Package: Analitica (via r-universe)

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Title Exploratory Data Analysis, Group Comparison Tools, and Other Procedures

Version 2.4.0

Description Provides a comprehensive set of tools for descriptive statistics, graphical data exploration, outlier detection, homoscedasticity testing, and multiple comparison procedures. Includes manual implementations of Levene's test, Bartlett's test, and the Fligner-Killeen test; parametric post hoc methods such as Tukey, Scheffe, Duncan, SNK, LSD, Games-Howell and Tamhane; and rank-based post hoc methods such as Dunn, Conover-Iman, Nemenyi, Dwass-Steel-Critchlow-Fligner and Bonferroni-corrected Mann-Whitney tests, with plots suited to each type of procedure. Also includes the Jonckheere-Terpstra trend test, the Jarque-Bera test with Glinskiy's (2024) correction, and a post hoc test planner that helps choose the most suitable procedure. Designed for use in teaching, applied statistical analysis, and reproducible research.

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`Analitica` *Analitica: Tools for Exploratory Data Analysis and Group Comparisons*

Description

The **Analitica** package provides tools for exploratory statistical analysis, data visualization, and comparison of groups using both parametric and non-parametric methods. It supports univariate and grouped descriptive summaries, outlier detection, homoscedasticity testing, and multiple post hoc procedures.

Details

Designed for applied analysis workflows, this package includes intuitive plotting functions and manual implementations of key statistical tests often needed in educational or research contexts.

Main Features

- `descripYG`: Descriptive statistics with visualizations (histograms, boxplots, density ridges).
- `Levene.Test`: Manual implementation of Levene's test for homogeneity of variances.
- `BartlettTest`: Manual implementation of Bartlett's test.
- `FKTest`: Manual implementation of the Fligner-Killeen test.
- `grubbs_outliers`: Outlier detection based on Grubbs' test.
- `GHTest`, `DuncanTest`, `SNKTest`, etc.: Post hoc comparison procedures.

Author(s)

Carlos Jiménez-Gallardo

`bar_error` *Bar Plot with Error Bars (Standard Deviation or Standard Error)*

Description

Creates a bar plot of group means with error bars representing either the standard deviation (SD) or the standard error (SE).

Usage

```
bar_error(
  dataSet,
  vD,
  vI,
  variation = "sd",
  title = "Bar plot with error bars",
  label_y = "Y Axis",
  label_x = "X Axis"
)
```

Arguments

dataSet	A data.frame or tibble containing the data.
vD	A string indicating the name of the numeric dependent variable.
vI	A string indicating the name of the categorical independent variable (grouping variable).
variation	Type of variation to display: "sd" for standard deviation or "se" for standard error. Default is "sd".
title	Title of the plot. Default is "Bar plot with error bars".
label_y	Label for the Y-axis. Default is "Y Axis".
label_x	Label for the X-axis. Default is "X Axis".

Value

A ggplot object representing the plot.

Examples

```
data(d_e, package = "Analitica")
bar_error(d_e, vD = Sueldo_actual, vI = labor, variation = "sd")
```

BartlettTest *Bartlett's Test for Homogeneity of Variances (Manual Implementation)*

Description

Conducts Bartlett's test to evaluate whether multiple groups have equal variances, based on a formula interface and raw data vectors, without requiring a fitted model. This implementation provides flexibility for exploratory variance testing in custom workflows.

Usage

```
BartlettTest(formula, data, alpha = 0.05)
```

Arguments

formula	A formula of the form y ~ group, where y is a numeric response and group is a factor indicating group membership.
data	A data frame containing the variables specified in the formula.
alpha	Significance level for the test (default is 0.05).

Details

Bartlett's test is appropriate when group distributions are approximately normal. It tests the null hypothesis that all groups have equal variances (homoscedasticity).

Advantages: - Straightforward to compute. - High sensitivity to variance differences under normality.

Disadvantages: - Highly sensitive to non-normal distributions. - Less robust than alternatives like Levene's test for skewed or heavy-tailed data.

Value

An object of class "homocedasticidad", containing:

- Statistic: Bartlett's chi-squared test statistic.
- df: Degrees of freedom associated with the test.
- p_value: The p-value for the test statistic.
- Decision: A character string indicating the conclusion ("Heterocedastic" or "Homocedastic").
- Method: A character string indicating the method used ("Bartlett").

References

Bartlett, M. S. (1937). "Properties of sufficiency and statistical tests." *Proceedings of the Royal Society of London*, Series A, 160(901), 268–282.

Examples

```
data(d_e, package = "Analitica")
res <- BartlettTest(Sueldo_actual ~ labor, data = d_e)
summary(res)

summary(BartlettTest(Sueldo_actual ~ as.factor(labor), data = d_e))
```

BMpTest *Brunner-Munzel Test (Permutation Version) for Two Independent Groups*

Description

Performs the Brunner-Munzel test using a permutation approach, suitable for comparing two independent samples when the assumption of equal variances may not hold.

Usage

```
BMpTest(
  grupo1,
  grupo2,
  alpha = 0.05,
  alternative = c("two.sided", "less", "greater"),
  nperm = 10000,
  seed = NULL
)
```

Arguments

grupo1	A numeric vector representing the first group.
grupo2	A numeric vector representing the second group.
alpha	Significance level (default is 0.05).
alternative	Character string specifying the alternative hypothesis: one of "two.sided" (default), "greater", or "less".
nperm	Number of permutations to perform (default = 10000).
seed	Optional random seed for reproducibility (default is NULL).

Details

This version computes an empirical p-value based on resampling, without relying on the t-distribution approximation.

Value

An object of class "comparacion" and "brunnermunzel_perm", containing:

- Resultados: A data frame with comparison name, mean difference, empirical p-value, and significance.
- Promedios: A named numeric vector of group means.
- Orden_Medias: Group names ordered by their mean.
- Metodo: Description of the method used.

References

Brunner, E., & Munzel, U. (2000). "The nonparametric Behrens-Fisher problem: Asymptotic theory and a small-sample approximation." *Biometrical Journal*, 42(1), 17–25.

Examples

```
data(d_e, package = "Analitica")
g1 <- d_e$Sueldo_actual[d_e$labor == 1]
g2 <- d_e$Sueldo_actual[d_e$labor == 2]
resultado <- BMpTest(g1, g2)
summary(resultado)
```

BMTest *Brunner-Munzel Test for Two Independent Samples*

Description

Performs the Brunner-Munzel nonparametric test for two independent groups, which estimates the probability that a randomly selected value from one group is less than a randomly selected value from the other group.

Usage

```
BMTest(
  grupo1,
  grupo2,
  alpha = 0.05,
  alternative = c("two.sided", "less", "greater")
)
```

Arguments

`grupo1`	Numeric vector of values from group 1.
`grupo2`	Numeric vector of values from group 2.
`alpha`	Significance level (default = 0.05).
`alternative`	Character string specifying the alternative hypothesis. One of `"two.sided"` (default), `"greater"`, or `"less"`.

Details

This test is suitable when group variances are unequal and/or sample sizes differ. It does not assume equal variances and is often used as a more robust alternative to the Wilcoxon test.

Advantages: - Handles unequal variances and non-normality. - Recommended when variance homogeneity is questionable.

Disadvantages: - Less well-known and supported. - Requires large sample sizes for accurate inference.

Value

An object of class "comparacion" and "brunnermunzel", containing:

- Resultados: A data frame with test statistics, p-value, and estimated effect size.
- Promedios: A named numeric vector of group means.
- Orden_Medias: Group names ordered by their mean values (descending).
- Metodo: A character string describing the test and hypothesis.
- p_hat: Estimated probability that a value from grupo1 is less than a value from grupo2 (plus 0.5 * ties).

References

Brunner, E., & Munzel, U. (2000). "The nonparametric Behrens-Fisher problem: Asymptotic theory and a small-sample approximation." *Biometrical Journal*, 42(1), 17–25. <https://doi.org/10.1002/(SICI)1521-4036(200001)42:1

Examples

```
data(d_e, package = "Analitica")
g1 <- d_e$Sueldo_actual[d_e$labor == 1]
g2 <- d_e$Sueldo_actual[d_e$labor == 2]
resultado <- BMTest(g1, g2, alternative = "greater")
summary(resultado)
```

BonferroniNPTest *Bonferroni-Corrected Mann-Whitney Tests (Non-Parametric)*

Description

Performs all pairwise comparisons using the Wilcoxon rank-sum test (Mann-Whitney) with Bonferroni correction for multiple testing.

Usage

```
BonferroniNPTest(formula, data, alpha = 0.05)
```

Arguments

formula	A formula of the form y ~ group.
data	A data frame containing the variables.
alpha	Significance level (default is 0.05).

Details

Suitable for non-parametric data where ANOVA assumptions are violated. Groups are ordered from highest to lowest mean rank, and each comparison is reported as "higher - lower", so the W statistic always refers to the first group of the pair.

Advantages: - Simple and intuitive non-parametric alternative to ANOVA post hoc tests. - Strong control of Type I error via Bonferroni correction. - Works with unequal group sizes.

Disadvantages: - Conservative with many groups. - Only valid for pairwise comparisons; does not support complex contrasts. - It is only useful in completely random or single-factor designs.

