(out)
```

box.test *Box F Test*

## Description

box.test performs Box F test.

## Usage

```
box.test(formula, data, alpha = 0.05, na.rm = TRUE, verbose = TRUE)
```

## Arguments

| | |
|---|---|
| formula | a formula of the form lhs ~ rhs where lhs gives the sample values and rhs the corresponding groups. |
| data | a tibble or data frame containing the variables in the formula formula |
| alpha | the level of significance to assess the statistical difference. Default is set to alpha = 0.05. |
| na.rm | a logical value indicating whether NA values should be stripped before the computation proceeds. |
| verbose | a logical for printing output to R console. |

## Value

A list with class "owt" containing the following components:

| | |
|---|---|
| statistic | the Box F test statistic. |
| parameter | the parameter(s) of the approximate F distribution of the test statistic. |
| p.value | the p-value of the test. |
| alpha | the level of significance to assess the statistical difference. |
| method | the character string "Box F Test". |
| data | a data frame containing the variables in which NA values (if exist) are removed. |
| formula | a formula of the form lhs ~ rhs where lhs gives the sample values and rhs the corresponding groups. |

## Author(s)

Osman Dag

## References

Box, G.E.P. (1954). Some Theorems on Quadratic Forms Applied in the Study of Analysis of Variance Problems, *Annals of Mathematical Statistics*, **25**, 290-302.

## Examples

```
library(onewaytests)

box.test(Sepal.Length ~ Species, data = iris)

out <- box.test(Sepal.Length ~ Species, data = iris)
paircomp(out)
```

---

`describe` *Descriptive Statistics*

---

## Description

`describe` produces basic descritive statistics including sample size, mean, standard deviation, median, minimum value, maximum value, 25th quantile, 75th quantile, skewness, kurtosis, the number of missing value.

## Usage

```
describe(formula, data)
```

## Arguments

| | |
|---|---|
| `formula` | a formula of the form `lhs ~ rhs` where `lhs` gives the sample values and `rhs` the corresponding groups. |
| `data` | a tibble or data frame containing the variables in the formula `formula` |

## Value

Returns a data.frame of output.

## Author(s)

Osman Dag

## Examples

```
library(onewaytests)

describe(Sepal.Length ~ Species, data = iris)
```

gp.test *Test for Equal Means in a One-Way Layout under Unequal Variances*

## Description

gp.test tests whether two or more samples from normal distributions have the same means when the variances are not necessarily equal.

## Usage

```
gp.test(formula, data, method = c("GT_Bootstrap","GT_Fiducial"), alpha = 0.05,
  na.rm = TRUE, verbose = TRUE)
```

## Arguments

| | |
|---|---|
| formula | a formula of the form lhs ~ rhs where lhs gives the sample values and rhs the corresponding groups. |
| data | a tibble or data frame containing the variables in the formula formula |
| method | a character string to select the method. "GT_Bootstrap": Generalized Test Equivalent to Parametric Bootstrap Test (size close to intended), "GT_Fiducial": Generalized Test Equivalent to Fiducial Test (size assured). |
| alpha | the level of significance to assess the statistical difference. Default is set to alpha = 0.05. |
| na.rm | a logical value indicating whether NA values should be stripped before the computation proceeds. |
| verbose | a logical for printing output to R console. |

## Value

A list with class "owt" containing the following components:

| | |
|---|---|
| p.value | the p-value of the corresponding test. |
| alpha | the level of significance to assess the statistical difference. |
| method | the selected method used in generalized test. |
| data | a data frame containing the variables in which NA values (if exist) are removed. |
| formula | a formula of the form lhs ~ rhs where lhs gives the sample values and rhs the corresponding groups. |

## Note

The methods underlying Generalized Tests are summarized in Weerahandi and Krishnamoorthy (2019), which shows that both the Fiducial and the Parametric Bootstrap tests are generalized tests based on an exact probability statement on alternative test variables. Greater details of them can be found in Krishnamoorthy et al. (2007) and Li et al. (2011). For greater details about Generalized

Inference, the reader is referred to Weerahandi (2004), which can be freely read at Generalized Inference.

For additional information about the methods and the code, the reader can contact the authors of this code, Sam Weerahandi or Malwane Ananda.

## Author(s)

Sam Weerahandi, Malwane Ananda

## References

Daniel, W.W., Cross, C.L. (2013). *Biostatistics: A Foundation for Analysis in the Health Sciences. (10th ed.)*. John Wiley and Sons, Inc.

Krishnamoorthy, K., Lu, F., Mathew, T. (2007). A parametric bootstrap approach for ANOVA with unequal variances: fixed and random models. *Computational Statistics and Data Analysis*, **51:12**, 5731-5742.

Li, X., Wang J., Liang H. (2011). Comparison of several means: a fiducial based approach. *Computational Statistics and Data Analysis*, **55:5**, 1993-2002.

Weerahandi, S. (2004). *Generalized Inference in Repeated Measures: Exact Methods in MANOVA and Mixed Models*, Series in Probability and Statistics. John Wiley and Sons, Inc.

Weerahandi, S., Krishnamoorthy, K. (2019). A note reconciling ANOVA tests under unequal error variances. *Communications in Statistics-Theory and Methods*, **48:3**, 689-693.

## Examples

