Package 'rstatix'

November 9, 2022

Type Package

Title Pipe-Friendly Framework for Basic Statistical Tests

Version 0.7.1

Description Provides a simple and intuitive pipe-
friendly framework, coherent with the 'tidyverse' design philosophy,
for performing basic statistical tests, including t-test, Wilcoxon test, ANOVA, Kruskal-
Wallis and correlation analyses.
The output of each test is automatically transformed into a tidy data frame to facilitate visualization.
Additional functions are available for reshaping, reordering, manipulating and visualizing correlation matrix.
Functions are also included to facilitate the analysis of factorial experiments, including purely 'within-Ss' designs
(repeated measures), purely 'between-Ss' designs, and mixed 'within-and-between-Ss' designs.
It's also possible to compute several effect size metrics, including ``eta squared'' for ANOVA, ``Cohen's d'' for t-test and
'Cramer V' for the association between categorical variables.
The package contains helper functions for identifying univariate and multivariate outliers, assessing normality and homogeneity of variances.

License GPL-2

Encoding UTF-8

Depends R (>= 3.3.0)

Imports stats, utils, tidyr (>= 1.0.0), purrr, broom (>= 0.7.4), rlang
(>= 0.3.1), tibble (>= 2.1.3), dplyr (>= 0.7.1), magrittr,
corrplot, tidyselect (>= 1.0.0), car, generics (>= 0.0.2)

Suggests knitr, rmarkdown, ggpubr, graphics, emmeans, coin, boot,
testthat, spelling

URL https://rpkgs.datanovia.com/rstatix/

BugReports https://github.com/kassambara/rstatix/issues

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Collate 'utilities.R' 'add_significance.R' 'adjust_pvalue.R' 'factorial_design.R' 'utilities_two_sample_test.R' 'anova_summary.R' 'anova_test.R' 'as_cor_mat.R' 'binom_test.R' 'box_m.R' 'chisq_test.R' 'cochran_qtest.R' 'cohens_d.R' 'cor_as_symbols.R' 'replace_triangle.R' 'pull_triangle.R' 'cor_mark_significant.R' 'cor_mat.R' 'cor_plot.R' 'cor_reorder.R' 'cor_reshape.R' 'cor_select.R' 'cor_test.R' 'counts_to_cases.R' 'cramer_v.R' 'df.R' 'doo.R' 't_test.R' 'dunn_test.R' 'emmeans_test.R' 'eta_squared.R' 'factors.R' 'fisher_test.R' 'freq_table.R' 'friedman_test.R' 'friedman_effsize.R' 'games_howell_test.R' 'get_comparisons.R' 'get_manova_table.R' 'get_mode.R' 'get_pvalue_position.R' 'get_summary_stats.R' 'get_test_label.R' 'kruskal_effesize.R' 'kruskal_test.R' 'levene_test.R' 'mahalanobis_distance.R' 'make_clean_names.R' 'mcnemar_test.R' 'multinom_test.R' 'outliers.R' 'p_value.R' 'prop_test.R' 'prop_trend_test.R' 'reexports.R' 'remove_ns.R' 'sample_n_by.R' 'shapiro_test.R' 'sign_test.R' 'tukey_hsd.R' 'utils-manova.R' 'utils-pipe.R' 'welch_anova_test.R' 'wilcox_effsize.R' 'wilcox_test.R'

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R topics documented:

add_significance *Add P-value Significance Symbols*

Description

Add p-value significance symbols into a data frame.

Usage

```
add_significance(
  data,
  p.col = NULL,
  output.col = NULL,
  cutpoints = c(0, 1e-04, 0.001, 0.01, 0.05, 1),
  symbols = c("****", "***", "**", "*", "ns")
)
```

Arguments

data	a data frame containing a p-value column.
p.col	column name containing p-values.
output.col	the output column name to hold the adjusted p-values.
cutpoints	numeric vector used for intervals.
symbols	character vector, one shorter than cutpoints, used as significance symbols.

Value

a data frame

Examples

```
# Perform pairwise comparisons and adjust p-values
ToothGrowth %>%
 t_test(len ~ dose) %>%
 adjust_pvalue() %>%
 add_significance("p.adj")
```

adjust_pvalue *Adjust P-values for Multiple Comparisons*

Description

A pipe-friendly function to add an adjusted p-value column into a data frame. Supports grouped data.

Usage

```
adjust_pvalue(data, p.col = NULL, output.col = NULL, method = "holm")
```

Arguments

data	a data frame containing a p-value column
p.col	column name containing p-values
output.col	the output column name to hold the adjusted p-values
method	method for adjusting p values (see p.adjust). Allowed values include "holm", "hochberg", "hommel", "bonferroni", "BH", "BY", "fdr", "none". If you don't want to adjust the p value (not recommended), use p.adjust.method = "none".

Value

a data frame

Examples

```
# Perform pairwise comparisons and adjust p-values
ToothGrowth %>%
 t_test(len ~ dose) %>%
 adjust_pvalue()
```

anova_summary *Create Nice Summary Tables of ANOVA Results*

Description

Create beautiful summary tables of ANOVA test results obtained from either Anova() or aov().

The results include ANOVA table, generalized effect size and some assumption checks.

Usage

```
anova_summary(object, effect.size = "ges", detailed = FALSE, observed = NULL)
```

Arguments

`object`	an object of returned by either `Anova()`, or `aov()`.
`effect.size`	the effect size to compute and to show in the ANOVA results. Allowed values can be either "ges" (generalized eta squared) or "pes" (partial eta squared) or both. Default is "ges".
`detailed`	If TRUE, returns extra information (sums of squares columns, intercept row, etc.) in the ANOVA table.
`observed`	Variables that are observed (i.e, measured) as compared to experimentally manipulated. The default effect size reported (generalized eta-squared) requires correct specification of the observed variables.

Value

return an object of class `anova_test` a data frame containing the ANOVA table for independent measures ANOVA. However, for repeated/mixed measures ANOVA, it is a list containing the following components are returned:

- **ANOVA**: a data frame containing ANOVA results
- **Mauchly's Test for Sphericity**: If any within-Ss variables with more than 2 levels are present, a data frame containing the results of Mauchly's test for Sphericity. Only reported for effects that have more than 2 levels because sphericity necessarily holds for effects with only 2 levels.
- **Sphericity Corrections**: If any within-Ss variables are present, a data frame containing the Greenhouse-Geisser and Huynh-Feldt epsilon values, and corresponding corrected p-values.

The **returned object might have an attribute** called `args` if you compute ANOVA using the function `anova_test()`. The attribute `args` is a list holding the arguments used to fit the ANOVA model, including: data, dv, within, between, type, model, etc.

The following abbreviations are used in the different results tables:

- DFn Degrees of Freedom in the numerator (i.e. DF effect).
- DFd Degrees of Freedom in the denominator (i.e., DF error).
- SSn Sum of Squares in the numerator (i.e., SS effect).
- SSd Sum of Squares in the denominator (i.e.,SS error).
- F F-value.
- p p-value (probability of the data given the null hypothesis).
- p<.05 Highlights p-values less than the traditional alpha level of .05.
- ges Generalized Eta-Squared measure of effect size.
- GGe Greenhouse-Geisser epsilon.
- p[GGe] p-value after correction using Greenhouse-Geisser epsilon.
- p[GGe]<.05 Highlights p-values (after correction using Greenhouse-Geisser epsilon) less than the traditional alpha level of .05.
- HFe Huynh-Feldt epsilon.
- p[HFe] p-value after correction using Huynh-Feldt epsilon.
- p[HFe]<.05 Highlights p-values (after correction using Huynh-Feldt epsilon) less than the traditional alpha level of .05.
- W Mauchly's W statistic

Author(s)

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See Also

anova_test(), factorial_design()

Examples

```
# Load data
#:::::::::::::::::::::::::::::::::::::::
data("ToothGrowth")
df <- ToothGrowth
df$dose <- as.factor(df$dose)

# Independent measures ANOVA
#:::::::::::::::::::::::::::::::::::::::::
# Compute ANOVA and display the summary
res.anova <- Anova(lm(len ~ dose*supp, data = df))
anova_summary(res.anova)

# Display both SSn and SSd using detailed = TRUE
# Show generalized eta squared using effect.size = "ges"
anova_summary(res.anova, detailed = TRUE, effect.size = "ges")

# Show partial eta squared using effect.size = "pes"
anova_summary(res.anova, detailed = TRUE, effect.size = "pes")

# Repeated measures designs using car::Anova()
#:::::::::::::::::::::::::::::::::::::::::
# Prepare the data
df$id <- as.factor(rep(1:10, 6)) # Add individuals ids
head(df)

# Easily perform repeated measures ANOVA using the car package
design <- factorial_design(df, dv = len, wid = id, within = c(supp, dose))
res.anova <- Anova(design$model, idata = design$idata, idesign = design$idesign, type = 3)
anova_summary(res.anova)

# Repeated measures designs using stats::Aov()
#:::::::::::::::::::::::::::::::::::::::::
res.anova <- aov(len ~ dose*supp + Error(id/(supp*dose)), data = df)
anova_summary(res.anova)
```

---

anova_test *Anova Test*

Description

Provides a pipe-friendly framework to perform different types of ANOVA tests, including:

- **Independent measures ANOVA**: between-Subjects designs,
- **Repeated measures ANOVA**: within-Subjects designs
- **Mixed ANOVA**: Mixed within within- and between-Subjects designs, also known as split-plot ANOVA and
- **ANCOVA: Analysis of Covariance**.

The function is an easy to use wrapper around `Anova()` and `aov()`. It makes ANOVA computation handy in R and It's highly flexible: can support model and formula as input. Variables can be also specified as character vector using the arguments `dv`, `wid`, `between`, `within`, `covariate`.