Value

An object of class `"bonferroni_np"`, `"comparaciones_np"` and `"comparaciones"`, containing:

- `Resultados`: Data frame with comparisons (ordered from highest to lowest mean rank), W-statistics, raw and adjusted p-values, and significance levels.
- `Promedios`: Mean ranks of each group, sorted from highest to lowest.
- `Orden_Medias`: Group names ordered from highest to lowest mean rank.
- `Metodo`: Name of the method used ("Bonferroni (non-parametric)").
- `Datos`: Data frame with the response and the group, used by `plot()`.

References

Wilcoxon, F. (1945). Individual Comparisons by Ranking Methods. *Biometrics Bulletin*, 1(6), 80–83. doi:10.2307/3001968

Dunn, O. J. (1964). Multiple Comparisons Using Rank Sums. *Technometrics*, 6(3), 241–252. doi:10.1080/00401706.1964.10490181

Shaffer, J. P. (1995). Multiple Hypothesis Testing. *Annual Review of Psychology*, 46(1), 561–584. doi:10.1146/annurev.ps.46.020195.003021

Examples

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

`BonferroniTest` *Bonferroni-Corrected Pairwise t-Tests v2.0*

Description

Performs pairwise t-tests with Bonferroni adjustment for multiple comparisons. This method controls the family-wise error rate by dividing the alpha level by the number of comparisons.

Usage

```
BonferroniTest(modelo, comparar = NULL, alpha = 0.05)
```

Arguments

modelo	An aov or lm object (full model: includes blocks, factors, etc.).
comparar	Character vector with the name(s) of the factor(s) to compare: - One name: main effect (e.g., "treatment" or "A") - Several names: interaction (e.g., c("A","B") for A:B) If omitted, it uses the first factor in modelo$xlevels.
alpha	Significance level (default 0.05).

Details

Advantages: - Very simple and easy to implement. - Strong control of Type I error. - Applicable to any set of independent comparisons.

Disadvantages: - Highly conservative, especially with many groups. - Can lead to low statistical power (increased Type II error). - Does not adjust test statistics, only p-values.

Value

An object of class "bonferroni" and "comparaciones" containing:

- Resultados: a data.frame with columns Comparacion, Diferencia, SE, t_value, p_value (unadjusted), p_ajustada (Bonferroni), Valor_Critico (critical difference), and Significancia.
- Promedios: a named vector of group means as defined by comparar.
- Orden_Medias: group names ordered from highest to lowest mean.
- Metodo: "Bonferroni-adjusted t-test".
- Termino: the term being compared (e.g., "A", "B", or "A:B").
- MSerror, df_error, N: useful for plots with error bars.

References

Dunn, O. J. (1964). Multiple Comparisons Using Rank Sums. *Technometrics*, 6(3), 241–252. doi:10.1080/00401706.1964.10490181

Wilcoxon, F. (1945). Individual Comparisons by Ranking Methods. *Biometrics Bulletin*, 1(6), 80–83. doi:10.2307/3001968

Examples

```
#DCA
data(d_e, package = "Analitica")
mod1 <- aov(Sueldo_actual ~ as.factor(labor), data = d_e)
summary(mod1)
resultado <- BonferroniTest(mod1)
summary(resultado)

DBA: y ~ tratamiento + bloque
mod2 <- aov(Sueldo_actual ~ as.factor(labor) + Sexo, data = d_e)
res <- BonferroniTest(mod2, comparar = "as.factor(labor)")
summary(res); plot(res)
```

```
# DFactorial: y ~ A * B
mod2 <- aov(Sueldo_actual ~ as.factor(labor) * Sexo, data = d_e)
resAB <- BonferroniTest(mod2, comparar = c("as.factor(labor)","Sexo")) # compara celdas A:B
summary(resAB, n = Inf); plot(resAB, horizontal = TRUE)
```

`BrownForsytheTest` *Brown-Forsythe Test for Homogeneity of Variances (Manual Implementation)*

Description

Performs the Brown-Forsythe test using absolute deviations from the median of each group, followed by a one-way ANOVA on those deviations.

Usage

```
BrownForsytheTest(formula, data, alpha = 0.05)
```

Arguments

`formula`	A formula of the form `y ~ group`, where `y` is numeric and `group` is a factor.
`data`	A data frame containing the variables.
`alpha`	Significance level (default is 0.05).

Details

This test is a robust alternative to Bartlett's test, especially useful when the assumption of normality is violated or when outliers are present.

Advantages: - More robust than Bartlett's test under non-normal distributions. - Less sensitive to outliers due to the use of the median.

Disadvantages: - Lower power than Bartlett's test when normality strictly holds. - Assumes that absolute deviations follow similar distributions across groups.

Value

An object of class `"homocedasticidad"`, with:

- `Statistic`: F-statistic.
- `df1`: Numerator degrees of freedom.
- `df2`: Denominator degrees of freedom.
- `p_value`: P-value.
- `Decision`: "Heterocedastic" or "Homocedastic".
- `Method`: "Brown-Forsythe".

References

Brown, M. B., & Forsythe, A. B. (1974). "Robust Tests for the Equality of Variances". *Journal of the American Statistical Association*, 69(346), 364–367.

Examples

```
data(d_e, package = "Analitica")
res <- BrownForsytheTest(Sueldo_actual ~ labor, data = d_e)
summary(res)
```

`ConoverTest` *Conover-Iman Test for Multiple Comparisons (Non-Parametric)*

Description

Performs non-parametric pairwise comparisons based on rank-transformed data using the Conover-Iman procedure. This method is typically applied as a post hoc test following a significant Kruskal-Wallis test to identify specific group differences.

Usage

```
ConoverTest(formula, data, alpha = 0.05, method.p = "holm")
```

Arguments

`formula`	A formula of the form `y ~ group`, where `y` is a numeric variable and `group` is a factor indicating group membership.
`data`	A data frame containing the variables specified in the formula.
`alpha`	Significance level for hypothesis testing (default is 0.05).
`method.p`	Method used to adjust p-values for multiple comparisons (default is `"holm"`).

Details

The Conover-Iman test uses rank-based t-statistics, offering improved statistical power over Dunn's test while maintaining flexibility in sample size.

Ranks are computed on the pooled sample (mid-ranks for ties). For each pair,

$$t_{ij} = \frac{|\bar{R}_i - \bar{R}_j|}{\sqrt{S^2 \, \frac{N-1-H}{N-k} \left(\frac{1}{n_i} + \frac{1}{n_j}\right)}}$$

with $S^2 = \frac{1}{N-1}\left(\sum R^2 - \frac{N(N+1)^2}{4}\right)$ and H the (tie-corrected) Kruskal-Wallis statistic. The statistic is compared with a t distribution with $N - k$ degrees of freedom.

Advantages: - More powerful than Dunn's test, especially with moderate group differences. - Robust to non-normal data and suitable for ordinal or skewed distributions. - Allows for unequal sample sizes across groups.

Disadvantages: - Sensitive to heteroscedasticity (non-constant variances). - Requires appropriate p-value adjustment to control the family-wise error rate. - It is only useful in completely random or single-factor designs.

Value

An object of class `"conover"`, `"comparaciones_np"` and `"comparaciones"`, containing:

- `Resultados`: A data frame with pairwise comparisons (higher - lower mean rank), t-statistics, raw and adjusted p-values, and significance markers.
- `Promedios`: A named numeric vector with mean ranks for each group, sorted from highest to lowest.
- `Orden_Medias`: A character vector with group names sorted from highest to lowest rank.
- `Metodo`: A string describing the method used ("Conover-Iman (non-parametric)").
- `Datos`: Data frame with the response and the group, used by `plot()`.
- `KruskalWallis`: Result of `kruskal.test()`.

References

Conover, W. J. & Iman, R. L. (1979). "Multiple comparisons using rank sums." *Technometrics*, 21(4), 489–495.

Examples

```
data(d_e, package = "Analitica")
ConoverTest(Sueldo_actual ~ labor, data = d_e)
```

---

d_e *Datos de clientes ficticios*

Description

Conjunto de dato, para ser utilizados como ejemplo. Las variables son:

Usage

```
data(d_e)
```

Format

Un data.frame con N filas y M columnas. Las variables típicas pueden incluir:

id ID del empleado

Sexo Sexo del empleado

FechaNac Fecha Nacimiento

educacion cantidad de años de estudio

labor area de trabajo dentro de la emrpesa

Sueldo_actual sueldo a la fecha

Sueldo_inicial sueldo al ingresar a la empresa

antiguedad meses trabajando en la empresa

experiencia meses de experiencia

ingreso Ingreso mensual estimado

minoria la pertenencia a una minoria

`descripYG` *Descriptive Analysis With Optional Grouping*

Description

Performs a descriptive analysis on a numeric dependent variable, either globally or grouped by an independent variable. Displays summary statistics such as mean, standard deviation, skewness, and kurtosis, and generates associated plots (histogram, boxplot, or density ridges).

Usage

```
descripYG(dataset, vd, vi = NULL)
```

Arguments

`dataset`	A `data.frame` or `tibble` containing the variables.
`vd`	A numeric variable to analyze (dependent variable).
`vi`	An optional grouping variable (independent variable, categorical or numeric).

Value

A `data.frame` with descriptive statistics. Also prints plots to the graphics device.