```
##Both examples given below are from the book written by Daniel and Cross (2013).
##They are One-way ANOVA examples, where it is not reasonable to assume equal variances.

###Example 1

library(onewaytests)

x <- factor(c(1,1,1,1,2,2,2,2,3,3,3,3,4,4,4))
y <- c(71.8,66.1,67.6,66.4,42.8,53.2,56.1,56.5,
       72.5,62.9,58.9,69.3,47.1,86.6,56)

Example1 <- data.frame(y, x)

describe(y ~ x, data = Example1)


out <- gp.test(y ~ x, data = Example1, alpha = 0.10)
paircomp(out)

gp.test(y ~ x, data = Example1, method = "GT_Fiducial")


###Example 2
```

```
library(onewaytests)

x <- factor(c(1,1,1,1,1,1,1,1,1,1,1,2,2,2,2,2,3,3,3,3,3,3,3,3))
y <- c(92,93,74,80.5,76,71,75.5,88.5,93,80.5,83,87,79,
       78,100,76.5,68,81.5,75,76.5,70.5,69,73.8,74,80)

Example2 <- data.frame(y, x)

describe(y ~ x, data = Example2)


out <- gp.test(y ~ x, data = Example2, method = "GT_Fiducial", alpha = 0.10)
paircomp(out)

out <- gp.test(y ~ x, data = Example2,
method = "GT_Bootstrap", alpha = 0.10)
paircomp(out)
```

---

gplot *Box-and-Whisker Plots and Error Bars*

---

## Description

gplot produce box-and-whisker plots and error bars of the given grouped values.

## Usage

```
gplot(formula, data, type = c("boxplot", "errorbar"), violin = TRUE, xlab = NULL,
  ylab = NULL, title = NULL, width = NULL, option = c("se", "sd"), na.rm = TRUE)
```

## Arguments

| | |
|---|---|
| formula | a formula of the form lhs ~ rhs where lhs gives the sample values and rhs the corresponding groups. |
| data | a tibble or data frame containing the variables in the formula formula |
| type | a character string to select one of the plots. "boxplot": box-and-whisker plot, "errorbar": error bar. |
| violin | a logical adding violin plot on box-and-whisker plot. |
| xlab | a label for the x axis, defaults to a description of x. |
| ylab | a label for the y axis, defaults to a description of y. |
| title | a main title for the plot. |
| width | a numeric giving the width of the boxes for box-and-whisker plots (defaults to 0.3) and the width of the little lines at the tops and bottoms of the error bars (defaults to 0.15). |

| | |
|---|---|
| option | a character string to select one of the options to draw error bars with standard error or standard deviation. "se": standard error, "sd": standard deviation. Defaults to "se". |
| na.rm | a logical indicating whether NA values should be stripped before the computation proceeds. |

## Details

The upper whisker of box-and-whisker plots extends from the hinge to the highest value that is within 1.5 * IQR of the hinge, where IQR is the inter-quartile range. The lower whisker extends from the hinge to the lowest value within 1.5 * IQR of the hinge. Data out of the ends of the whiskers are outliers and plotted as points.

## Author(s)

Osman Dag

## See Also

geom_boxplot geom_violin

## Examples