The results include ANOVA table, generalized effect size and some assumption checks.

Usage

```
anova_test(
  data,
  formula,
  dv,
  wid,
  between,
  within,
  covariate,
  type = NULL,
  effect.size = "ges",
  error = NULL,
  white.adjust = FALSE,
  observed = NULL,
  detailed = FALSE
)

get_anova_table(x, correction = c("auto", "GG", "HF", "none"))

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

## S3 method for class 'anova_test'
plot(x, ...)
```

Arguments

`data` a data.frame or a model to be analyzed.

`formula` a formula specifying the ANOVA model similar to aov. Can be of the form `y ~ group` where `y` is a numeric variable giving the data values and `group` is a factor with one or multiple levels giving the corresponding groups. For example, `formula = TP53 ~ cancer_group`.

Examples of supported formula include:

- Between-Ss ANOVA (independent measures ANOVA): `y ~ b1*b2`
- Within-Ss ANOVA (repeated measures ANOVA): `y ~ w1*w2 + Error(id/(w1*w2))`
- Mixed ANOVA: `y ~ b1*b2*w1 + Error(id/w1)`

If the formula doesn't contain any within vars, a linear model is directly fitted and passed to the ANOVA function. For repeated designs, the ANOVA variables are parsed from the formula.

`dv` (numeric) dependent variable name.

`wid` (factor) column name containing individuals/subjects identifier. Should be unique per individual.

`between` (optional) between-subject factor variables.

`within` (optional) within-subjects factor variables

`covariate` (optional) covariate names (for ANCOVA)

`type` the type of sums of squares for ANOVA. Allowed values are either 1, 2 or 3. `type = 2` is the default because this will yield identical ANOVA results as type = 1 when data are balanced but type = 2 will additionally yield various assumption tests where appropriate. When the data are unbalanced the `type = 3` is used by popular commercial softwares including SPSS.

`effect.size` the effect size to compute and to show in the ANOVA results. Allowed values can be either "ges" (generalized eta squared) or "pes" (partial eta squared) or both. Default is "ges".

`error` (optional) for a linear model, an lm model object from which the overall error sum of squares and degrees of freedom are to be calculated. Read more in `Anova()` documentation.

`white.adjust` Default is FALSE. If TRUE, heteroscedasticity correction is applied to the coefficient of covariance matrix. Used only for independent measures ANOVA.

`observed` Variables that are observed (i.e, measured) as compared to experimentally manipulated. The default effect size reported (generalized eta-squared) requires correct specification of the observed variables.

`detailed` If TRUE, returns extra information (sums of squares columns, intercept row, etc.) in the ANOVA table.

`x` an object of class `anova_test`

`correction` character. Used only in repeated measures ANOVA test to specify which correction of the degrees of freedom should be reported for the within-subject factors. Possible values are:

- "GG": applies Greenhouse-Geisser correction to all within-subjects factors even if the assumption of sphericity is met (i.e., Mauchly's test is not significant, p > 0.05).
- "HF": applies Hyunh-Feldt correction to all within-subjects factors even if the assumption of sphericity is met,
- "none": returns the ANOVA table without any correction and
- "auto": apply automatically GG correction to only within-subjects factors violating the sphericity assumption (i.e., Mauchly's test p-value is significant, p <= 0.05).

`...` additional arguments

Details

The setting in `anova_test()` is done in such a way that it gives the same results as SPSS, one of the most used commercial software. By default, R uses treatment contrasts, where each of the levels is compared to the first level used as baseline. The default contrast can be checked using `options('contrasts')`. In the function `anova_test()`, the following setting is used `options(contrasts=c('contr.sum'` which gives orthogonal contrasts where you compare every level to the overall mean. This setting gives the same output as the most commonly used commercial softwares, like SPSS. If you want to obtain the same result with the function `car::Anova()` as the one obtained with `rstatix::anova_test()`, then don't forget to set `options(contrasts=c('contr.sum','contr.poly'))`.

Value

return an object of class `anova_test` a data frame containing the ANOVA table for independent measures ANOVA.

However, for repeated/mixed measures ANOVA, a list containing the following components are returned: ANOVA table, Mauchly's Test for Sphericity, Sphericity Corrections. These table are described more in the documentation of the function `anova_summary()`.

The **returned object has an attribute** called `args`, which is a list holding the arguments used to fit the ANOVA model, including: data, dv, within, between, type, model, etc.

Functions

- `anova_test`: perform anova test
- `get_anova_table`: extract anova table from an object of class `anova_test`. When within-subject factors are present, either sphericity corrected or uncorrected degrees of freedom can be reported.

Author(s)

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See Also

`anova_summary()`, `factorial_design()`

Examples

```
# Load data
#:::::::::::::::::::::::::::::::::::::::
data("ToothGrowth")
df <- ToothGrowth

# One-way ANOVA test
#:::::::::::::::::::::::::::::::::::::::::
df %>% anova_test(len ~ dose)

# Grouped One-way ANOVA test
#:::::::::::::::::::::::::::::::::::::::::
df %>%
```

```
  group_by(supp) %>%
  anova_test(len ~ dose)

# Two-way ANOVA test
#:::::::::::::::::::::::::::::::::::::::::
df %>% anova_test(len ~ supp*dose)

# Two-way repeated measures ANOVA
#:::::::::::::::::::::::::::::::::::::::::
df$id <- rep(1:10, 6) # Add individuals id
# Use formula

df %>% anova_test(len ~ supp*dose + Error(id/(supp*dose)))



# or use character vector
df %>% anova_test(dv = len, wid = id, within = c(supp, dose))

# Extract ANOVA table and apply correction
#:::::::::::::::::::::::::::::::::::::::::
res.aov <- df %>% anova_test(dv = len, wid = id, within = c(supp, dose))
get_anova_table(res.aov, correction = "GG")


# Use model as arguments
#:::::::::::::::::::::::::::::::::::::::::
.my.model <- lm(yield ~ block + N*P*K, npk)
anova_test(.my.model)
```

---

as_cor_mat *Convert a Correlation Test Data Frame into a Correlation Matrix*

Description

Convert a correlation test data frame, returned by the cor_test(), into a correlation matrix format.

Usage

```
as_cor_mat(x)
```

Arguments

x	an object of class cor_test.

Value

Returns a data frame containing the matrix of the correlation coefficients. The output has an attribute named "pvalue", which contains the matrix of the correlation test p-values.

See Also

cor_mat(), cor_test()

Examples

```
# Pairwise correlation tests between variables
#:::::::::::::::::::::::::::::::::::::::::::::::
res.cor.test <- mtcars %>%
  select(mpg, disp, hp, drat, wt, qsec) %>%
  cor_test()
res.cor.test

# Convert the correlation test into a correlation matrix
#:::::::::::::::::::::::::::::::::::::::::::::::
res.cor.test %>% as_cor_mat()
```

---

binom_test *Exact Binomial Test*

Description

Performs exact binomial test and pairwise comparisons following a significant exact multinomial test. Wrapper around the R base function `link[stats]{binom.test}()` that returns a data frame as a result.

Usage

```
binom_test(
  x,
  n,
  p = 0.5,
  alternative = "two.sided",
  conf.level = 0.95,
  detailed = FALSE
)

pairwise_binom_test(
  x,
  p.adjust.method = "holm",
  alternative = "two.sided",
  conf.level = 0.95
)

pairwise_binom_test_against_p(
  x,
  p = rep(1/length(x), length(x)),
  p.adjust.method = "holm",
```

```
  alternative = "two.sided",
  conf.level = 0.95
)
```

Arguments

x	numeric vector containing the counts.
n	number of trials; ignored if x has length 2.
p	a vector of probabilities of success. The length of p must be the same as the number of groups specified by x, and its elements must be greater than 0 and less than 1.
alternative	indicates the alternative hypothesis and must be one of "two.sided", "greater" or "less". You can specify just the initial letter.
conf.level	confidence level for the returned confidence interval.
detailed	logical value. Default is FALSE. If TRUE, a detailed result is shown.
p.adjust.method	method to adjust p values for multiple comparisons. Used when pairwise comparisons are performed. Allowed values include "holm", "hochberg", "hommel", "bonferroni", "BH", "BY", "fdr", "none". If you don't want to adjust the p value (not recommended), use p.adjust.method = "none".

Value

return a data frame containing the p-value and its significance. with some the following columns:

- group, group1, group2: the categories or groups being compared.
- statistic: the number of successes.
- parameter: the number of trials.
- p: p-value of the test.
- p.adj: the adjusted p-value.
- method: the used statistical test.
- p.signif, p.adj.signif: the significance level of p-values and adjusted p-values, respectively.
- estimate: the estimated probability of success.
- alternative: a character string describing the alternative hypothesis.
- conf.low,conf.high: Lower and upper bound on a confidence interval for the probability of success.

The **returned object has an attribute called args**, which is a list holding the test arguments.

Functions

- binom_test: performs exact binomial test. Wrapper around the R base function binom.test that returns a dataframe as a result.

- pairwise_binom_test: performs pairwise comparisons (binomial test) following a significant exact multinomial test.
- pairwise_binom_test_against_p: performs pairwise comparisons (binomial test) following a significant exact multinomial test for given probabilities.