Examples

```
data(d_e, package = "Analitica")
descripYG(d_e, vd = Sueldo_actual)
descripYG(d_e, vd = Sueldo_actual, vi = labor)
descripYG(d_e,Sueldo_actual,labor)
```

`DSCFTest` *Dwass-Steel-Critchlow-Fligner (DSCF) Test (Non-Parametric)*

Description

All-pairs non-parametric multiple comparison procedure, usually applied after a Kruskal-Wallis test. Unlike Dunn or Conover-Iman, each pair of groups is ranked separately (only the observations of those two groups), and the standardized Wilcoxon statistic is referred to the studentized range distribution with k groups and infinite degrees of freedom.

Usage

```
DSCFTest(
  formula,
  data,
  alpha = 0.05,
  method.p = NULL,
  na.rm = TRUE,
  include_kw = TRUE
)
```

Arguments

`formula`	A formula of the form `y ~ group`.
`data`	A data frame containing the variables.
`alpha`	Significance level (default 0.05).
`method.p`	Ignored. Kept for backward compatibility: the studentized range distribution already controls the family-wise error rate.
`na.rm`	Remove NA (TRUE by default).
`include_kw`	If TRUE, add the Kruskal-Wallis test to the output.

Details

For groups i and j, with W_i the sum of the ranks of group i in the joint ranking of both groups,

$$W_{ij}^* = \sqrt{2}\,\frac{W_i - n_i(n_i+n_j+1)/2}{\sqrt{V_{ij}}}$$

$$V_{ij} = \frac{n_i n_j}{12}\left(n_i+n_j+1-\frac{\sum(t^3-t)}{(n_i+n_j)(n_i+n_j-1)}\right)$$

where t are the sizes of the tie groups within the pair. The p-value is $P(Q_{k,\infty} \geq |W_{ij}^*|)$, which already controls the family-wise error rate.

Advantages: - Strong control of the family-wise error rate with unequal sample sizes. - Each comparison only uses the data of the two groups involved.

Disadvantages: - Computationally more complex. - Less commonly available in standard software. - It is only useful in completely random or single-factor designs.

Value

An object of class "dscf", "comparaciones_np" and "comparaciones", containing:

- Resultados: Data frame with comparisons (higher - lower mean rank), W statistic, p-values and significance codes.
- Promedios: Mean ranks of each group (pooled ranking), sorted from highest to lowest.
- Orden_Medias: Group names ordered from highest to lowest mean rank.
- N_por_grupo: Sample size of each group.
- Metodo: "DSCF (non-parametric)".
- Datos: Data frame with the response and the group, used by plot().
- KruskalWallis: Result of kruskal.test() (if include_kw = TRUE).

References

Dwass, M. (1960). Some k-sample rank-order tests. In I. Olkin et al. (Eds.), *Contributions to Probability and Statistics: Essays in Honor of Harold Hotelling* (pp. 198-202). Stanford University Press.

Steel, R. G. D. (1960). A rank sum test for comparing all pairs of treatments. *Technometrics*, 2(2), 197-207. doi:10.1080/00401706.1960.10489894

Critchlow, D. E. & Fligner, M. A. (1991). On distribution-free multiple comparisons in the one-way analysis of variance. *Communications in Statistics - Theory and Methods*, 20(1), 127-139. doi:10.1080/03610929108830487

Examples

```
data(d_e, package = "Analitica")
DSCFTest(Sueldo_actual ~ labor, data = d_e)
```

DuncanTest *Duncan Multiple Range Test (DMRT) v2.0*

Description

Performs the Duncan test for pairwise comparisons after an ANOVA. This method is more liberal than Tukey's HSD, using a stepwise approach with critical values from the studentized range distribution.

Usage

```
DuncanTest(modelo, comparar = NULL, alpha = 0.05)
```

Arguments

modelo	An aov or lm object (full model: includes blocks, factors, etc.).
comparar	Character vector with the name(s) of the factor(s) to compare: - One name: main effect (e.g., "treatment" or "A") - Several names: interaction (e.g., c("A","B") for A:B) If omitted, it uses the first factor in modelo$xlevels.
alpha	Significance level (default 0.05).

Details

Advantages: - High power for detecting differences. - Simple to interpret and implement.

Disadvantages: - Inflates Type I error rate. - Not recommended for confirmatory research.

Value

An object of class "duncan" and "comparaciones" containing:

- Resultados: a data.frame with columns Comparacion, Diferencia, SE, t_value, p_value (unadjusted), p_ajustada (duncan), Valor_Critico (critical difference), and Significancia.
- Promedios: a named vector of group means as defined by comparar.
- Orden_Medias: group names ordered from highest to lowest mean.
- Metodo: "Duncan t-test".
- Termino: the term being compared (e.g., "A", "B", or "A:B").
- MSerror, df_error, N: useful for plots with error bars.

References

Duncan, D. B. (1955). "Multiple range and multiple F tests." Biometrics, 11(1), 1-42.

Examples

```
# DCA
data(d_e, package = "Analitica")
mod1 <- aov(Sueldo_actual ~ as.factor(labor), data = d_e)
resultado <- DuncanTest(mod1)
summary(resultado)
plot(resultado)

# DBA
mod2 <- aov(Sueldo_actual ~ as.factor(labor) + Sexo, data = d_e)
res <- DuncanTest(mod2, comparar = "as.factor(labor)")
summary(res); plot(res)

# DFactorial
mod3 <- aov(Sueldo_actual ~as.factor(labor) * Sexo, data = d_e)
resAB <- DuncanTest(mod3, comparar = c("as.factor(labor)","Sexo"))  # celdas A:B
summary(resAB, n = Inf); plot(resAB, horizontal = TRUE)
```

`DunnTest` *Dunn's Test for Multiple Comparisons (Non-Parametric)*

Description

Performs Dunn's test for pairwise comparisons following a Kruskal-Wallis test. Suitable for non-parametric data (ordinal or non-normal), using rank sums. Includes Holm correction by default for multiple comparisons.

Usage

```
DunnTest(formula, data, alpha = 0.05, method.p = "holm")
```

Arguments

`formula`	A formula of the form `y ~ group`.
`data`	A data frame containing the variables.
`alpha`	Significance level (default is 0.05).
`method.p`	Method for p-value adjustment (default is "holm").

Details

For each pair, $z_{ij} = |\bar{R}_i - \bar{R}_j| / \sqrt{\frac{N(N+1)}{12} C \left(\frac{1}{n_i} + \frac{1}{n_j}\right)}$, where $C = 1 - \sum(t^3 - t)/(N^3 - N)$ corrects for ties.

Advantages: - Simple and widely used non-parametric alternative to Tukey's test. - Handles unequal sample sizes. - Compatible with various p-value corrections (e.g., Holm, Bonferroni).

Disadvantages: - Less powerful than DSCF or Conover when sample sizes vary widely. - Requires ranking all data and can be conservative depending on adjustment.

Value

An object of class `"dunn"`, `"comparaciones_np"` and `"comparaciones"`, including:

- `Resultados`: Data frame with group comparisons (higher - lower mean rank), z-values, raw and adjusted p-values, and significance.
- `Promedios`: Mean ranks of each group, sorted from highest to lowest.
- `Orden_Medias`: Group names ordered from highest to lowest rank.
- `Metodo`: "Dunn (non-parametric)".
- `Datos`: Data frame with the response and the group, used by `plot()`.
- `KruskalWallis`: Result of `kruskal.test()`.

References

Dunn, O. J. (1964). Multiple comparisons using rank sums. *Technometrics*, 6(3), 241–252. doi:10.1080/00401706.1964.10490181

Examples

```
data(d_e, package = "Analitica")
DunnTest(Sueldo_actual ~ labor, data = d_e)
```

`FKTest` *Fligner-Killeen Test for Homogeneity of Variances (Manual Implementation)*

Description

Performs a non-parametric Fligner-Killeen test for equality of variances across two or more groups, using raw vectors via a formula interface.

Usage

```
FKTest(formula, data, alpha = 0.05)
```

Arguments

`formula`	A formula of the form `y ~ group`, where `y` is numeric and `group` is a grouping variable (factor or coercible to factor).
`data`	A data frame containing the variables in the formula.
`alpha`	Significance level (default is 0.05).

Details

This test is particularly useful when the assumption of normality is violated, as it is robust to outliers and distributional deviations. It serves as a reliable alternative to Bartlett's test when data do not follow a normal distribution.

Advantages: - Non-parametric: No assumption of normality. - Robust to outliers. - Suitable for heterogeneous sample sizes.

Disadvantages: - Less powerful than parametric tests under normality. - May be computationally intensive with large datasets.

Value

An object of class `"homocedasticidad"`, containing:

Statistic The Fligner-Killeen chi-squared statistic.

df Degrees of freedom.

p_value The p-value for the test.

Decision `"Homoscedastic"` or `"Heteroscedastic"` depending on the test result.

Method A string indicating the method used ("Fligner-Killeen").

References

Fligner, M. A., & Killeen, T. J. (1976). "Distribution-free two-sample tests for scale." *Journal of the American Statistical Association*, 71(353), 210–213. <https://doi.org/10.1080/01621459.1976.10480351>

Examples

```
data(d_e, package = "Analitica")
res <- FKTest(Sueldo_actual ~ labor, data = d_e)
summary(res)
```

`GabrielTest` *Gabriel's Post Hoc Test for Multiple Comparisons v 2.0*

Description

A modification of Tukey's test for use with moderately unequal sample sizes.