```
library(onewaytests)

gplot(Sepal.Length ~ Species, data = iris, type = "boxplot")
gplot(Sepal.Length ~ Species, data = iris, type = "boxplot", violin = FALSE)
gplot(Sepal.Length ~ Species, data = iris, type = "errorbar", option = "se")
gplot(Sepal.Length ~ Species, data = iris, type = "errorbar", option = "sd")
```

---

# homog.test *Variance Homogeneity Tests*

---

## Description

homog.test performs variance homogeneity tests including Levene, Bartlett, Fligner-Killeen tests.

## Usage

```
homog.test(formula, data, method = c("Levene", "Bartlett", "Fligner"),
  alpha = 0.05, na.rm = TRUE, verbose = TRUE)
```

## Arguments

| | |
|---|---|
| formula | a formula of the form lhs ~ rhs where lhs gives the sample values and rhs the corresponding groups. |
| data | a tibble or data frame containing the variables in the formula formula |
| method | a character string to select one of the variance homogeneity tests. "Levene": Levene's test, "Bartlett": Bartlett's test, "Fligner": Fligner-Killeen test. |
| alpha | the level of significance to assess variance homogenity. Default is set to alpha = 0.05. |
| na.rm | a logical value indicating whether NA values should be stripped before the computation proceeds. |
| verbose | a logical for printing output to R console. |

## Value

A list containing the following components:

| | |
|---|---|
| statistic | the corresponding test statistic. |
| parameter | the parameter(s) of the approximate corresponding distribution of the test statistic. The corresponding distribution is F distribution for Levene's test, Chi-square disribution for Bartlett's test and Fligner-Killeen test. |
| p.value | the p-value of the test. |

## Author(s)

Osman Dag

## See Also

leveneTest bartlett.test fligner.test

## Examples

```
library(onewaytests)

homog.test(Sepal.Length ~ Species, data = iris)
homog.test(Sepal.Length ~ Species, data = iris, method = "Bartlett")
```

`james.test` *James Second Order Test*

## Description

`james.test` performs James second order test.

## Usage

```
james.test(formula, data, alpha = 0.05, na.rm = TRUE, verbose = TRUE)
```

## Arguments

| | |
|---|---|
| `formula` | a formula of the form `lhs ~ rhs` where `lhs` gives the sample values and `rhs` the corresponding groups. |
| `data` | a tibble or data frame containing the variables in the formula `formula` |
| `alpha` | a significance level. Defaults alpha = 0.05. |
| `na.rm` | a logical value indicating whether NA values should be stripped before the computation proceeds. |
| `verbose` | a logical for printing output to R console. |

## Value

A list with class "jt" containing the following components:

| | |
|---|---|
| `statistic` | the James second order test statistic. |
| `criticalValue` | the critical value of the James second order test statistic. |
| `alpha` | the level of significance to assess the statistical difference. |
| `method` | the character string "James Second Order Test". |
| `data` | a data frame containing the variables in which NA values (if exist) are removed. |
| `formula` | a formula of the form `lhs ~ rhs` where `lhs` gives the sample values and `rhs` the corresponding groups. |

## Author(s)

Anil Dolgun

## References

Cribbie, R. A., Fiksenbaum, L., Keselman, H. J., Wilcox, R. R. (2012). Effect of Non-Normality on Test Statistics for One-Way Independent Groups Designs. *British Journal of Mathematical and Statistical Psychology*, **65**, 56-73.

Dag, O., Dolgun, A., Konar, N.M. (2018). onewaytests: An R Package for One-Way Tests in Independent Groups Designs. *The R Journal*, **10:1**, 175-199.

## Examples