See Also

multinom_test

Examples

```
# Exact binomial test
#%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
# Data: 160 mice with cancer including 95 male and 65 female
# Q1: Does cancer affect more males than females?
binom_test(x = 95, n = 160)
# => yes, there are a significant difference


# Q2: compare the observed proportion of males
# to an expected proportion (p = 3/5)
binom_test(x = 95, n = 160, p = 3/5)
# => there are no significant difference

# Multinomial test
#%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
# Data
tulip <- c(red = 81, yellow = 50, white = 27)
# Question 1: are the color equally common ?
# this is a test of homogeneity
res <- multinom_test(tulip)
res
attr(res, "descriptives")

# Pairwise comparisons between groups
pairwise_binom_test(tulip, p.adjust.method = "bonferroni")


# Question 2: comparing observed to expected proportions
# this is a goodness-of-fit test
expected.p <- c(red = 0.5, yellow = 0.33, white = 0.17)
res <- multinom_test(tulip, expected.p)
res
attr(res, "descriptives")

# Pairwise comparisons against a given probabilities
pairwise_binom_test_against_p(tulip, expected.p)
```

`box_m` *Box's M-test for Homogeneity of Covariance Matrices*

Description

Performs the Box's M-test for homogeneity of covariance matrices obtained from multivariate normal data according to one grouping variable. The test is based on the chi-square approximation.

Usage

```
box_m(data, group)
```

Arguments

`data`	a numeric data.frame or matrix containing n observations of p variables; it is expected that n > p.
`group`	a vector of length n containing the class of each observation; it is usually a factor.

Value

A data frame containing the following components:

- statistic an approximated value of the chi-square distribution.
- parameter the degrees of freedom related of the test statistic in this case that it follows a Chi-square distribution.
- p.value the p-value of the test.
- method the character string "Box's M-test for Homogeneity of Covariance Matrices".

Examples

```
data(iris)
box_m(iris[, -5], iris[, 5])
```

`chisq_test` *Chi-squared Test for Count Data*

Description

Performs chi-squared tests, including goodness-of-fit, homogeneity and independence tests.

Usage

```
chisq_test(
  x,
  y = NULL,
  correct = TRUE,
  p = rep(1/length(x), length(x)),
  rescale.p = FALSE,
  simulate.p.value = FALSE,
  B = 2000
)

pairwise_chisq_gof_test(x, p.adjust.method = "holm", ...)

pairwise_chisq_test_against_p(
  x,
  p = rep(1/length(x), length(x)),
  p.adjust.method = "holm",
  ...
)

chisq_descriptives(res.chisq)

expected_freq(res.chisq)

observed_freq(res.chisq)

pearson_residuals(res.chisq)

std_residuals(res.chisq)
```

Arguments

x	a numeric vector or matrix. x and y can also both be factors.
y	a numeric vector; ignored if x is a matrix. If x is a factor, y should be a factor of the same length.
correct	a logical indicating whether to apply continuity correction when computing the test statistic for 2 by 2 tables: one half is subtracted from all $\|O-E\|$ differences; however, the correction will not be bigger than the differences themselves. No correction is done if simulate.p.value = TRUE.
p	a vector of probabilities of the same length of x. An error is given if any entry of p is negative.
rescale.p	a logical scalar; if TRUE then p is rescaled (if necessary) to sum to 1. If rescale.p is FALSE, and p does not sum to 1, an error is given.
simulate.p.value	a logical indicating whether to compute p-values by Monte Carlo simulation.
B	an integer specifying the number of replicates used in the Monte Carlo test.

p.adjust.method
: method to adjust p values for multiple comparisons. Used when pairwise comparisons are performed. Allowed values include "holm", "hochberg", "hommel", "bonferroni", "BH", "BY", "fdr", "none". If you don't want to adjust the p value (not recommended), use p.adjust.method = "none".

...
: other arguments passed to the function {chisq_test}().

res.chisq
: an object of class chisq_test.

Value

return a data frame with some the following columns:

- n: the number of participants.
- group, group1, group2: the categories or groups being compared.
- statistic: the value of Pearson's chi-squared test statistic.
- df: the degrees of freedom of the approximate chi-squared distribution of the test statistic. NA if the p-value is computed by Monte Carlo simulation.
- p: p-value.
- p.adj: the adjusted p-value.
- method: the used statistical test.
- p.signif, p.adj.signif: the significance level of p-values and adjusted p-values, respectively.
- observed: observed counts.
- expected: the expected counts under the null hypothesis.

The **returned object has an attribute called args**, which is a list holding the test arguments.

Functions

- chisq_test: performs chi-square tests including goodness-of-fit, homogeneity and independence tests.
- pairwise_chisq_gof_test: perform pairwise comparisons between groups following a global chi-square goodness of fit test.
- pairwise_chisq_test_against_p: perform pairwise comparisons after a global chi-squared test for given probabilities. For each group, the observed and the expected proportions are shown. Each group is compared to the sum of all others.
- chisq_descriptives: returns the descriptive statistics of the chi-square test. These include, observed and expected frequencies, proportions, residuals and standardized residuals.
- expected_freq: returns the expected counts from the chi-square test result.
- observed_freq: returns the observed counts from the chi-square test result.
- pearson_residuals: returns the Pearson residuals, (observed - expected) / sqrt(expected).
- std_residuals: returns the standardized residuals

Examples

```
# Chi-square goodness of fit test
#%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
tulip <- c(red = 81, yellow = 50, white = 27)
# Q1: Are the colors equally common?
chisq_test(tulip)
pairwise_chisq_gof_test(tulip)
# Q2: comparing observed to expected proportions
chisq_test(tulip, p = c(1/2, 1/3, 1/6))
pairwise_chisq_test_against_p(tulip, p = c(0.5, 0.33, 0.17))

# Homogeneity of proportions between groups
#%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
# Data: Titanic
xtab <- as.table(rbind(
  c(203, 118, 178, 212),
  c(122, 167, 528, 673)
))
dimnames(xtab) <- list(
  Survived = c("Yes", "No"),
  Class = c("1st", "2nd", "3rd", "Crew")
)
xtab
# Chi-square test
chisq_test(xtab)
# Compare the proportion of survived between groups
pairwise_prop_test(xtab)
```

---

cochran_qtest *Cochran's Q Test*

Description

Performs the Cochran's Q test for unreplicated randomized block design experiments with a binary response variable and paired data. This test is analogue to the `friedman.test()` with 0,1 coded response. It's an extension of the McNemar Chi-squared test for comparing more than two paired proportions.

Usage

```
cochran_qtest(data, formula)
```

Arguments

`data`	a data frame containing the variables in the formula.
`formula`	a formula of the form `a ~ b	c`, where `a` is the outcome variable name; b is the within-subjects factor variables; and c (factor) is the column name containing individuals/subjects identifier. Should be unique per individual.

Examples

```
# Generate a demo data
mydata <- data.frame(
  outcome = c(0,1,1,0,0,1,0,1,1,1,1,1,0,0,1,1,0,1,0,1,1,0,0,1,0,1,1,0,0,1),
  treatment = gl(3,1,30,labels=LETTERS[1:3]),
  participant = gl(10,3,labels=letters[1:10])
)
mydata$outcome <- factor(
  mydata$outcome, levels = c(1, 0),
  labels = c("success", "failure")
  )
# Cross-tabulation
xtabs(~outcome + treatment, mydata)

# Compare the proportion of success between treatments
cochran_qtest(mydata, outcome ~ treatment|participant)

# pairwise comparisons between groups
pairwise_mcnemar_test(mydata, outcome ~ treatment|participant)
```

---

cohens_d *Compute Cohen's d Measure of Effect Size*

Description

Compute the effect size for t-test. T-test conventional effect sizes, proposed by Cohen, are: 0.2 (small effect), 0.5 (moderate effect) and 0.8 (large effect).

Cohen's `d` is calculated as the difference between means or mean minus `mu` divided by the estimated standardized deviation.

For independent samples t-test, there are two possibilities implemented. If the t-test did not make a homogeneity of variance assumption, (the Welch test), the variance term will mirror the Welch test, otherwise a pooled estimate is used.

If a paired samples t-test was requested, then effect size desired is based on the standard deviation of the differences.

It can also returns confidence intervals by bootstap.

Usage

```
cohens_d(
  data,
  formula,
  comparisons = NULL,
  ref.group = NULL,
  paired = FALSE,
  mu = 0,
  var.equal = FALSE,
```

```
    hedges.correction = FALSE,
    ci = FALSE,
    conf.level = 0.95,
    ci.type = "perc",
    nboot = 1000
  )
```

Arguments

`data`	a data.frame containing the variables in the formula.
`formula`	a formula of the form `x ~ group` where `x` is a numeric variable giving the data values and `group` is a factor with one or multiple levels giving the corresponding groups. For example, `formula = TP53 ~ cancer_group`.
`comparisons`	A list of length-2 vectors specifying the groups of interest to be compared. For example to compare groups "A" vs "B" and "B" vs "C", the argument is as follow: `comparisons = list(c("A", "B"), c("B","C"))`
`ref.group`	a character string specifying the reference group. If specified, for a given grouping variable, each of the group levels will be compared to the reference group (i.e. control group). If `ref.group = "all"`, pairwise two sample tests are performed for comparing each grouping variable levels against all (i.e. basemean).
`paired`	a logical indicating whether you want a paired test.
`mu`	theoretical mean, use for one-sample t-test. Default is 0.
`var.equal`	a logical variable indicating whether to treat the two variances as being equal. If TRUE then the pooled variance is used to estimate the variance otherwise the Welch (or Satterthwaite) approximation to the degrees of freedom is used. Used only for unpaired or independent samples test.
`hedges.correction`	logical indicating whether apply the Hedges correction by multiplying the usual value of Cohen's d by `(N-3)/(N-2.25)` (for unpaired t-test) and by `(n1-2)/(n1-1.25)` for paired t-test; where `N` is the total size of the two groups being compared (N = n1 + n2).
`ci`	If TRUE, returns confidence intervals by bootstrap. May be slow.
`conf.level`	The level for the confidence interval.
`ci.type`	The type of confidence interval to use. Can be any of "norm", "basic", "perc", or "bca". Passed to `boot::boot.ci`.
`nboot`	The number of replications to use for bootstrap.