Usage

```
GabrielTest(modelo, comparar = NULL, alpha = 0.05)
```

Arguments

`modelo`	An `aov` or `lm` object (full model: includes blocks, factors, etc.).
`comparar`	Character vector with the name(s) of the factor(s) to compare: - One name: main effect (e.g., "treatment" or "A") - Several names: interaction (e.g., `c("A","B")` for `A:B`) If omitted, it uses the first factor in `modelo$xlevels`.
`alpha`	Significance level (default 0.05).

Details

Advantages: - More powerful than Tukey for unequal group sizes. - Controls error rates effectively with moderate imbalance.

Disadvantages: - Can be anti-conservative with large differences in group sizes. - Less common in standard statistical software.

Value

An object of class `"gabriel"` and `"comparaciones"` containing:

- `Resultados`: a data.frame with columns `Comparacion`, `Diferencia`, `SE`, `t_value`, `p_value` (unadjusted), `p_ajustada` (gabriel), `Valor_Critico` (critical difference), and `Significancia`.
- `Promedios`: a named vector of group means as defined by `comparar`.
- `Orden_Medias`: group names ordered from highest to lowest mean.
- `Metodo`: "Gabriel t-test".
- `Termino`: the term being compared (e.g., "A", "B", or "A:B").
- `MSerror`, `df_error`, `N`: useful for plots with error bars.

References

Hochberg, Y., & Tamhane, A. C. (1987). Multiple Comparison Procedures.

Examples

```
# DCA
data(d_e, package = "Analitica")
mod1 <- aov(Sueldo_actual ~ as.factor(labor), data = d_e)
resultado <- GabrielTest(mod1)
summary(resultado)
plot(resultado)

# RCBD
mod2 <- aov(Sueldo_actual ~ as.factor(labor) + Sexo, data = d_e)
res <- GabrielTest(mod2, comparar = "as.factor(labor)")
summary(res); plot(res)

# Factorial
mod3 <- aov(Sueldo_actual ~ as.factor(labor) * Sexo, data = d_e)
resAB <- GabrielTest(mod3, comparar = c("as.factor(labor)","Sexo"))  # celdas A:B
summary(resAB, n = Inf); plot(resAB, horizontal = TRUE)
```

GHTest *Games-Howell Post Hoc Test v.2.2.0*

Description

Performs the Games-Howell test for pairwise comparisons after ANOVA, without assuming equal variances or sample sizes. It is suitable when Levene or Bartlett test indicates heterogeneity of variances.

Usage

```
GHTest(modelo, comparar = NULL, alpha = 0.05)
```

Arguments

modelo	An aov or lm object (full model: includes blocks, factors, etc.).
comparar	Character vector with the name(s) of the factor(s) to compare: - One name: main effect (e.g., "treatment" or "A") - Several names: interaction (e.g., c("A","B") for A:B) If omitted, it uses the first factor in modelo$xlevels.
alpha	Significance level (default is 0.05).

Details

Advantages: - Excellent for heteroscedastic data. - Controls Type I error across unequal group sizes.

Disadvantages: - Slightly conservative in small samples. - More complex to compute than Tukey.

Value

An object of class "gameshowell" and "comparaciones", which contains:

- Resultados: A data frame with pairwise comparisons, including: Comparacion, Diferencia, t_value, gl, p_value, and Significancia.
- Promedios: A named numeric vector of group means as defined by comparar.
- Orden_Medias: Group names ordered from highest to lowest mean.
- Metodo: A character string indicating the method used ("Games-Howell").
- Termino: The term being compared (e.g., "A", "B", or "A:B").

References

Games, P. A., & Howell, J. F. (1976). "Pairwise Multiple Comparison Procedures with Unequal N's and/or Variances: A Monte Carlo Study". Journal of Educational Statistics, 1(2), 113–125. <https://doi.org/10.1002/j.2162-6057.1976.tb00211.x>

Examples

```
data(d_e, package = "Analitica")
mod <- aov(Sueldo_actual ~ as.factor(labor), data = d_e)
# Comparación sobre el primer factor del modelo
resultado <- GHTest(mod)
summary(resultado)
plot(resultado)

# Con bloques, comparando solo el factor de interés
mod2 <- aov(Sueldo_actual ~ as.factor(labor) + Sexo, data = d_e)
res2 <- GHTest(mod2, comparar = "as.factor(labor)")
summary(res2)
plot(res2)

# Modelo con interacción
mod3 <- aov(Sueldo_actual ~ as.factor(labor) * Sexo, data = d_e)
# efecto principal
resA <- GHTest(mod3, comparar = "as.factor(labor)")
# interacción
resAB <- GHTest(mod3, comparar = c("as.factor(labor)", "Sexo"))
summary(resAB)
plot(resAB)
```

---

grubbs_outliers *Outlier Detection Using Grubbs' Test (Iterative)*

Description

Detects one or more outliers in a numeric variable using the iterative Grubbs' test, which assumes the data follow a normal distribution.

Usage

```
grubbs_outliers(dataSet, vD, alpha = 0.05)
```

Arguments

dataSet	A data.frame containing the data.
vD	Unquoted name of the numeric variable to be tested for outliers.
alpha	Significance level for the test (default is 0.05).

Details

The function applies Grubbs' test iteratively, removing the most extreme value and retesting until no further significant outliers are found. The test is valid only under the assumption of normality.

Value

A data.frame identical to the input, with an added logical column outL indicating which observations were identified as outliers (TRUE or FALSE).

References

Grubbs, F. E. (1969). "Procedures for Detecting Outlying Observations in Samples." *Technometrics*, 11(1), 1–21. doi:10.1080/00401706.1969.10490657

Examples

```
data(d_e, package = "Analitica")
d<-grubbs_outliers(d_e, Sueldo_actual)
```

HolmTest *Holm-Adjusted (Holm-Bonferroni) Pairwise Comparisons v2.0*

Description

Performs pairwise t-tests with p-values adjusted using Holm's sequential method.

Usage

```
HolmTest(modelo, comparar = NULL, alpha = 0.05)
```

Arguments

modelo	An aov or lm object (full model: includes blocks, factors, etc.).
comparar	Character vector with the name(s) of the factor(s) to compare: - One name: main effect (e.g., "treatment" or "A") - Several names: interaction (e.g., c("A","B") for A:B) If omitted, it uses the first factor in modelo$xlevels.
alpha	Significance level (default 0.05).

Details

Advantages: - Controls family-wise error rate more efficiently than Bonferroni. - Easy to apply over any set of p-values.

Disadvantages: - Does not adjust test statistics, only p-values. - Slightly more conservative than false discovery rate (FDR) methods.

Value

An object of class "holm" and "comparaciones" containing:

- Resultados: a data.frame with columns Comparacion, Diferencia, SE, t_value, p_value (unadjusted), p_ajustada (Holm), Valor_Critico (critical difference), and Significancia.
- Promedios: a named vector of group means as defined by comparar.
- Orden_Medias: group names ordered from highest to lowest mean.
- Metodo: "Holm t-test".
- Termino: the term being compared (e.g., "A", "B", or "A:B").
- MSerror, df_error, N: useful for plots with error bars.

References

Holm, S. (1979). A simple sequentially rejective multiple test procedure.Scandinavian Journal of Statistics, 6(2), 65–70.

Examples

```
data(d_e, package = "Analitica")
mod <- aov(Sueldo_actual ~ as.factor(labor), data = d_e)
resultado <- HolmTest(mod)
summary(resultado)
plot(resultado)

# RCBD
mod <- aov(Sueldo_actual ~ as.factor(labor) + Sexo, data = d_e)
res <- HolmTest(mod, comparar = "as.factor(labor)")
summary(res); plot(res)               # usa p_ajustada automaticamente

# Factorial
mod2 <- aov(Sueldo_actual ~ as.factor(labor) * Sexo, data = d_e)
resAB <- HolmTest(mod2, comparar = c("as.factor(labor)","Sexo"))
summary(resAB, n = Inf); plot(resAB, horizontal = TRUE)
```

JBGTest *Jarque-Bera Test with Glinskiy Corrections*

Description

Performs the Jarque-Bera test for normality with optional corrections proposed by Glinskiy et al. (2024), depending on whether the mean, variance, or both are known a priori.

Usage

```
JBGTest(y, mu = NULL, sigma2 = NULL, alpha = 0.05)
```

Arguments

y	A numeric vector to test for normality.
mu	Optional known mean value. Default is NULL.
sigma2	Optional known variance value. Default is NULL.
alpha	Significance level for the test (default is 0.05).

Value

An object of class "normalidad", containing:

- statistic: Test statistic value.
- df: Degrees of freedom (always 2).
- p_value: P-value of the test.
- decision: Conclusion about normality.
- variant: Type of JB test applied.
- method: "Jarque-Bera (Glinskiy)"

References

Glinskiy, Vladimir & Ismayilova, Yulia & Khrushchev, Sergey & Logachov, Artem & Logachova, Olga & Serga, Lyudmila & Yambartsev, Anatoly & Zaykov, Kirill. (2024). Modifications to the Jarque–Bera Test. Mathematics. 12. 2523. 10.3390/math12162523.

Examples

```
data(d_e, package = "Analitica")
JBGTest(d_e$Sueldo_actual)
#output different of result
summary(JBGTest(d_e$Sueldo_actual))
```

`JT_Test` *Jonckheere-Terpstra Test for Ordered Alternatives (with Tie Correction)*

Description

Performs the Jonckheere-Terpstra test to evaluate the presence of a monotonic trend (increasing or decreasing) across three or more independent ordered groups. This test is non-parametric and is particularly useful when the independent variable is ordinal and the response is continuous or ordinal.