```
library(onewaytests)

james.test(Sepal.Length ~ Species, data = iris, alpha = 0.05)

out <- james.test(Sepal.Length ~ Species, data = iris, alpha = 0.05)
paircomp(out)
```

---

johansen.test *Johansen F Test*

---

## Description

johansen.test performs Johansen F test.

## Usage

```
johansen.test(formula, data, alpha = 0.05, na.rm = TRUE, verbose = TRUE)
```

## Arguments

| | |
|---|---|
| formula | a formula of the form lhs ~ rhs where lhs gives the sample values and rhs the corresponding groups. |
| data | a tibble or data frame containing the variables in the formula formula |
| alpha | the level of significance to assess the statistical difference. Default is set to alpha = 0.05. |
| na.rm | a logical value indicating whether NA values should be stripped before the computation proceeds. |
| verbose | a logical for printing output to R console. |

## Value

A list with class "owt" containing the following components:

| | |
|---|---|
| statistic | the Johansen F test statistic. |
| parameter | the parameter(s) of the approximate F distribution of the test statistic. |
| p.value | the p-value of the test. |
| alpha | the level of significance to assess the statistical difference. |
| method | the character string "Johansen F Test". |
| data | a data frame containing the variables in which NA values (if exist) are removed. |
| formula | a formula of the form lhs ~ rhs where lhs gives the sample values and rhs the corresponding groups. |

## Author(s)

Osman Dag

## References

Johansen, S. (1980). The Welch-James Approximation to the Distribution of the Residual Sum of Squares in a Weighted Linear Regression, *Biometrika*, **67:1**, 58-92.

## Examples

```
library(onewaytests)

johansen.test(Sepal.Length ~ Species, data = iris)

out <- johansen.test(Sepal.Length ~ Species, data = iris)
paircomp(out)
```

---

# kw.test *Kruskal-Wallis Test*

---

## Description

`kw.test` performs Kruskal-Wallis test.

## Usage

```
kw.test(formula, data, alpha = 0.05, na.rm = TRUE, verbose = TRUE)
```

## Arguments

| | |
|---|---|
| `formula` | a formula of the form `lhs ~ rhs` where `lhs` gives the sample values and `rhs` the corresponding groups. |
| `data` | a tibble or data frame containing the variables in the formula `formula` |
| `alpha` | the level of significance to assess the statistical difference. Default is set to alpha = 0.05. |
| `na.rm` | a logical value indicating whether NA values should be stripped before the computation proceeds. |
| `verbose` | a logical for printing output to R console. |

## Value

A list with class "owt" containing the following components:

| | |
|---|---|
| `statistic` | the Kruskal-Wallis test statistic. |
| `parameter` | the parameter(s) of the approximate chi-squared distribution of the test statistic. |
| `p.value` | the p-value of the test. |
| `alpha` | the level of significance to assess the statistical difference. |
| `data` | a data frame containing the variables in which NA values (if exist) are removed. |
| `formula` | a formula of the form `lhs ~ rhs` where `lhs` gives the sample values and `rhs` the corresponding groups. |

## Author(s)

Anil Dolgun

## References

Dag, O., Dolgun, A., Konar, N.M. (2018). onewaytests: An R Package for One-Way Tests in Independent Groups Designs. *The R Journal*, **10:1**, 175-199.

Sheskin, D. J. (2004). *Handbook of Parametric and Nonparametric Statistical Procedures*. 3rd Edition. Chapman and Hall CRC. Florida: Boca Raton.

## Examples

```
library(onewaytests)

kw.test(Sepal.Length ~ Species, data = iris)

out <- kw.test(Sepal.Length ~ Species, data = iris)
paircomp(out)
```

---

# mw.test *Mann-Whitney U Test*

---

## Description

`mw.test` performs Mann-Whitney U test for two samples.

## Usage