Details

Quantification of the effect size magnitude is performed using the thresholds defined in Cohen (1992). The magnitude is assessed using the thresholds provided in (Cohen 1992), i.e. `|d| < 0.2` "negligible", `|d| < 0.5` "small", `|d| < 0.8` "medium", otherwise "large".

Value

return a data frame with some of the following columns:

- `.y.`: the y variable used in the test.
- `group1,group2`: the compared groups in the pairwise tests.
- `n,n1,n2`: Sample counts.
- `effsize`: estimate of the effect size (`d` value).
- `magnitude`: magnitude of effect size.
- `conf.low,conf.high`: lower and upper bound of the effect size confidence interval.

References

- Cohen, J. (1988). Statistical power analysis for the behavioral sciences (2nd ed.). New York:Academic Press.
- Cohen, J. (1992). A power primer. Psychological Bulletin, 112, 155-159.
- Hedges, Larry & Olkin, Ingram. (1985). Statistical Methods in Meta-Analysis. 10.2307/1164953.
- Navarro, Daniel. 2015. Learning Statistics with R: A Tutorial for Psychology Students and Other Beginners (Version 0.5).

Examples

```
# One-sample t test effect size
ToothGrowth %>% cohens_d(len ~ 1, mu = 0)

# Two indepedent samples t-test effect size
ToothGrowth %>% cohens_d(len ~ supp, var.equal = TRUE)

# Paired samples effect size
df <- data.frame(
  id = 1:5,
  pre  = c(110, 122, 101, 120, 140),
  post = c(150, 160, 110, 140, 155)
)
df <- df %>% gather(key = "treatment", value = "value", -id)
head(df)

df %>% cohens_d(value ~ treatment, paired = TRUE)
```

`convert_as_factor` *Factors*

Description

Provides pipe-friendly functions to convert simultaneously multiple variables into a factor variable. Helper functions are also available to set the reference level and the levels order.

Usage

```
convert_as_factor(data, ..., vars = NULL, make.valid.levels = FALSE)

set_ref_level(data, name, ref)

reorder_levels(data, name, order)
```

Arguments

data	a data frame
...	one unquoted expressions (or variable name) specifying the name of the variables you want to convert into factor. Alternative to the argument vars.
vars	a character vector specifying the variables to convert into factor.
make.valid.levels	logical. Default is FALSE. If TRUE, converts the variable to factor and add a leading character (x) if starting with a digit.
name	a factor variable name. Can be unquoted. For example, use group or "group".
ref	the reference level.
order	a character vector specifying the order of the factor levels

Functions

- convert_as_factor: Convert one or multiple variables into factor.
- set_ref_level: Change a factor reference level or group.
- reorder_levels: Change the order of a factor levels

Examples

```
# Create a demo data
df <- tibble(
  group = c("a", "a", "b", "b", "c", "c"),
  time = c("t1", "t2", "t1", "t2", "t1", "t2"),
  value = c(5, 6, 1, 3, 4, 5)
)
df
# Convert group and time into factor variable
result <- df %>% convert_as_factor(group, time)
result
# Show group levels
levels(result$group)

# Set c as the reference level (the first one)
result <- result %>%
  set_ref_level("group", ref = "c")
levels(result$group)

# Set the order of levels
result <- result %>%
```

```
  reorder_levels("group", order = c("b", "c", "a"))
levels(result$group)
```

cor_as_symbols *Replace Correlation Coefficients by Symbols*

Description

Take a correlation matrix and replace the correlation coefficients by symbols according to the level of the correlation.

Usage

```
cor_as_symbols(
  x,
  cutpoints = c(0, 0.25, 0.5, 0.75, 1),
  symbols = c(" ", ".", "+", "*")
)
```

Arguments

x	a correlation matrix. Particularly, an object of class `cor_mat`.
cutpoints	numeric vector used for intervals. Default values are `c(0, 0.25, 0.5, 0.75, 1)`.
symbols	character vector, one shorter than cutpoints, used as correlation coefficient symbols. Default values are `c(" ", ".", "+","*")`.

See Also

`cor_mat()`

Examples

```
# Compute correlation matrix
#::::::::::::::::::::::::::::::::::::::::::
cor.mat <- mtcars %>%
  select(mpg, disp, hp, drat, wt, qsec) %>%
  cor_mat()

# Replace correlation coefficient by symbols
#::::::::::::::::::::::::::::::::::::::::::
cor.mat %>%
  cor_as_symbols() %>%
  pull_lower_triangle()
```

cor_gather *Reshape Correlation Data*

Description

Reshape correlation analysis results. Key functions:

- `cor_gather()`: takes a correlation matrix and collapses (i.e. melt) it into a paired list (long format).
- `cor_spread()`: spread a long correlation data format across multiple columns. Particularly, it takes the results of `cor_test` and transforms it into a correlation matrix.

Usage

```
cor_gather(data, drop.na = TRUE)

cor_spread(data, value = "cor")
```

Arguments

`data`	a data frame or matrix.
`drop.na`	logical. If TRUE, drop rows containing missing values after gathering the data.
`value`	column name containing the value to spread.

Functions

- `cor_gather`: takes a correlation matrix and collapses (or melt) it into long format data frame (paired list)
- `cor_spread`: spread a long correlation data frame into wide format. Expects the columns "var1", "var2" and "cor" in the data. (correlation matrix).

See Also

`cor_mat()`, `cor_reorder()`

Examples

```
# Data preparation
#:::::::::::::::::::::::::::::::::::::::::::
mydata <- mtcars %>%
  select(mpg, disp, hp, drat, wt, qsec)
head(mydata, 3)

# Reshape a correlation matrix
#:::::::::::::::::::::::::::::::::::::::::::
# Compute a correlation matrix
cor.mat <- mydata %>% cor_mat()
cor.mat
```

```
# Collapse the correlation matrix into long format
# paired list data frame
long.format <- cor.mat %>% cor_gather()
long.format

# Spread a correlation data format
#::::::::::::::::::::::::::::::::::::::::
# Spread the correlation coefficient value
long.format %>% cor_spread(value = "cor")
# Spread the p-value
long.format %>% cor_spread(value = "p")
```

---

cor_mark_significant *Add Significance Levels To a Correlation Matrix*

Description

Combines correlation coefficients and significance levels in a correlation matrix data.

Usage

```
cor_mark_significant(
  x,
  cutpoints = c(0, 1e-04, 0.001, 0.01, 0.05, 1),
  symbols = c("****", "***", "**", "*", "")
)
```

Arguments

x	an object of class cor_mat().
cutpoints	numeric vector used for intervals.
symbols	character vector, one shorter than cutpoints, used as significance symbols.

Value

a data frame containing the lower triangular part of the correlation matrix marked by significance symbols.

Examples

```
mtcars %>%
  select(mpg, disp, hp, drat, wt, qsec) %>%
  cor_mat() %>%
  cor_mark_significant()
```

`cor_mat` *Compute Correlation Matrix with P-values*

Description

Compute correlation matrix with p-values. Numeric columns in the data are detected and automatically selected for the analysis. You can also specify variables of interest to be used in the correlation analysis.

Usage

```
cor_mat(
  data,
  ...,
  vars = NULL,
  method = "pearson",
  alternative = "two.sided",
  conf.level = 0.95
)

cor_pmat(
  data,
  ...,
  vars = NULL,
  method = "pearson",
  alternative = "two.sided",
  conf.level = 0.95
)

cor_get_pval(x)
```

Arguments

`data`	a data.frame containing the variables.
`...`	One or more unquoted expressions (or variable names) separated by commas. Used to select a variable of interest.
`vars`	a character vector containing the variable names of interest.
`method`	a character string indicating which correlation coefficient is to be used for the test. One of `"pearson"`, `"kendall"`, or `"spearman"`, can be abbreviated.
`alternative`	indicates the alternative hypothesis and must be one of `"two.sided"`, `"greater"` or `"less"`. You can specify just the initial letter. `"greater"` corresponds to positive association, `"less"` to negative association.
`conf.level`	confidence level for the returned confidence interval. Currently only used for the Pearson product moment correlation coefficient if there are at least 4 complete pairs of observations.
`x`	an object of class `cor_mat`

Value

a data frame

Functions

- `cor_mat`: compute correlation matrix with p-values. Returns a data frame containing the matrix of the correlation coefficients. The output has an attribute named "pvalue", which contains the matrix of the correlation test p-values.
- `cor_pmat`: compute the correlation matrix but returns only the p-values of the tests.
- `cor_get_pval`: extract a correlation matrix p-values from an object of class `cor_mat()`. P-values are not adjusted.

See Also

`cor_test()`, `cor_reorder()`, `cor_gather()`, `cor_select()`, `cor_as_symbols()`, `pull_triangle()`, `replace_triangle()`

Examples

```
# Data preparation
#:::::::::::::::::::::::::::::::::::::::::::
mydata <- mtcars %>%
  select(mpg, disp, hp, drat, wt, qsec)
head(mydata, 3)

# Compute correlation matrix
#::::::::::::::::::::::::::::::::::::::::::
# Correlation matrix between all variables
cor.mat <- mydata %>% cor_mat()
cor.mat

# Specify some variables of interest
mydata %>% cor_mat(mpg, hp, wt)

# Or remove some variables in the data
# before the analysis
mydata %>% cor_mat(-mpg, -hp)

# Significance levels
#::::::::::::::::::::::::::::::::::::::::::
cor.mat %>% cor_get_pval()


# Visualize
#::::::::::::::::::::::::::::::::::::::::::
# Insignificant correlations are marked by crosses
cor.mat %>%
  cor_reorder() %>%
  pull_lower_triangle() %>%
  cor_plot(label = TRUE)
```

```
# Gather/collapse correlation matrix into long format
#::::::::::::::::::::::::::::::::::::::::
cor.mat %>% cor_gather()
```

---

cor_plot *Visualize Correlation Matrix Using Base Plot*

Description

Provide a tibble-friendly framework to visualize a correlation matrix. Wrapper around the R base function `corrplot()`. Compared to `corrplot()`, it can handle directly the output of the functions `cor_mat()` (in rstatix), `rcorr()` (in Hmisc), `correlate()` (in corrr) and `cor()` (in stats).