Usage

```
JT_Test(formula, data)
```

Arguments

`formula`	A formula of the type y ~ group, where 'group' is an ordered factor.
`data`	A data.frame containing the variables in the formula.

Details

The Jonckheere-Terpstra test compares all pairwise combinations of groups and counts the number of times values in higher-ordered groups exceed those in lower-ordered groups. This implementation includes a full correction for ties in the data, which ensures more accurate inference.

Advantages: - Non-parametric: does not assume normality or equal variances. - More powerful than Kruskal-Wallis when there is an a priori ordering of groups. - Tie correction included, improving robustness in real-world data.

Disadvantages: - Requires that the group variable be ordered (ordinal). - Detects overall trend but not specific group differences. - Sensitive to large numbers of ties or very unbalanced group sizes.

Value

An object of class "jonckheere" with:

- `J`: Total Jonckheere-Terpstra statistic.
- `J_pares`: Pairwise J statistics between group combinations.
- `mu_J`: Expected value of J under the null hypothesis.
- `var_J`: Variance of J (with complete tie correction).
- `Z`: Standardized test statistic.
- `p_value`: Two-sided p-value.
- `Trend`: Detected trend ("increasing", "decreasing", or "none").
- `Method`: Description of the method.

References

Hollander, M., Wolfe, D. A., & Chicken, E. (2014). Nonparametric statistical methods. p. 202 (3rd ed.). Wiley.

Examples

```
df <- data.frame(
  group = factor(rep(1:3, each = 6), ordered = TRUE),
  y = c(40,35,38,43,44,41,38,40,47,44,40,42,48,40,45,43,46,44)
)
res <- JT_Test(y ~ group, data = df)
```

`Levene.Test` *Levene's Test for Homogeneity of Variances (Manual Implementation) v2.1*

Description

Performs Levene's test for equality of variances across groups using a formula interface. This test evaluates the null hypothesis that the variances are equal across groups, and is commonly used as a preliminary test before ANOVA or other parametric analyses.

Usage

```
Levene.Test(
  formula,
  data,
  alpha = 0.05,
  center = "median",
  decompose = TRUE,
  anova_type = c("I", "II", "III")
)
```

Arguments

`formula`	y ~ factors (e.g., y ~ A or y ~ A * B).
`data`	data.frame with variables in the formula.
`alpha`	Significance level (default 0.05).
`center`	"median" (Brown-Forsythe, default) or "mean" (classical Levene).
`decompose`	logical. If TRUE and there are >= 2 factors, run ANOVA on |Y - cell_center|.
`anova_type`	"I", "II" (2-way only) or "III" (any number of factors, no 'car').

Details

Levene's test is based on an analysis of variance (ANOVA) applied to the absolute deviations from each group's center (either the mean or, more robustly, the median). It is less sensitive to departures from normality than Bartlett's test.

Advantages: - Robust to non-normality, especially when using the median. - Suitable for equal or unequal sample sizes across groups. - Widely used in practice for checking homoscedasticity.

Disadvantages: - Less powerful than parametric alternatives under strict normality.

Value

An object of class `"homocedasticidad"`, containing:

Statistic F statistic of the Levene test.

df Degrees of freedom (between and within groups).

p_value The p-value for the test.

Decision `"Homoscedastic"` or `"Heteroscedastic"` depending on the test result.

Method A string indicating the method used ("Levene").

References

Levene, H. (1960). "Robust Tests for Equality of Variances." In Contributions to Probability and Statistics: Essays in Honor of Harold Hotelling (pp.278-292). Stanford University Press.

Examples

```
data(d_e, package = "Analitica")
res <- Levene.Test(Sueldo_actual ~ as.factor(labor), data = d_e)
summary(res)

# RCBD
resB<-Levene.Test(Sueldo_actual ~ as.factor(labor)+Sexo, data = d_e)
summary(resB)

# anova 2-ways
resC<-Levene.Test(Sueldo_actual ~ as.factor(labor)*Sexo, data = d_e)
summary(resC)
```

LSDTest *Least Significant Difference (LSD) Test v2.0*

Description

Performs unadjusted pairwise t-tests following a significant ANOVA.

Usage

```
LSDTest(modelo, comparar = NULL, alpha = 0.05)
```

Arguments

modelo	An aov or lm object (full model: includes blocks, factors, etc.).
comparar	Character vector with the name(s) of the factor(s) to compare: - One name: main effect (e.g., "treatment" or "A") - Several names: interaction (e.g., c("A","B") for A:B) If omitted, it uses the first factor in modelo$xlevels.
alpha	Significance level (default 0.05).

Details

Advantages: - Very powerful when assumptions are met. - Simple and easy to interpret.

Disadvantages: - High risk of Type I error without correction. - Not recommended if many comparisons are made.

Value

An object of class "lsd" and "comparaciones" containing:

- Resultados: a data.frame with columns Comparacion, Diferencia, SE, t_value, p_value (unadjusted), p_ajustada (LSD), Valor_Critico (critical difference), and Significancia.
- Promedios: a named vector of group means as defined by comparar.
- Orden_Medias: group names ordered from highest to lowest mean.
- Metodo: "LSD t-test".
- Termino: the term being compared (e.g., "A", "B", or "A:B").
- MSerror, df_error, N: useful for plots with error bars.

References

Fisher, R. A. (1935). The Design of Experiments. Oliver & Boyd.

Examples

```
data(d_e, package = "Analitica")
mod <- aov(Sueldo_actual ~ as.factor(labor), data = d_e)
resultado <- LSDTest(mod)
summary(resultado)
plot(resultado)

# RCBD
mod <- aov(Sueldo_actual ~ as.factor(labor) + Sexo, data = d_e)
res <- LSDTest(mod, comparar = "as.factor(labor)")
summary(res); plot(res)                      # plot usara p_value

# Factorial
mod2 <- aov(Sueldo_actual ~ as.factor(labor) * Sexo, data = d_e)
```

```
resAB <- LSDTest(mod2, comparar = c("as.factor(labor)","Sexo"))
summary(resAB, n = Inf); plot(resAB, horizontal = TRUE)
```

`MauchlyTest` *Mauchly's Test for Sphericity (1 factor) v1.0*

Description

Tests for sphericity in repeated measures designs. Uses an interface for type formula `dv ~ within | id`, where:

- `dv`: variable numerical response,
- `within`: within-subjects factor (repeated levels),
- `id`: subject/sample identifier.

Usage

```
MauchlyTest(formula, data, alpha = 0.05, digits = 4, do_print = TRUE)
```

Arguments

`formula`	Formula `dv ~ within	id`.
`data`	`data.frame` with the variables.
`alpha`	Significance level (default 0.05).
`digits`	Decimals for printing (default 4).
`do_print`	if `TRUE`, print a friendly summary.

Details

Calculates Mauchly's statistic W, its approximation W corrected, the p-value and the correction coefficients for lack of sphericity (Greenhouse–Geisser y Huynh–Feldt).

Value

Objeto de clase `"sphericity"` with:

Method Cadena con el método.

Statistic Lista con `W` y `Chi2`.

df Grados de libertad.

p_value Valor-p.

Decision `"Sphericity"` o `"No sphericity"` según `alpha`.

Epsilons `GG` and `HF`.

Components List with `n` (subjects), `k` (levels), `S` (covariances), `eigen` (eigenvalues).

References

Mauchly, J. W. (1940). Significance test for sphericity of a normal n-variate distribution. The Annals of Mathematical Statistics, 11(2), 204–209. https://doi.org/10.1214/aoms/1177731915

Examples

```
# Ejemplo mínimo (datos ficticios):
set.seed(1)
d <- data.frame(
  id = rep(1:10, each = 4),
  within = rep(paste0("t", 1:4), times = 10),
  y = as.numeric(rep(rnorm(10, 10, 2), each = 4)) +
      rep(c(0, .5, 1.2, .8), times = 10) + rnorm(40, 0, 1)
)
res <- MauchlyTest(y ~ within | id, data = d, do_print = TRUE)
summary(res)
```

MWTest *Mann-Whitney U Test (Wilcoxon Rank-Sum, Manual Implementation)*

Description

Performs the Mann-Whitney U test (Wilcoxon rank-sum) for two independent groups, using a manual implementation. Suitable when the assumptions of parametric tests (normality, homogeneity of variances) are not met.

Usage

```
MWTest(
  grupo1,
  grupo2,
  alpha = 0.05,
  alternative = c("two.sided", "less", "greater"),
  continuity = TRUE
)
```

Arguments

grupo1	Numeric vector for the first group.
grupo2	Numeric vector for the second group.
alpha	Significance level (default = 0.05).
alternative	Character string specifying the alternative hypothesis. Options are "two.sided" (default), "less", or "greater".
continuity	Logical indicating whether to apply continuity correction (default = TRUE).

Details

Advantages: - Does not assume normality. - More powerful than t-test for skewed distributions.

Disadvantages: - Only compares two groups at a time. - Sensitive to unequal variances or shapes. - It is only useful in completely random or single-factor designs.

This implementation allows one- or two-sided alternatives and optionally applies a continuity correction.

Value

An object of class `"comparacion"` and `"mannwhitney"`, containing:

- `Resultados`: A data frame with the comparison name, difference in means, p-value, and significance.
- `Promedios`: A named numeric vector of group means.
- `Orden_Medias`: A character vector of group names ordered from highest to lowest mean.
- `Metodo`: A string describing the test and hypothesis direction.