```
mw.test(formula, data, alpha = 0.05, na.rm = TRUE, verbose = TRUE)
```

## Arguments

| | |
|---|---|
| formula | a formula of the form lhs ~ rhs where lhs gives the sample values and rhs the corresponding groups. |
| data | a tibble or data frame containing the variables in the formula formula |
| alpha | the level of significance to assess the statistical difference. Default is set to alpha = 0.05. |
| na.rm | a logical value indicating whether NA values should be stripped before the computation proceeds. |
| verbose | a logical for printing output to R console. |

## Details

Approximation to normal distribution is used to obtain the p-value.

## Value

A list with class "owt" containing the following components:

| | |
|---|---|
| statistic | the Z statistic. |
| p.value | the p-value of the test. |
| alpha | the level of significance to assess the statistical difference. |
| data | a data frame containing the variables in which NA values (if exist) are removed. |
| formula | a formula of the form lhs ~ rhs where lhs gives the sample values and rhs the corresponding groups. |

## Author(s)

Osman Dag

## See Also

wilcox.test st.test wt.test

## Examples

```
library(AID)
data(AADT)

library(onewaytests)
describe(aadt ~ control, data = AADT)

mw.test(aadt ~ control, data = AADT)
```

nor.test *Normality Tests*

## Description

nor.test performs normality tests including Shapiro-Wilk, Shapiro-Francia, Kolmogorov-Smirnov, Anderson-Darling, Cramer-von Mises, Pearson Chi-square tests, and also assess the normality of each group through plots.

## Usage

```
nor.test(formula, data, method = c("SW", "SF", "LT", "AD", "CVM", "PT"),
  alpha = 0.05, plot = c("qqplot-histogram", "qqplot", "histogram"), mfrow = NULL,
   na.rm = TRUE, verbose = TRUE)
```

## Arguments

| | |
|---|---|
| formula | a formula of the form lhs ~ rhs where lhs gives the sample values and rhs the corresponding groups. |
| data | a tibble or data frame containing the variables in the formula formula |
| method | a character string to select one of the normality tests. "SW": Shapiro-Wilk test, "SF": Shapiro-Francia test, "LT": Lilliefors (Kolmogorov-Smirnov) test, "AD": Anderson-Darling test, "CVM": Cramer-von Mises test, "PT": Pearson Chi-square test. |
| alpha | the level of significance to assess normality. Default is set to alpha = 0.05. |
| plot | a character string to select one of the plots including qqplot-histogram, qqplot, histogram. The red line is the density line of normal distribution. |
| mfrow | a two element vector to draw subsequent figures. |
| na.rm | a logical value indicating whether NA values should be stripped before the computation proceeds. |
| verbose | a logical for printing output to R console. |

## Value

A data frame gives the test results for the normality of groups via corresponding normality.

## Author(s)

Osman Dag

## See Also

homog.test gplot shapiro.test

## Examples

```
library(onewaytests)

nor.test(Sepal.Length ~ Species, data = iris, method = "SW", plot = "qqplot-histogram")
nor.test(Sepal.Length ~ Species, data = iris, method = "SF", plot = "qqplot", mfrow = c(1,3))
```

---

paircomp *Pairwise Comparisons*

---

## Description

paircomp is a generic function for pairwise comparisons by adjusting p-values.

## Usage

```
## S3 method for class 'owt'
paircomp(x, adjust.method = c("bonferroni", "holm", "hochberg", "hommel", "BH",
  "BY", "fdr", "none"), ...)
```

## Arguments

| | |
|---|---|
| x | a owt object. |
| adjust.method | Method for adjusting p values (see p.adjust). Default is set to "bonferroni". |
| ... | Additional arguments affecting multiple comparisons of groups in one-way independent designs. |

## Value

Returns a data.frame of output.

## Author(s)

Osman Dag

## Examples

```
library(onewaytests)

out <- aov.test(Sepal.Length ~ Species, data = iris)
paircomp(out)
paircomp(out, adjust.method = "hochberg")

out2 <- kw.test(Sepal.Length ~ Species, data = iris)
paircomp(out2)
paircomp(out2, adjust.method = "hommel")
```