The p-values contained in the outputs of the functions `cor_mat()` and `rcorr()` are automatically detected and used in the visualization.

Usage

```
cor_plot(
  cor.mat,
  method = "circle",
  type = "full",
  palette = NULL,
  p.mat = NULL,
  significant.level = 0.05,
  insignificant = c("cross", "blank"),
  label = FALSE,
  font.label = list(),
  ...
)
```

Arguments

`cor.mat`	the correlation matrix to visualize
`method`	Character, the visualization method of correlation matrix to be used. Currently, it supports seven methods, named "circle" (default), "square", "ellipse", "number", "pie", "shade" and "color". See examples for details. The areas of circles or squares show the absolute value of corresponding correlation coefficients. Method "pie" and "shade" came from Michael Friendly's job (with some adjustment about the shade added on), and "ellipse" came from D.J. Murdoch and E.D. Chow's job, see in section References.
`type`	Character, "full" (default), "upper" or "lower", display full matrix, lower triangular or upper triangular matrix.
`palette`	character vector containing the color palette.

p.mat matrix of p-value corresponding to the correlation matrix.

significant.level
: significant level, if the p-value is bigger than significant.level, then the corresponding correlation coefficient is regarded as insignificant.

insignificant character, specialized insignificant correlation coefficients, "cross" (default), "blank". If "blank", wipe away the corresponding glyphs; if "cross", add crosses (X) on corresponding glyphs.

label logical value. If TRUE, shows the correlation coefficient labels.

font.label a list with one or more of the following elements: size (e.g., 1), color (e.g., "black") and style (e.g., "bold"). Used to customize the correlation coefficient labels. For example font.label = list(size = 1, color = "black", style = "bold").

... additional options not listed (i.e. "tl.cex") here to pass to corrplot.

See Also

cor_as_symbols()

Examples

```
# Compute correlation matrix
#::::::::::::::::::::::::::::::::::::::::::
cor.mat <- mtcars %>%
  select(mpg, disp, hp, drat, wt, qsec) %>%
  cor_mat()

# Visualize correlation matrix
#::::::::::::::::::::::::::::::::::::::::::
# Full correlation matrix,
# insignificant correlations are marked by crosses
cor.mat %>% cor_plot()

# Reorder by correlation coefficient
# pull lower triangle and visualize
cor.lower.tri <- cor.mat %>%
  cor_reorder() %>%
  pull_lower_triangle()
cor.lower.tri %>% cor_plot()

# Change visualization methods
#::::::::::::::::::::::::::::::::::::::::::
cor.lower.tri %>%
  cor_plot(method = "pie")

cor.lower.tri %>%
  cor_plot(method = "color")

cor.lower.tri %>%
  cor_plot(method = "number")
```

```
# Show the correlation coefficient: label = TRUE
# Blank the insignificant correlation
#::::::::::::::::::::::::::::::::::::::::::
cor.lower.tri %>%
  cor_plot(
    method = "color",
    label = TRUE,
    insignificant = "blank"
  )

# Change the color palettes
#::::::::::::::::::::::::::::::::::::::::::

# Using custom color palette
# Require ggpubr: install.packages("ggpubr")
if(require("ggpubr")){
  my.palette <- get_palette(c("red", "white", "blue"), 200)
  cor.lower.tri %>%
   cor_plot(palette = my.palette)
}

# Using RcolorBrewer color palette
if(require("ggpubr")){
  my.palette <- get_palette("PuOr", 200)
  cor.lower.tri %>%
   cor_plot(palette = my.palette)
}
```

`cor_reorder` *Reorder Correlation Matrix*

Description

reorder correlation matrix, according to the coefficients, using the hierarchical clustering method.

Usage

```
cor_reorder(x)
```

Arguments

x	a correlation matrix. Particularly, an object of class `cor_mat`.

Value

a data frame

See Also

`cor_mat()`, `cor_gather()`, `cor_spread()`

Examples

```
# Compute correlation matrix
#::::::::::::::::::::::::::::::::::::::::::
cor.mat <- mtcars %>%
  select(mpg, disp, hp, drat, wt, qsec) %>%
  cor_mat()

# Reorder by correlation and get p-values
#::::::::::::::::::::::::::::::::::::::::::
# Reorder
cor.mat %>%
  cor_reorder()
# Get p-values of the reordered cor_mat
cor.mat %>%
  cor_reorder() %>%
  cor_get_pval()
```

`cor_select` *Subset Correlation Matrix*

Description

Subset Correlation Matrix

Usage

```
cor_select(x, ..., vars = NULL)
```

Arguments

`x`	a correlation matrix. Particularly, an object of class `cor_mat`.
`...`	One or more unquoted expressions (or variable names) separated by commas. Used to select variables of interest.
`vars`	a character vector containing the variable names of interest.

Value

a data frame

See Also

`cor_mat()`, `pull_triangle()`, `replace_triangle()`

Examples

```
# Compute correlation matrix
#::::::::::::::::::::::::::::::::::::::::::
cor.mat <- mtcars %>%
  select(mpg, disp, hp, drat, wt, qsec) %>%
  cor_mat()

# Subsetting correlation matrix
#::::::::::::::::::::::::::::::::::::::::::

# Select some variables of interest
cor.mat %>%
  cor_select(mpg, drat, wt)

# Remove variables
cor.mat %>%
  cor_select(-mpg, -wt)
```

`cor_test` *Correlation Test*

Description

Provides a pipe-friendly framework to perform correlation test between paired samples, using Pearson, Kendall or Spearman method. Wrapper around the function `cor.test()`.

Can also performs multiple pairwise correlation analyses between more than two variables or between two different vectors of variables. Using this function, you can also compute, for example, the correlation between one variable vs many.

Usage

```
cor_test(
  data,
  ...,
  vars = NULL,
  vars2 = NULL,
  alternative = "two.sided",
  method = "pearson",
  conf.level = 0.95,
  use = "pairwise.complete.obs"
)
```

Arguments

`data`	a data.frame containing the variables.
`...`	One or more unquoted expressions (or variable names) separated by commas. Used to select a variable of interest. Alternative to the argument `vars`.

vars — optional character vector containing variable names for correlation analysis. Ignored when dot vars are specified.

- If vars is NULL, multiple pairwise correlation tests is performed between all variables in the data.
- If vars contain only one variable, a pairwise correlation analysis is performed between the specified variable vs either all the remaining numeric variables in the data or variables in vars2 (if specified).
- If vars contain two or more variables: i) if vars2 is not specified, a pairwise correlation analysis is performed between all possible combinations of variables. ii) if vars2 is specified, each element in vars is tested against all elements in vars2

. Accept unquoted variable names: c(var1, var2).

vars2 — optional character vector. If specified, each element in vars is tested against all elements in vars2. Accept unquoted variable names: c(var1, var2).

alternative — indicates the alternative hypothesis and must be one of "two.sided", "greater" or "less". You can specify just the initial letter. "greater" corresponds to positive association, "less" to negative association.

method — a character string indicating which correlation coefficient is to be used for the test. One of "pearson", "kendall", or "spearman", can be abbreviated.

conf.level — confidence level for the returned confidence interval. Currently only used for the Pearson product moment correlation coefficient if there are at least 4 complete pairs of observations.

use — an optional character string giving a method for computing covariances in the presence of missing values. This must be (an abbreviation of) one of the strings "everything", "all.obs", "complete.obs", "na.or.complete", or "pairwise.complete.obs".

Value

return a data frame with the following columns:

- var1, var2: the variables used in the correlation test.
- cor: the correlation coefficient.
- statistic: Test statistic used to compute the p-value.
- p: p-value.
- conf.low,conf.high: Lower and upper bounds on a confidence interval.
- method: the method used to compute the statistic.

Functions

- cor_test: correlation test between two or more variables.

See Also

cor_mat(), as_cor_mat()

Examples

```
# Correlation between the specified variable vs
# the remaining numeric variables in the data
#::::::::::::::::::::::::::::::::::::::::
mtcars %>% cor_test(mpg)

# Correlation test between two variables
#::::::::::::::::::::::::::::::::::::::::
mtcars %>% cor_test(wt, mpg)

# Pairwise correlation between multiple variables
#::::::::::::::::::::::::::::::::::::::::
mtcars %>% cor_test(wt, mpg, disp)

# Grouped data
#::::::::::::::::::::::::::::::::::::::::
iris %>%
  group_by(Species) %>%
 cor_test(Sepal.Width, Sepal.Length)

# Multiple correlation test
#::::::::::::::::::::::::::::::::::::::::
# Correlation between one variable vs many
mtcars %>% cor_test(
  vars = "mpg",
  vars2 = c("disp", "hp", "drat")
 )

# Correlation between two vectors of variables
# Each element in vars is tested against all elements in vars2
mtcars %>% cor_test(
  vars = c("mpg", "wt"),
  vars2 = c("disp", "hp", "drat")
 )
```

---

counts_to_cases *Convert a Table of Counts into a Data Frame of cases*

Description

converts a contingency table or a data frame of counts into a data frame of individual observations.