References

Mann, H. B., & Whitney, D. R. (1947). "On a Test of Whether One of Two Random Variables is Stochastically Larger than the Other." *Annals of Mathematical Statistics*, 18(1), 50–60.

Examples

```
data(d_e, package = "Analitica")
g1 <- d_e$Sueldo_actual[d_e$labor == 1]
g2 <- d_e$Sueldo_actual[d_e$labor == 2]
resultado <- MWTest(g1, g2, alternative = "greater")
summary(resultado)
```

NemenyiTest *Nemenyi Test for Multiple Comparisons (Non-Parametric)*

Description

Performs the Nemenyi (Nemenyi-Damico-Wolfe) all-pairs test after a significant Kruskal-Wallis test, using mean ranks computed on the pooled sample and the studentized range distribution.

Usage

```
NemenyiTest(formula, data, alpha = 0.05)
```

Arguments

`formula`	A formula of the form `y ~ group`.
`data`	A data frame containing the variables.
`alpha`	Significance level (default is 0.05).

Details

For each pair of groups the statistic is

$$q_{ij} = \frac{|\bar{R}_i - \bar{R}_j|}{\sqrt{\frac{N(N+1)}{12} C \frac{1}{2}\left(\frac{1}{n_i} + \frac{1}{n_j}\right)}}$$

where $C = 1 - \sum(t^3 - t)/(N^3 - N)$ is the tie correction. The p-value is obtained from the studentized range distribution with k means and infinite degrees of freedom, so it already controls the family-wise error rate. With unequal group sizes the Tukey-Kramer extension is used.

Advantages: - Controls the family-wise error rate without an additional p-value adjustment. - Direct non-parametric analogue of Tukey's HSD.

Disadvantages: - Exact only for equal group sizes; with unequal sizes it is an approximation (Tukey-Kramer). - Usually less powerful than Conover-Iman. - It is only useful in completely random or single-factor designs (for blocked designs use a Friedman-type procedure).

Value

An object of class `"nemenyi"`, `"comparaciones_np"` and `"comparaciones"`, including:

- `Resultados`: Data frame with comparisons (higher - lower mean rank), mean-rank difference, q statistic, critical difference, p-values and significance codes.
- `Promedios`: Mean ranks of each group, sorted from highest to lowest.
- `Orden_Medias`: Group names ordered from highest to lowest mean rank.
- `Metodo`: Name of the method ("Nemenyi (non-parametric)").
- `Datos`: Data frame with the response and the group, used by `plot()`.
- `KruskalWallis`: Result of `kruskal.test()`.

References

Nemenyi, P. (1963). *Distribution-free Multiple Comparisons*. PhD thesis, Princeton University.

Hollander, M., Wolfe, D. A. & Chicken, E. (2014). *Nonparametric Statistical Methods* (3rd ed.). Wiley.

Examples

```
set.seed(123)
datos <- data.frame(
  grupo = rep(c("A", "B", "C", "D"), each = 10),
  medida = c(rnorm(10, 10), rnorm(10, 12), rnorm(10, 15), rnorm(10, 11))
)
resultado <- NemenyiTest(medida ~ grupo, data = datos)
summary(resultado)
plot(resultado)
```

`plot.comparaciones` *Plot for parametric multiple-comparison tests (with multcompView letters)*

Description

Bar chart of group means with compact letter display. Groups sharing a letter are not significantly different. For rank-based (non-parametric) procedures see `plot.comparaciones_np`.

Usage

```
## S3 method for class 'comparaciones'
plot(
  x,
  alpha = 0.05,
  p_column = c("auto", "p_ajustada", "p_value", "p"),
  horizontal = FALSE,
  fill = "steelblue",
  label_size = 5,
  label_color = "black",
  angle_x = 45,
  show_se = FALSE,
  se_type = c("se", "ci95"),
  pad_frac = 0.35,
  errorbar_width = 0.2,
  ...
)
```

Arguments

`x`	An object of class `comparaciones`.
`alpha`	Significance threshold for the letters (default 0.05).
`p_column`	Which p-value column: "auto","p_ajustada","p_value","p".
`horizontal`	If TRUE, draw horizontal bars.
`fill`	Bar fill color.
`label_size`	Letter size.
`label_color`	Letter color.
`angle_x`	Angle of x-axis labels (if `horizontal = FALSE`).
`show_se`	If TRUE and `x$MSerror`, `x$N` exist, draws error bars.
`se_type`	"se" (default) or "ci95".
`pad_frac`	Fraction of y-span used to place letters (default 0.35).
`errorbar_width`	Width of errorbar whiskers.
`...`	Not used.

Value

A ggplot object.

See Also

plot.comparaciones_np

---

plot.comparaciones_np *Plot for rank-based (non-parametric) multiple-comparison tests*

Description

Rank-based procedures (Dunn, Conover-Iman, Nemenyi, DSCF, Bonferroni-Mann-Whitney) compare distributions through ranks, not means, so a bar chart of means can contradict the test. This method shows the data instead: a boxplot with the individual observations (default), a violin plot, or the mean ranks used by the test. Groups are ordered from highest to lowest mean rank and the sample size of each group is shown on the x axis.

Usage

```
## S3 method for class 'comparaciones_np'
plot(
  x,
  tipo = c("boxplot", "violin", "rangos"),
  letras = FALSE,
  alpha = 0.05,
  p_column = c("auto", "p_ajustada", "p_value", "p"),
  fill = "steelblue",
  point_color = "steelblue4",
  label_size = 5,
  angle_x = 0,
  ...
)
```

Arguments

x	An object of class comparaciones_np (returned by DunnTest, ConoverTest, NemenyiTest, DSCFTest or BonferroniNPTest).
tipo	Type of plot: "boxplot" (boxplot + points, default), "violin" (violin + narrow boxplot) or "rangos" (mean rank per group).
letras	If TRUE, adds the compact letter display above each group. Groups sharing a letter were not found to be different. Default FALSE.
alpha	Significance threshold for the letters (default 0.05).
p_column	Which p-value column to use for the letters: "auto", "p_ajustada", "p_value" or "p".

`fill`	Fill color.
`point_color`	Color of the individual points.
`label_size`	Letter size.
`angle_x`	Angle of the x-axis labels.
`...`	Not used.

Value

A `ggplot` object.

See Also

`plot.comparaciones`

Examples

```
data(d_e, package = "Analitica")
res <- DunnTest(Sueldo_actual ~ labor, data = d_e)
plot(res)
plot(res, tipo = "violin")
plot(res, tipo = "rangos", letras = TRUE)
```

Posthoc_planner *Post Hoc Planner for FWER and Test Recommendation v1.6*

Description

One-shot planner for factor or cell comparisons, reporting m, FWER, suggested adjustments (Bonferroni/Sidak) and a post hoc recommendation (Holm, Tukey, Duncan, Gabriel, Scheffe, SNK, etc.) before testing.

Usage

```
Posthoc_planner(
  model,
  compare = NULL,
  alpha = 0.05,
  scope = c("factor", "cells"),
  equal_var = TRUE,
  unequal_n = FALSE,
  independence = TRUE,
  liberal_ok = FALSE,
  orientation = c("rows", "cols"),
  digits = 4,
  percent_digits = 1,
  observed_cells = TRUE
)
```

Arguments

model	aov or lm object (complete model). Data are reconstructed with model.frame().
compare	Character with the name(s) of the factor(s) to compare: - One name: main effect. - Several names: if scope="cells" compares A:B:... cells; if scope="factor", reports each factor. If omitted, uses all factors when scope="factor", or the first factor when scope="cells".
alpha	Overall significance level (FWER target), default 0.05.
scope	"factor" compares each factor separately; "cells" compares interaction cells.
equal_var	Logical; assume homoscedasticity (default TRUE).
unequal_n	Logical; expect moderate imbalance of group sizes (default FALSE).
independence	Logical; if TRUE reports FWER "under independence" (default TRUE).
liberal_ok	Logical; allows more liberal suggestions (LSD/Duncan/SNK) (default FALSE).
orientation	"rows" (metrics as rows, default) or "cols".
digits	Decimal places for numeric output, default 4.
percent_digits	Decimal places for percentages, default 1.
observed_cells	Logical; in scope="cells", count only observed cells (drop NA). Default TRUE.

Value

data.frame. - orientation="rows": first column "Metric", rest columns are units (factor/cells). - orientation="cols": one row per unit, metrics as columns. Includes: g levels, m comparisons, global alpha, Bonferroni/Sidak alphas, FWERs (under independence), "Suggested p-value adjustment" and "Post hoc suggestion".

References

#' Bonferroni, C. (1936). *Teoria statistica delle classi e calcolo delle probabilità*. Pubblicazioni del R. Istituto Superiore di Scienze Economiche e Commerciali di Firenze.

Fisher, R. A. (1935). *The design of experiments*. Oliver & Boyd.

Duncan, D. B. (1955). Multiple range and multiple F tests. *Biometrics, 11*(1), 1–42.

Gabriel, K. R. (1978). A simple method of multiple comparisons of means. *Journal of the American Statistical Association, 73*(364), 724–729.

Games, P. A., & Howell, J. F. (1976). Pairwise multiple comparison procedures with unequal n's and/or variances: A Monte Carlo study. *Journal of Educational Statistics, 1*(2), 113–125.