```
out3 <- kw.test(Sepal.Length ~ Species, data = iris)
paircomp(out3)
paircomp(out3, adjust.method = "holm")
```

---

paircomp.jt *Pairwise Comparisons for James Second Order Test*

---

## Description

paircomp.jt performs multiple comparisons by adjusting the level of significance for James second order test.

## Usage

```
## S3 method for class 'jt'
paircomp(x, adjust.method = c("bonferroni", "none"), ...)
```

## Arguments

| | |
|---|---|
| x | a jt object. |
| adjust.method | Method for adjusting the significance level. "bonferroni": Bonferroni correction, "none": No correction. |
| ... | Additional arguments affecting multiple comparisons of groups in one-way independent designs. |

## Value

Returns a data.frame of output.

## Author(s)

Osman Dag

## Examples

```
library(onewaytests)

out <- james.test(Sepal.Length ~ Species, data = iris, alpha = 0.05)
paircomp(out, adjust.method = "bonferroni")
```

`ss.test` *Scott-Smith Test*

## Description

`ss.test` performs Scott-Smith test.

## Usage

```
ss.test(formula, data, alpha = 0.05, na.rm = TRUE, verbose = TRUE)
```

## Arguments

| | |
|---|---|
| `formula` | a formula of the form `lhs ~ rhs` where `lhs` gives the sample values and `rhs` the corresponding groups. |
| `data` | a tibble or data frame containing the variables in the formula `formula` |
| `alpha` | the level of significance to assess the statistical difference. Default is set to alpha = 0.05. |
| `na.rm` | a logical value indicating whether NA values should be stripped before the computation proceeds. |
| `verbose` | a logical for printing output to R console. |

## Value

A list with class "owt" containing the following components:

| | |
|---|---|
| `statistic` | the Scott-Smith test statistic. |
| `parameter` | the parameter(s) of the approximate chi-squared distribution of the test statistic. |
| `p.value` | the p-value of the test. |
| `alpha` | the level of significance to assess the statistical difference. |
| `method` | the character string "Scott-Smith Test". |
| `data` | a data frame containing the variables in which NA values (if exist) are removed. |
| `formula` | a formula of the form `lhs ~ rhs` where `lhs` gives the sample values and `rhs` the corresponding groups. |

## Author(s)

Osman Dag

## References

Scott, A., Smith, T. (1971). Interval Estimates for Linear Combinations of Means. *Journal of the Royal Statistical Society: Series C (Applied Statistics)*, **20:3**, 276-285.

## Examples

```
library(onewaytests)

ss.test(Sepal.Length ~ Species, data = iris)

out <- ss.test(Sepal.Length ~ Species, data = iris)
paircomp(out)
```

---

`st.test` *Student's t-Test*

---

## Description

`st.test` performs student's t-test for two samples.

## Usage

```
st.test(formula, data, alpha = 0.05, na.rm = TRUE, verbose = TRUE)
```

## Arguments

| | |
|---|---|
| `formula` | a formula of the form `lhs ~ rhs` where `lhs` gives the sample values and `rhs` the corresponding groups. |
| `data` | a tibble or data frame containing the variables in the formula `formula` |
| `alpha` | the level of significance to assess the statistical difference. Default is set to alpha = 0.05. |
| `na.rm` | a logical value indicating whether NA values should be stripped before the computation proceeds. |
| `verbose` | a logical for printing output to R console. |

## Value

A list with class "owt" containing the following components:

| | |
|---|---|
| `statistic` | the Student's t-test statistic. |
| `parameter` | the parameter(s) of the approximate t distribution of the test statistic. |
| `p.value` | the p-value of the test. |
| `alpha` | the level of significance to assess the statistical difference. |
| `data` | a data frame containing the variables in which NA values (if exist) are removed. |
| `formula` | a formula of the form `lhs ~ rhs` where `lhs` gives the sample values and `rhs` the corresponding groups. |

## Author(s)

Osman Dag

## See Also

t.test wt.test

## Examples