Usage

```
counts_to_cases(x, count.col = "Freq")
```

Arguments

x	a contingency table or a data frame
count.col	the name of the column containing the counts. Default is "Freq".

Value

a data frame of cases

Examples

```
# Create a cross-tabulation demo data
#%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
xtab <- as.table(
  rbind(c(20, 5), c(16,9))
)
dimnames(xtab) <- list(
  before = c("non.smoker", "smoker"),
  after = c("non.smoker", "smoker")
)
xtab

# Convert into a data frame of cases
#%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
df <- counts_to_cases(xtab)
head(df)
```

---

cramer_v — *Compute Cramer's V*

Description

Compute Cramer's V, which measures the strength of the association between categorical variables.

Usage

```
cramer_v(x, y = NULL, correct = TRUE, ...)
```

Arguments

x	a numeric vector or matrix. x and y can also both be factors.
y	a numeric vector; ignored if x is a matrix. If x is a factor, y should be a factor of the same length.
correct	a logical indicating whether to apply continuity correction when computing the test statistic for 2 by 2 tables: one half is subtracted from all $\lvert O-E \rvert$ differences; however, the correction will not be bigger than the differences themselves. No correction is done if simulate.p.value = TRUE.
...	other arguments passed to the function chisq.test().

Examples

```
# Data preparation
df <- as.table(rbind(c(762, 327, 468), c(484, 239, 477)))
dimnames(df) <- list(
  gender = c("F", "M"),
  party = c("Democrat","Independent", "Republican")
)
df
# Compute cramer's V
cramer_v(df)
```

---

df_arrange *Arrange Rows by Column Values*

Description

Order the rows of a data frame by values of specified columns. Wrapper arround the `arrange()` function. Supports standard and non standard evaluation.

Usage

```
df_arrange(data, ..., vars = NULL, .by_group = FALSE)
```

Arguments

`data`	a data frame
`...`	One or more unquoted expressions (or variable names) separated by commas. Used to select a variable of interest. Use `desc()` to sort a variable in descending order.
`vars`	a character vector containing the variable names of interest.
`.by_group`	If TRUE, will sort first by grouping variable. Applies to grouped data frames only.

Value

a data frame

Examples

```
df <- head(ToothGrowth)
df

# Select column using standard evaluation
df %>% df_arrange(vars = c("dose", "len"))

# Select column using non-standard evaluation
df %>% df_arrange(dose, desc(len))
```

df_get_var_names — *Get User Specified Variable Names*

Description

Returns user specified variable names. Supports standard and non standard evaluation.

Usage

```
df_get_var_names(data, ..., vars = NULL)
```

Arguments

data	a data frame
...	One or more unquoted expressions (or variable names) separated by commas. Used to select a variable of interest.
vars	a character vector containing the variable names of interest.

Value

a character vector

Examples

```
# Non standard evaluation
ToothGrowth %>%
 df_get_var_names(dose, len)

# Standard evaluation
ToothGrowth %>%
 df_get_var_names(vars = c("len", "dose"))
```

df_group_by — *Group a Data Frame by One or more Variables*

Description

Group a data frame by one or more variables. Supports standard and non standard evaluation.

Usage

```
df_group_by(data, ..., vars = NULL)
```

Arguments

data	a data frame
...	One or more unquoted expressions (or variable names) separated by commas. Used to select a variable of interest.
vars	a character vector containing the variable names of interest.

Examples

```
# Non standard evaluation
by_dose <- head(ToothGrowth) %>%
   df_group_by(dose)
by_dose

# Standard evaluation
head(ToothGrowth) %>%
   df_group_by(vars = c("dose", "supp"))
```

---

df_label_both *Functions to Label Data Frames by Grouping Variables*

Description

Functions to label data frame rows by one or multiple grouping variables.

Usage

```
df_label_both(data, ..., vars = NULL, label_col = "label", sep = c(", ", ":"))

df_label_value(data, ..., vars = NULL, label_col = "label", sep = ", ")
```

Arguments

data	a data frame
...	One or more unquoted expressions (or variable names) separated by commas. Used as grouping variables.
vars	a character vector containing the grouping variables of interest.
label_col	column to hold the label of the data subsets. Default column name is "label".
sep	String separating labelling variables and values. Should be of length 2 in the function `df_label_both()`. 1) One sep is used to separate groups, for example ','; 2) The other sep between group name and levels; for example ':'.

Value

a modified data frame with a column containing row labels.

Functions

- `df_label_both`: Displays both the variable name and the factor value.
- `df_label_value`: Displays only the value of a factor.

Examples

```
# Data preparation
df <- head(ToothGrowth)

# Labelling: Non standard evaluation
df %>%
  df_label_both(dose, supp)

# Standard evaluation
df %>%
  df_label_both(dose, supp)

# Nesting the data then label each subset by groups
ToothGrowth %>%
  df_nest_by(dose, supp) %>%
  df_label_both(supp, dose)
```

`df_nest_by` *Nest a Tibble By Groups*

Description

Nest a tibble data frame using grouping specification. Supports standard and non standard evaluation.

Usage

```
df_nest_by(data, ..., vars = NULL)
```

Arguments

`data`	a data frame
`...`	One or more unquoted expressions (or variable names) separated by commas. Used as grouping variables.
`vars`	a character vector containing the grouping variables of interest.

Value

A tbl with one row per unique combination of the grouping variables. The first columns are the grouping variables, followed by a list column of tibbles with matching rows of the remaining columns.

Examples

```
# Non standard evaluation
ToothGrowth %>%
 df_nest_by(dose, supp)

# Standard evaluation
ToothGrowth %>%
 df_nest_by(vars = c("dose", "supp"))
```

---

df_select *Select Columns in a Data Frame*

Description

A wrapper around the `select()` function for selection data frame columns. Supports standard and non standard evaluations. Usefull to easily program with `dplyr`

Usage

```
df_select(data, ..., vars = NULL)
```

Arguments

`data`	a data frame
`...`	One or more unquoted expressions (or variable names) separated by commas. Used to select a variable of interest.
`vars`	a character vector containing the variable names of interest.

Value

a data frame

Examples

```
df <- head(ToothGrowth)
df

# Select column using standard evaluation
df %>% df_select(vars = c("dose", "len"))

# Select column using non-standard evaluation
df %>% df_select(dose, len)
```

`df_split_by` *Split a Data Frame into Subset*

Description

Split a data frame by groups into subsets or data panel. Very similar to the function `df_nest_by()`. The only difference is that, it adds label to each data subset. Labels are the combination of the grouping variable levels. The column holding labels are named "label".

Usage

```
df_split_by(
  data,
  ...,
  vars = NULL,
  label_col = "label",
  labeller = df_label_both,
  sep = c(", ", ":")
)
```

Arguments

`data`	a data frame
`...`	One or more unquoted expressions (or variable names) separated by commas. Used as grouping variables.
`vars`	a character vector containing the grouping variables of interest.
`label_col`	column to hold the label of the data subsets. Default column name is "label".
`labeller`	A function that takes a data frame, the grouping variables, label_col and label_sep arguments, and add labels into the data frame. Example of possible values are: `df_label_both()` and `df_label_value()`.
`sep`	String separating labelling variables and values. Should be of length 2 in the function `df_label_both()`. 1) One sep is used to separate groups, for example ','; 2) The other sep between group name and levels; for example ':'.

Value

A tbl with one row per unique combination of the grouping variables. The first columns are the grouping variables, followed by a list column of tibbles with matching rows of the remaining columns, and a column named label, containing labels.

Examples

```
# Split a data frame
# :::::::::::::::::::::::::::::::::::::::::::::::::
# Create a grouped data
```

```
res <- ToothGrowth %>%
  df_split_by(dose, supp)
res

# Show subsets
res$data

# Add panel/subset labels
res <- ToothGrowth %>%
  df_split_by(dose, supp)
res
```

---

df_unite *Unite Multiple Columns into One*

Description

Paste together multiple columns into one. Wrapper arround `unite()` that supports standard and non standard evaluation.

Usage

```
df_unite(data, col, ..., vars = NULL, sep = "_", remove = TRUE, na.rm = FALSE)

df_unite_factors(
  data,
  col,
  ...,
  vars = NULL,
  sep = "_",
  remove = TRUE,
  na.rm = FALSE
)
```

Arguments

data	a data frame
col	the name of the new column as a string or a symbol.
...	a selection of columns. One or more unquoted expressions (or variable names) separated by commas.
vars	a character vector containing the column names of interest.
sep	Separator to use between values.
remove	If TRUE, remove input columns from output data frame.
na.rm	If TRUE, missing values will be remove prior to uniting each value.

Functions

- `df_unite`: Unite multiple columns into one.
- `df_unite_factors`: Unite factor columns. First, order factors levels then merge them into one column. The output column is a factor.

Examples

```
# Non standard evaluation
head(ToothGrowth) %>%
 df_unite(col = "dose_supp", dose, supp)

# Standard evaluation
head(ToothGrowth) %>%
 df_unite(col = "dose_supp", vars = c("dose", "supp"))
```

---

doo *Alternative to dplyr::do for Doing Anything*

Description

Provides a flexible alternative to the `dplyr:do()` function. Technically it uses `nest()` + `mutate()` + `map()` to apply arbitrary computation to a grouped data frame.

The output is a data frame. If the applied function returns a data frame, then the output will be automatically unnested. Otherwise, the output includes the grouping variables and a column named ".results." (by default), which is a "list-columns" containing the results for group combinations.

Usage

```
doo(data, .f, ..., result = ".results.")
```

Arguments

`data`	a (grouped) data frame
`.f`	A function, formula, or atomic vector. For example `~t.test(len ~ supp, data = .)`.
`...`	Additional arguments passed on to .f
`result`	the column name to hold the results. Default is ".results.".