Holm, S. (1979). A simple sequentially rejective multiple test procedure. *Scandinavian Journal of Statistics, 6*(2), 65–70.

Newman, D. (1939). The distribution of range in samples from a normal population, expressed in terms of an independent estimate of standard deviation. *Biometrika, 31*(1/2), 20–36.

Scheffé, H. (1953). A method for judging all contrasts in the analysis of variance. *Biometrika, 40*(1–2), 87–104.

Šidák, Z. (1967). Rectangular confidence regions for the means of multivariate normal distributions. *Journal of the American Statistical Association, 62*(318), 626–633.

Tukey, J. W. (1949). Comparing individual means in the analysis of variance. *Biometrics, 5*(2), 99–114.

Examples

```
## =========================
## Ejemplo 1: One-way ANOVA
## =========================
# Datos: PlantGrowth (3 grupos balanceados)
data(PlantGrowth)
m1 <- aov(weight ~ group, data = PlantGrowth)
# Comparar por factor (default scope="factor")
Posthoc_planner(m1)
# Variante: salida por columnas
Posthoc_planner(m1, orientation = "cols")
# Variante: alpha más estricto
Posthoc_planner(m1, alpha = 0.01)

## ============================================
## Ejemplo 2: Dos factores y comparación de celdas
## ============================================
# Datos: ToothGrowth (suplemento x dosis)
data(ToothGrowth)
TG <- ToothGrowth
TG$dose <- factor(TG$dose)  # tratar "dose" como factor
m2 <- aov(len ~ supp * dose, data = TG)
# scope="cells" compara celdas de la interacción (supp:dose)
Posthoc_planner(
  m2,
compare = c("supp","dose"),
scope   = "cells",        # comparar celdas
observed_cells = TRUE     # contar solo celdas observadas (default)
)
# También puedes pedir el resumen por factor dentro del mismo modelo
Posthoc_planner(
m2,
compare = c("supp","dose"),
scope   = "factor"        # reporte por cada factor por separado
)
```

`print.comparaciones` *Print Method for Objects of Class 'comparaciones'*

Description

Short description of a multiple-comparison object. Use `summary()` to see the full results.

Usage

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

Arguments

x	An object of class "comparaciones".
...	Additional arguments (currently ignored).

Value

Invisibly returns x.

ScheffeTest *Scheffe Test for Multiple Comparisons v2.0*

Description

Performs Scheffe's post hoc test after fitting an ANOVA model. This test compares all possible pairs of group means, using a critical value based on the F-distribution.

Usage

```
ScheffeTest(modelo, comparar = NULL, alpha = 0.05)
```

Arguments

modelo	An aov or lm object (full model: includes blocks, factors, etc.).
comparar	Character vector with the name(s) of the factor(s) to compare: - One name: main effect (e.g., "treatment" or "A") - Several names: interaction (e.g., c("A","B") for A:B) If omitted, it uses the first factor in modelo$xlevels.
alpha	Significance level (default 0.05).

Details

The Scheffe test is a conservative method, making it harder to detect significant differences, but reducing the likelihood of Type I errors (false positives). It is especially appropriate when the comparisons were not pre-planned and the number of contrasts is large.

Assumptions: normally distributed residuals and homogeneity of variances.

Advantages: - Very robust to violations of assumptions. - Suitable for complex comparisons, not just pairwise.

Disadvantages: - Very conservative; reduced power. - Not ideal for detecting small differences.

Value

Objeto de clase "scheffe" and "comparaciones" with:

- Resultados: data.frame with Comparacion, Diferencia, SE2 (= MSerror*(1/n_i+1/n_j)), F_obs, Valor_Critico, p_value, Significancia.
- Promedios, Orden_Medias, Metodo="Scheffe", Termino.
- MSerror, df_error, N (utiles para plot.comparaciones()).

References

Scheffe, H. (1953). "A method for judging all contrasts in the analysis of variance." *Biometrika*, 40(1/2), 87–104. <https://doi.org/10.1093/biomet/40.1-2.87>

Examples

```
data(d_e, package = "Analitica")
mod <- aov(Sueldo_actual ~ as.factor(labor), data = d_e)
resultado <- ScheffeTest(mod)
summary(resultado)
plot(resultado)

# RCBD
mod <- aov(Sueldo_actual ~ as.factor(labor) + Sexo, data = d_e)
res <- ScheffeTest(mod, comparar = "as.factor(labor)")
summary(res); plot(res)                      # plot usara p_value

# Factorial
mod2 <- aov(Sueldo_actual ~ as.factor(labor) * Sexo, data = d_e)
resAB <- ScheffeTest(mod2, comparar = c("as.factor(labor)","Sexo"))
summary(resAB, n = Inf); plot(resAB, horizontal = TRUE)
```

SidakTest *Sidak Test for Multiple Comparisons v2.0*

Description

Performs pairwise comparisons using the Sidak correction to adjust p-values and control the family-wise error rate in multiple testing scenarios. This method assumes independence between comparisons and is slightly less conservative than Bonferroni.

Usage

```
SidakTest(modelo, comparar = NULL, alpha = 0.05)
```

Arguments

`modelo`	An `aov` or `lm` object (full model: includes blocks, factors, etc.).
`comparar`	Character vector with the name(s) of the factor(s) to compare: - One name: main effect (e.g., "treatment" or "A") - Several names: interaction (e.g., `c("A","B")` for `A:B`) If omitted, it uses the first factor in `modelo$xlevels`.
`alpha`	Significance level (default 0.05).

Details

The Sidak procedure adjusts the significance level to maintain an overall alpha across all pairwise tests, providing an effective post hoc tool following ANOVA or similar global tests.

Advantages: - Controls the family-wise error rate under independence assumption. - Slightly more powerful than Bonferroni. - Simple to compute and interpret.

Disadvantages: - Assumes independence of tests (may not hold in correlated data). - Less robust when variances are unequal or data are non-normal.

Value

An object of class `"sidak"` and `"comparaciones"` containing:

- `Resultados`: a data.frame with columns `Comparacion`, `Diferencia`, `SE`, `t_value`, `p_value` (unadjusted), `p_ajustada` (Sidak), `Valor_Critico` (critical difference), and `Significancia`.
- `Promedios`: a named vector of group means as defined by `comparar`.
- `Orden_Medias`: group names ordered from highest to lowest mean.
- `Metodo`: "Sidak-adjusted t-test".
- `Termino`: the term being compared (e.g., "A", "B", or "A:B").
- `MSerror`, `df_error`, `N`: useful for plots with error bars.

References

Sidak, Z. (1967). "Rectangular confidence regions for the means of multivariate normal distributions." *Journal of the American Statistical Association*, 62(318), 626–633.

Examples

```
data(d_e, package = "Analitica")
mod <- aov(Sueldo_actual ~ as.factor(labor), data = d_e)
resultado <- SidakTest(mod)
summary(resultado)
plot(resultado)

# RCBD
mod <- aov(Sueldo_actual ~ as.factor(labor) + Sexo, data = d_e)
res <- SidakTest(mod, comparar = "as.factor(labor)")
summary(res); plot(res)                      # plot usara p_value

# Factorial
mod2 <- aov(Sueldo_actual ~ as.factor(labor) * Sexo, data = d_e)
resAB <- SidakTest(mod2, comparar = c("as.factor(labor)","Sexo"))
summary(resAB, n = Inf); plot(resAB, horizontal = TRUE)
```

SNKTest *Student-Newman-Keuls (SNK) Test for Multiple Comparisons v2.0*

Description

Performs the Student-Newman-Keuls (SNK) post hoc test for pairwise comparisons after fitting an ANOVA model. The test uses a stepwise approach where the critical value depends on the number of means spanned between groups (range r).

Usage

```
SNKTest(modelo, comparar = NULL, alpha = 0.05)
```

Arguments

modelo	An aov or lm object (full model: includes blocks, factors, etc.).
comparar	Character vector with the name(s) of the factor(s) to compare: - One name: main effect (e.g., "treatment" or "A") - Several names: interaction (e.g., c("A","B") for A:B) If omitted, it uses the first factor in modelo$xlevels.
alpha	Significance level (default 0.05).

Details

SNK is more powerful but less conservative than Tukey's HSD, increasing the chance of detecting real differences while slightly raising the Type I error rate.

Assumptions: normality, homogeneity of variances, and independence of observations.

Advantages: - More powerful than Tukey when differences are large. - Intermediate control of Type I error.

Disadvantages: - Error control is not family-wise. - Type I error increases with more comparisons.

Value

An object of class "SNK" and "comparaciones" containing:

- Resultados: a data.frame with columns Comparacion, Diferencia, SE, t_value, p_value (unadjusted), p_ajustada (SNK), Valor_Critico (critical difference), and Significancia.
- Promedios: a named vector of group means as defined by comparar.
- Orden_Medias: group names ordered from highest to lowest mean.
- Metodo: "SNK t-test".
- Termino: the term being compared (e.g., "A", "B", or "A:B").
- MSerror, df_error, N: useful for plots with error bars.