```
library(AID)
data(AADT)

library(onewaytests)
describe(aadt ~ control, data = AADT)

st.test(aadt ~ control, data = AADT)
```

---

`welch.test` *Welch's Heteroscedastic F Test and Welch's Heteroscedastic F Test with Trimmed Means and Winsorized Variances*

---

## Description

`welch.test` performs Welch's heteroscedastic F test and Welch's heteroscedastic F test with trimmed means and Winsorized variances.

## Usage

```
welch.test(formula, data, rate = 0, alpha = 0.05, na.rm = TRUE, verbose = TRUE)
```

## Arguments

| | |
|---|---|
| `formula` | a formula of the form `lhs ~ rhs` where `lhs` gives the sample values and `rhs` the corresponding groups. |
| `data` | a tibble or data frame containing the variables in the formula `formula` |
| `rate` | the rate of observations trimmed and winsorized from each tail of the distribution. If rate = 0, it performs Welch's heteroscedastic F test. Otherwise, Welch's heteroscedastic F test with trimmed means and Winsorized variances is performed. Default is set to rate = 0. |
| `alpha` | the level of significance to assess the statistical difference. Default is set to alpha = 0.05. |
| `na.rm` | a logical value indicating whether NA values should be stripped before the computation proceeds. |
| `verbose` | a logical for printing output to R console. |

## Value

A list with class "owt" containing the following components:

| | |
|---|---|
| `statistic` | the value of the test statistic with a name describing it. |
| `parameter` | the parameter(s) of the approximate F distribution of the test statistic. |
| `p.value` | the p-value of the test. |
| `alpha` | the level of significance to assess the statistical difference. |
| `method` | the character string "Welch's Heteroscedastic F Test" or "Welch's Heteroscedastic F Test with Trimmed Means and Winsorized Variances" depending on the choice. |
| `rate` | the rate of observations trimmed and winsorized from each tail of the distribution. |
| `data` | a data frame containing the variables in which NA values (if exist) are removed. |
| `formula` | a formula of the form `lhs ~ rhs` where `lhs` gives the sample values and `rhs` the corresponding groups. |

## Author(s)

Osman Dag

## References

Dag, O., Dolgun, A., Konar, N.M. (2018). onewaytests: An R Package for One-Way Tests in Independent Groups Designs. *The R Journal*, **10:1**, 175-199.

Welch, B. L.(1951). On the Comparison of Several Mean Values: An Alternative Approach. *Biometrika*, **38**, 330-336.

## Examples

```
library(onewaytests)

welch.test(Sepal.Length ~ Species, data = iris)
welch.test(Sepal.Length ~ Species, data = iris, rate = 0.1)

out <- welch.test(Sepal.Length ~ Species, data = iris)
paircomp(out)
```

`wt.test` *Welch's t-Test*

## Description

`wt.test` performs Welch's t-test for two samples.

## Usage

```
wt.test(formula, data, alpha = 0.05, na.rm = TRUE, verbose = TRUE)
```

## Arguments

| | |
|---|---|
| `formula` | a formula of the form `lhs ~ rhs` where `lhs` gives the sample values and `rhs` the corresponding groups. |
| `data` | a tibble or data frame containing the variables in the formula `formula` |
| `alpha` | the level of significance to assess the statistical difference. Default is set to alpha = 0.05. |
| `na.rm` | a logical value indicating whether NA values should be stripped before the computation proceeds. |
| `verbose` | a logical for printing output to R console. |

## Value

A list with class "owt" containing the following components:

| | |
|---|---|
| `statistic` | the Welch's t-test statistic. |
| `parameter` | the parameter(s) of the approximate t distribution of the test statistic. |
| `p.value` | the p-value of the test. |
| `alpha` | the level of significance to assess the statistical difference. |
| `data` | a data frame containing the variables in which NA values (if exist) are removed. |
| `formula` | a formula of the form `lhs ~ rhs` where `lhs` gives the sample values and `rhs` the corresponding groups. |

## Author(s)

Osman Dag

## See Also

`t.test` `st.test`

## Examples

```
library(AID)
data(AADT)

library(onewaytests)
describe(aadt ~ control, data = AADT)

wt.test(aadt ~ control, data = AADT)
```

# Index