Value

a data frame

Examples

```
# Custom function
#%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
stat_test <- function(data, formula){
  t.test(formula, data) %>%
    tidy()
}
# Example 1: pipe-friendly stat_test().
# Two possibilities of usage are available
#%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
# Use this
ToothGrowth %>%
  group_by(dose) %>%
  doo(~stat_test(data =., len ~ supp))

# Or this
ToothGrowth %>%
  group_by(dose) %>%
  doo(stat_test, len ~ supp)

# Example 2: R base function t.test() (not pipe friendly)
# One possibility of usage
#%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
comparisons <- ToothGrowth %>%
   group_by(dose) %>%
   doo(~t.test(len ~ supp, data =.))
comparisons
comparisons$.results.

# Example 3: R base function combined with tidy()
#%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
ToothGrowth %>%
   group_by(dose) %>%
   doo(~t.test(len ~ supp, data =.) %>% tidy())
```

`dunn_test` *Dunn's Test of Multiple Comparisons*

Description

Performs Dunn's test for pairwise multiple comparisons of the ranked data. The mean rank of the different groups is compared. Used for post-hoc test following Kruskal-Wallis test.

The default of the `rstatix::dunn_test()` function is to perform a two-sided Dunn test like the well known commercial softwares, such as SPSS and GraphPad. This is not the case for some other R packages (`dunn.test` and `jamovi`), where the default is to perform one-sided test. This discrepancy is documented at https://github.com/kassambara/rstatix/issues/50.

Usage

```
dunn_test(data, formula, p.adjust.method = "holm", detailed = FALSE)
```

Arguments

`data` a data.frame containing the variables in the formula.

`formula` a formula of the form `x ~ group` where `x` is a numeric variable giving the data values and `group` is a factor with one or multiple levels giving the corresponding groups. For example, `formula = TP53 ~ cancer_group`.

`p.adjust.method`
method to adjust p values for multiple comparisons. Used when pairwise comparisons are performed. Allowed values include "holm", "hochberg", "hommel", "bonferroni", "BH", "BY", "fdr", "none". If you don't want to adjust the p value (not recommended), use p.adjust.method = "none".

`detailed` logical value. Default is FALSE. If TRUE, a detailed result is shown.

Details

DunnTest performs the post hoc pairwise multiple comparisons procedure appropriate to follow up a Kruskal-Wallis test, which is a non-parametric analog of the one-way ANOVA. The Wilcoxon rank sum test, itself a non-parametric analog of the unpaired t-test, is possibly intuitive, but inappropriate as a post hoc pairwise test, because (1) it fails to retain the dependent ranking that produced the Kruskal-Wallis test statistic, and (2) it does not incorporate the pooled variance estimate implied by the null hypothesis of the Kruskal-Wallis test.

Value

return a data frame with some of the following columns:

- `.y.`: the y (outcome) variable used in the test.
- `group1,group2`: the compared groups in the pairwise tests.
- `n1,n2`: Sample counts.
- `estimate`: mean ranks difference.
- `estimate1, estimate2`: show the mean rank values of the two groups, respectively.
- `statistic`: Test statistic (z-value) used to compute the p-value.
- `p`: p-value.
- `p.adj`: the adjusted p-value.
- `method`: the statistical test used to compare groups.
- `p.signif, p.adj.signif`: the significance level of p-values and adjusted p-values, respectively.

The **returned object has an attribute called args**, which is a list holding the test arguments.

References

Dunn, O. J. (1964) Multiple comparisons using rank sums Technometrics, 6(3):241-252.

Examples

```
# Simple test
ToothGrowth %>% dunn_test(len ~ dose)

# Grouped data
ToothGrowth %>%
  group_by(supp) %>%
  dunn_test(len ~ dose)
```

---

emmeans_test *Pairwise Comparisons of Estimated Marginal Means*

Description

Performs pairwise comparisons between groups using the estimated marginal means. Pipe-friendly wrapper arround the functions `emmans()` + `contrast()` from the `emmeans` package, which need to be installed before using this function. This function is useful for performing post-hoc analyses following ANOVA/ANCOVA tests.

Usage

```
emmeans_test(
  data,
  formula,
  covariate = NULL,
  ref.group = NULL,
  comparisons = NULL,
  p.adjust.method = "bonferroni",
  conf.level = 0.95,
  model = NULL,
  detailed = FALSE
)

get_emmeans(emmeans.test)
```

Arguments

`data`	a data.frame containing the variables in the formula.
`formula`	a formula of the form `x ~ group` where `x` is a numeric variable giving the data values and `group` is a factor with one or multiple levels giving the corresponding groups. For example, `formula = TP53 ~ cancer_group`.
`covariate`	(optional) covariate names (for ANCOVA)
`ref.group`	a character string specifying the reference group. If specified, for a given grouping variable, each of the group levels will be compared to the reference group (i.e. control group). If `ref.group = "all"`, pairwise two sample tests are performed for comparing each grouping variable levels against all (i.e. basemean).

comparisons
: A list of length-2 vectors specifying the groups of interest to be compared. For example to compare groups "A" vs "B" and "B" vs "C", the argument is as follow: `comparisons = list(c("A", "B"), c("B","C"))`

p.adjust.method
: method to adjust p values for multiple comparisons. Used when pairwise comparisons are performed. Allowed values include "holm", "hochberg", "hommel", "bonferroni", "BH", "BY", "fdr", "none". If you don't want to adjust the p value (not recommended), use p.adjust.method = "none".

conf.level
: confidence level of the interval.

model
: a fitted-model objects such as the result of a call to `lm()`, from which the overall degrees of freedom are to be calculated.

detailed
: logical value. Default is FALSE. If TRUE, a detailed result is shown.

emmeans.test
: an object of class `emmeans_test`.

Value

return a data frame with some the following columns:

- `.y.`: the y variable used in the test.
- `group1,group2`: the compared groups in the pairwise tests.
- `statistic`: Test statistic (t.ratio) used to compute the p-value.
- `df`: degrees of freedom.
- `p`: p-value.
- `p.adj`: the adjusted p-value.
- `method`: the statistical test used to compare groups.
- `p.signif, p.adj.signif`: the significance level of p-values and adjusted p-values, respectively.
- `estimate`: estimate of the effect size, that is the difference between the two emmeans (estimated marginal means).
- `conf.low,conf.high`: Lower and upper bound on a confidence interval of the estimate.

The **returned object has an attribute called args**, which is a list holding the test arguments. It has also an attribute named "emmeans", a data frame containing the groups emmeans.

Functions

- `get_emmeans`: returns the estimated marginal means from an object of class `emmeans_test`

Examples

```
# Data preparation
df <- ToothGrowth
df$dose <- as.factor(df$dose)

# Pairwise comparisons
res <- df %>%
```

```
  group_by(supp) %>%
  emmeans_test(len ~ dose, p.adjust.method = "bonferroni")
res

# Display estimated marginal means
attr(res, "emmeans")

# Show details
df %>%
  group_by(supp) %>%
  emmeans_test(len ~ dose, p.adjust.method = "bonferroni", detailed = TRUE)
```

`eta_squared` *Effect Size for ANOVA*

Description

Compute eta-squared and partial eta-squared for all terms in an ANOVA model.

Usage

```
eta_squared(model)

partial_eta_squared(model)
```

Arguments

`model`	an object of class aov or anova.

Value

a numeric vector with the effect size statistics

Functions

- `eta_squared`: compute eta squared
- `partial_eta_squared`: compute partial eta squared.

Examples

```
# Data preparation
df <- ToothGrowth
df$dose <- as.factor(df$dose)

# Compute ANOVA
res.aov <- aov(len ~ supp*dose, data = df)
summary(res.aov)

# Effect size
eta_squared(res.aov)
partial_eta_squared(res.aov)
```

factorial_design *Build Factorial Designs for ANOVA*

Description

Provides helper functions to build factorial design for easily computing ANOVA using the Anova() function. This might be very useful for repeated measures ANOVA, which is hard to set up with the car package.

Usage

```
factorial_design(data, dv, wid, between, within, covariate)
```

Arguments

data	a data frame containing the variables
dv	(numeric) dependent variable name.
wid	(factor) column name containing individuals/subjects identifier. Should be unique per individual.
between	(optional) between-subject factor variables.
within	(optional) within-subjects factor variables
covariate	(optional) covariate names (for ANCOVA)

Value

a list with the following components:

- **the specified arguments**: dv, wid, between, within
- **data**: the original data (long format) or independent ANOVA. The wide format is returned for repeated measures ANOVA.
- **idata**: an optional data frame giving the levels of factors defining the intra-subject model for multivariate repeated-measures data.
- **idesign**: a one-sided model formula using the "data" in idata and specifying the intra-subject design.
- **repeated**: logical. Value is TRUE when the data is a repeated design.
- **lm_formula**: the formula used to build the lm model.
- **lm_data**: the data used to build the lm model. Can be either in a long format (i.e., the original data for independent measures ANOVA) or in a wide format (case of repeated measures ANOVA).
- **model**: the lm model

Author(s)

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See Also

anova_test(), anova_summary()

Examples

```
# Load data
#:::::::::::::::::::::::::::::::::::::::
data("ToothGrowth")
df <- ToothGrowth
head(df)

# Repeated measures designs
#:::::::::::::::::::::::::::::::::::::::::
# Prepare the data
df$id <- rep(1:10, 6) # Add individuals id
head(df)
# Build factorial designs
design <- factorial_design(df, dv = len, wid = id, within = c(supp, dose))
design
# Easily perform repeated measures ANOVA using the car package
res.anova <- Anova(design$model, idata = design$idata, idesign = design$idesign, type = 3)
summary(res.anova, multivariate = FALSE)

# Independent measures designs
#:::::::::::::::::::::::::::::::::::::::::
# Build factorial designs
df$id <- 1:nrow(df)
design <- factorial_design(df, dv = len, wid = id, between = c(supp, dose))
design
# Perform ANOVA
Anova(design$model, type = 3)
```

---

fisher_test *Fisher's Exact Test for Count Data*

Description

Performs Fisher's exact test for testing the null of independence of rows and columns in a contingency table.