References

Student, Newman, and Keuls (1952). "Student-Newman-Keuls Procedure". See also: <https://doi.org/10.1002/bimj.2003100

Examples

```
data(d_e, package = "Analitica")
mod <- aov(Sueldo_actual ~ as.factor(labor), data = d_e)
resultado <- SNKTest(mod)
summary(resultado)
plot(resultado)

# RCBD
mod <- aov(Sueldo_actual ~ as.factor(labor) + Sexo, data = d_e)
res <- SNKTest(mod, comparar = "as.factor(labor)")
summary(res); plot(res)                      # plot usara p_value

# Factorial
mod2 <- aov(Sueldo_actual ~ as.factor(labor) * Sexo, data = d_e)
resAB <- SNKTest(mod2, comparar = c("as.factor(labor)","Sexo"))
summary(resAB, n = Inf); plot(resAB, horizontal = TRUE)
```

---

summary.comparacion *Summary Method for Objects of Class 'comparacion'*

Description

Displays a formatted summary of the results from a pairwise comparison test of two independent groups. Compatible with objects returned by functions like `BMTest()` or `MWTest()`.

Usage

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

Arguments

`object`	An object of class `"comparacion"`.
`...`	Additional arguments (currently ignored).

Value

Invisibly returns a one-row data frame with the summary statistics.

summary.comparaciones *Summary Method for Objects of Class 'comparaciones'*

Description

Prints the method, the group means (or mean ranks for rank-based procedures), their order from highest to lowest, and the table of pairwise comparisons.

Usage

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

Arguments

`object`	An object of class `"comparaciones"`.
`...`	Additional arguments (currently ignored).

Value

Invisibly returns `object`.

summary.homocedasticidad *Summary Method for Homoscedasticity Test Results (extended) v2.0*

Description

Displays a summary of variance homogeneity tests such as Bartlett, Fligner-Killeen, or Levene (1-via global and if exists, factorial decomposition on |Y - centro_celda|).

Usage

```
## S3 method for class 'homocedasticidad'
summary(object, digits = 4, ...)
```

Arguments

`object`	An object of class `"homocedasticidad"`.
`digits`	Number of digits for F; default 4.
`...`	Currently ignored.

Value

Invisibly returns the input object (invisible).

T2Test *Tamhane's T2 Post Hoc Test v2.2.0*

Description

Performs the Tamhane T2 test for pairwise comparisons after an ANOVA model, assuming unequal variances and/or unequal sample sizes. This test is appropriate when the assumption of homogeneity of variances is violated, such as when Levene's test or Bartlett's test is significant.

Usage

```
T2Test(modelo, comparar = NULL, alpha = 0.05)
```

Arguments

modelo	An object of class aov or lm (full model: includes blocks, factors, etc.).
comparar	Character vector with the name(s) of the factor(s) to compare: - One name: main effect (e.g., "treatment" or "A") - Several names: interaction (e.g., c("A","B") for A:B) If omitted, it uses the first factor in modelo$xlevels.
alpha	Significance level (default is 0.05).

Details

The test uses a modified t-test with Welch-Satterthwaite degrees of freedom and a conservative approach to control for multiple comparisons.

Advantages: - Controls Type I error under heteroscedasticity. - No assumption of equal sample sizes.

Disadvantages: - Conservative; may reduce power. - Not as powerful as Games-Howell in some contexts.

Value

An object of class "tamhanet2" and "comparaciones", containing:

- Resultados: A data frame with pairwise comparisons, mean differences, t_value, gl, p_value, and significance codes.
- Promedios: A named numeric vector of group means as defined by comparar.
- Orden_Medias: Group names ordered from highest to lowest mean.
- Metodo: A character string indicating the method used ("Tamhane T2").
- Termino: The term being compared (e.g., "A", "B", or "A:B").

References

Tamhane, A. C. (1977). "Multiple comparisons in model I one-way ANOVA with unequal variances." *Communications in Statistics - Theory and Methods*, 6(1), 15–32. <https://doi.org/10.1080/03610927708827524>

Examples

```
data(d_e, package = "Analitica")
mod <- aov(Sueldo_actual ~ as.factor(labor), data = d_e)
resultado <- T2Test(mod)
summary(resultado)
plot(resultado)

# Con bloques, comparando solo el factor de interés
mod2 <- aov(Sueldo_actual ~ as.factor(labor) + Sexo, data = d_e)
res2 <- T2Test(mod2, comparar = "as.factor(labor)")
summary(res2)
plot(res2)

# Modelo con interacción
mod3 <- aov(Sueldo_actual ~ as.factor(labor) * Sexo, data = d_e)
res3 <- T2Test(mod3, comparar = c("as.factor(labor)", "Sexo"))
summary(res3)
plot(res3)
```

`T3Test` *Dunnett's T3 Post Hoc Test v2.2.0*

Description

Performs Dunnett's T3 test for pairwise comparisons after an ANOVA model. This test is recommended when group variances are unequal and sample sizes differ. It is based on the studentized range distribution and provides conservative control over Type I error without assuming homoscedasticity.

Usage

```
T3Test(modelo, comparar = NULL, alpha = 0.05)
```

Arguments

`modelo`	An object of class `aov` or `lm` (full model: includes blocks, factors, etc.).
`comparar`	Character vector with the name(s) of the factor(s) to compare: - One name: main effect (e.g., "treatment" or "A") - Several names: interaction (e.g., `c("A","B")` for `A:B`) If omitted, it uses the first factor in `modelo$xlevels`.
`alpha`	Significance level (default is 0.05).

Details

Advantages: - More powerful than T2 when group sizes are small. - Adjusted for unequal variances.

Disadvantages: - Complex critical value estimation. - Less frequently used and harder to find in software.

Value

An object of class "dunnettt3" and "comparaciones", containing:

- Resultados: A data frame with pairwise comparisons, mean differences, q_value, gl, p_value, and significance indicators.
- Promedios: A named numeric vector of group means as defined by comparar.
- Orden_Medias: A character vector of group names ordered from highest to lowest mean.
- Metodo: A character string with the test name ("Dunnett T3").
- Termino: The term being compared (e.g., "A", "B", or "A:B").

References

Dunnett, C. W. (1980). "Pairwise multiple comparisons in the unequal variance case." *Journal of the American Statistical Association*, 75(372), 796–800. <https://doi.org/10.1080/01621459.1980.10477558>

Examples

```
data(d_e, package = "Analitica")
mod <- aov(Sueldo_actual ~ as.factor(labor), data = d_e)
resultado <- T3Test(mod)
summary(resultado)
plot(resultado)

# Con bloques, comparando solo el factor de interés
mod2 <- aov(Sueldo_actual ~ as.factor(labor) + Sexo, data = d_e)
res2 <- T3Test(mod2, comparar = "as.factor(labor)")
summary(res2)
plot(res2)

# Modelo con interacción
mod3 <- aov(Sueldo_actual ~ as.factor(labor) * Sexo, data = d_e)
res3 <- T3Test(mod3, comparar = c("as.factor(labor)", "Sexo"))
summary(res3)
plot(res3)
```

TukeyTest *Tukey HSD Test for Multiple Comparisons v2.0*

Description

Performs Tukey's Honest Significant Difference (HSD) test for all pairwise comparisons after fitting an ANOVA model. This post hoc method uses the studentized range distribution and is appropriate when variances are equal across groups and observations are independent.

Usage

```
TukeyTest(modelo, comparar = NULL, alpha = 0.05)
```

Arguments

modelo	An aov or lm object (full model: includes blocks, factors, etc.).
comparar	Character vector with the name(s) of the factor(s) to compare: - One name: main effect (e.g., "treatment" or "A") - Several names: interaction (e.g., c("A","B") for A:B) If omitted, it uses the first factor in modelo$xlevels.
alpha	Significance level (default 0.05).

Details

Tukey's test controls the family-wise error rate and is widely used when group comparisons have not been planned in advance.

Advantages: - Strong control of Type I error rate. - Ideal for balanced designs with equal variances.

Disadvantages: - Assumes equal variances and sample sizes. - Less powerful with heteroscedasticity.

Value

An object of class "tukey" and "comparaciones" containing:

- Resultados: a data.frame with columns Comparacion, Diferencia, SE, t_value, p_value (unadjusted), p_ajustada (Tukey), Valor_Critico (critical difference), and Significancia.
- Promedios: a named vector of group means as defined by comparar.
- Orden_Medias: group names ordered from highest to lowest mean.
- Metodo: "Tukey test".
- Termino: the term being compared (e.g., "A", "B", or "A:B").
- MSerror, df_error, N: useful for plots with error bars.

References

Tukey, J. W. (1949). "Comparing individual means in the analysis of variance." *Biometrics*, 5(2), 99–114. <https://doi.org/10.2307/3001913>

Examples

```
#Caso DCA
data(d_e, package = "Analitica")
mod1 <- aov(Sueldo_actual ~ as.factor(labor), data = d_e)
summary(mod1)
resultado <- TukeyTest(mod1)
summary(resultado)
plot(resultado)

#Caso DBA
mod2 <- aov(Sueldo_actual ~ as.factor(labor) + Sexo, data = d_e)
summary(mod2)
# Comparar niveles de 'tratamiento' (ajustando el error por el modelo con bloque)
res <- TukeyTest(mod2, comparar = "as.factor(labor)")
```

```
summary(res)
plot(res)

#Caso DFA Two Ways
mod3 <- aov(Sueldo_actual ~ as.factor(labor) * Sexo, data = d_e)
summary(mod3)
# promedios de as.factor(labor) (promediando sobre B)
resA <- TukeyTest(mod3, comparar = "as.factor(labor)")
summary(resA)
plot(resA)

# promedios de la interaccion entre factor A y factor B
resB <- TukeyTest(mod3, comparar = c("as.factor(labor)","Sexo"))
summary(resB)
plot(resB)
```

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