Wrappers around the R base function fisher.test() but have the advantage of performing pairwise and row-wise fisher tests, the post-hoc tests following a significant chi-square test of homogeneity for 2xc and rx2 contingency tables.

Usage

```
fisher_test(
  xtab,
```

```
  workspace = 2e+05,
  alternative = "two.sided",
  conf.int = TRUE,
  conf.level = 0.95,
  simulate.p.value = FALSE,
  B = 2000,
  detailed = FALSE,
  ...
)

pairwise_fisher_test(xtab, p.adjust.method = "holm", detailed = FALSE, ...)

row_wise_fisher_test(xtab, p.adjust.method = "holm", detailed = FALSE, ...)
```

Arguments

xtab	a contingency table in a matrix form.
workspace	an integer specifying the size of the workspace used in the network algorithm. In units of 4 bytes. Only used for non-simulated p-values larger than 2×2 tables. Since R version 3.5.0, this also increases the internal stack size which allows larger problems to be solved, however sometimes needing hours. In such cases, simulate.p.values=TRUE may be more reasonable.
alternative	indicates the alternative hypothesis and must be one of "two.sided", "greater" or "less". You can specify just the initial letter. Only used in the 2×2 case.
conf.int	logical indicating if a confidence interval for the odds ratio in a 2×2 table should be computed (and returned).
conf.level	confidence level for the returned confidence interval. Only used in the 2×2 case and if conf.int = TRUE.
simulate.p.value	a logical indicating whether to compute p-values by Monte Carlo simulation, in larger than 2×2 tables.
B	an integer specifying the number of replicates used in the Monte Carlo test.
detailed	logical value. Default is FALSE. If TRUE, a detailed result is shown.
...	Other arguments passed to the function fisher_test().
p.adjust.method	method to adjust p values for multiple comparisons. Used when pairwise comparisons are performed. Allowed values include "holm", "hochberg", "hommel", "bonferroni", "BH", "BY", "fdr", "none". If you don't want to adjust the p value (not recommended), use p.adjust.method = "none".

Value

return a data frame with some the following columns:

- group: the categories in the row-wise proportion tests.
- p: p-value.

- `p.adj`: the adjusted p-value.
- `method`: the used statistical test.
- `p.signif, p.adj.signif`: the significance level of p-values and adjusted p-values, respectively.
- `estimate`: an estimate of the odds ratio. Only present in the 2 by 2 case.
- `alternative`: a character string describing the alternative hypothesis.
- `conf.low,conf.high`: a confidence interval for the odds ratio. Only present in the 2 by 2 case and if argument conf.int = TRUE.

The **returned object has an attribute called args**, which is a list holding the test arguments.

Functions

- `fisher_test`: performs Fisher's exact test for testing the null of independence of rows and columns in a contingency table with fixed marginals. Wrapper around the function `fisher.test()`.
- `pairwise_fisher_test`: pairwise comparisons between proportions, a post-hoc tests following a significant Fisher's exact test of homogeneity for 2xc design.
- `row_wise_fisher_test`: performs row-wise Fisher's exact test of count data, a post-hoc tests following a significant chi-square test of homogeneity for rx2 contingency table. The test is conducted for each category (row).

Examples

```
# Comparing two proportions
#%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
# Data: frequencies of smokers between two groups
xtab <- as.table(rbind(c(490, 10), c(400, 100)))
dimnames(xtab) <- list(
  group = c("grp1", "grp2"),
  smoker = c("yes", "no")
)
xtab
# compare the proportion of smokers
fisher_test(xtab, detailed = TRUE)

# Homogeneity of proportions between groups
#%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
# H0: the proportion of smokers is similar in the four groups
# Ha:  this proportion is different in at least one of the populations.
#
# Data preparation
grp.size <- c( 106, 113, 156, 102 )
smokers  <- c( 50, 100, 139, 80 )
no.smokers <- grp.size - smokers
xtab <- as.table(rbind(
  smokers,
  no.smokers
))
```

```
dimnames(xtab) <- list(
  Smokers = c("Yes", "No"),
  Groups = c("grp1", "grp2", "grp3", "grp4")
)
xtab

# Compare the proportions of smokers between groups
fisher_test(xtab, detailed = TRUE)

# Pairwise comparison between groups
pairwise_fisher_test(xtab)


# Pairwise proportion tests
#%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
# Data: Titanic
xtab <- as.table(rbind(
  c(122, 167, 528, 673),
  c(203, 118, 178, 212)
))
dimnames(xtab) <- list(
  Survived = c("No", "Yes"),
  Class = c("1st", "2nd", "3rd", "Crew")
)
xtab
# Compare the proportion of survived between groups
pairwise_fisher_test(xtab)

# Row-wise proportion tests
#%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
# Data: Titanic
xtab <- as.table(rbind(
  c(180, 145), c(179, 106),
  c(510, 196), c(862, 23)
))
dimnames(xtab) <- list(
  Class = c("1st", "2nd", "3rd", "Crew"),
  Gender = c("Male", "Female")
)
xtab
# Compare the proportion of males and females in each category
row_wise_fisher_test(xtab)

# A r x c table  Agresti (2002, p. 57) Job Satisfaction
Job <- matrix(c(1,2,1,0, 3,3,6,1, 10,10,14,9, 6,7,12,11), 4, 4,
              dimnames = list(income = c("< 15k", "15-25k", "25-40k", "> 40k"),
                              satisfaction = c("VeryD", "LittleD", "ModerateS", "VeryS")))
fisher_test(Job)
fisher_test(Job, simulate.p.value = TRUE, B = 1e5)
```

`freq_table` *Compute Frequency Table*

Description

compute frequency table.

Usage

```
freq_table(data, ..., vars = NULL, na.rm = TRUE)
```

Arguments

`data`	a data frame
`...`	One or more unquoted expressions (or variable names) separated by commas. Used to specify variables of interest.
`vars`	optional character vector containing variable names.
`na.rm`	logical value. If TRUE (default), remove missing values in the variables used to create the frequency table.

Value

a data frame

Examples

```
data("ToothGrowth")
ToothGrowth %>% freq_table(supp, dose)
```

`friedman_effsize` *Friedman Test Effect Size (Kendall's W Value)*

Description

Compute the effect size estimate (referred to as `w`) for Friedman test: `W = X2/N(K-1)`; where `W` is the Kendall's W value; `X2` is the Friedman test statistic value; `N` is the sample size. `k` is the number of measurements per subject.

The Kendall's W coefficient assumes the value from 0 (indicating no relationship) to 1 (indicating a perfect relationship).

Kendalls uses the Cohen's interpretation guidelines of `0.1 - < 0.3` (small effect), `0.3 - < 0.5` (moderate effect) and >= `0.5` (large effect)

Confidence intervals are calculated by bootstap.

Usage

```
friedman_effsize(
  data,
  formula,
  ci = FALSE,
  conf.level = 0.95,
  ci.type = "perc",
  nboot = 1000,
  ...
)
```

Arguments

data	a data.frame containing the variables in the formula.
formula	a formula of the form a ~ b | c, where a (numeric) is the dependent variable name; b is the within-subjects factor variables; and c (factor) is the column name containing individuals/subjects identifier. Should be unique per individual.
ci	If TRUE, returns confidence intervals by bootstrap. May be slow.
conf.level	The level for the confidence interval.
ci.type	The type of confidence interval to use. Can be any of "norm", "basic", "perc", or "bca". Passed to boot::boot.ci.
nboot	The number of replications to use for bootstrap.
...	other arguments passed to the function friedman.test()

Value

return a data frame with some of the following columns:

- .y.: the y variable used in the test.
- n: Sample counts.
- effsize: estimate of the effect size.
- magnitude: magnitude of effect size.
- conf.low,conf.high: lower and upper bound of the effect size confidence interval.

References

Maciej Tomczak and Ewa Tomczak. The need to report effect size estimates revisited. An overview of some recommended measures of effect size. Trends in Sport Sciences. 2014; 1(21):19-25.

Examples

```
# Load data
#:::::::::::::::::::::::::::::::::::::::
data("ToothGrowth")
df <- ToothGrowth %>%
    filter(supp == "VC") %>%
    mutate(id = rep(1:10, 3))
```

```
head(df)

# Friedman test effect size
#:::::::::::::::::::::::::::::::::::::::::
df %>% friedman_effsize(len ~ dose | id)
```

---

friedman_test *Friedman Rank Sum Test*

Description

Provides a pipe-friendly framework to perform a Friedman rank sum test, which is the non-parametric alternative to the one-way repeated measures ANOVA test. Wrapper around the function `friedman.test()`. Read more: Friedman test in R.

Usage

```
friedman_test(data, formula, ...)
```

Arguments

`data`	a data.frame containing the variables in the formula.
`formula`	a formula of the form `a ~ b	c`, where `a` (numeric) is the dependent variable name; `b` is the within-subjects factor variables; and `c` (factor) is the column name containing individuals/subjects identifier. Should be unique per individual.
`...`	other arguments to be passed to the function `friedman.test`.

Value

return a data frame with the following columns:

- `.y.`: the y (dependent) variable used in the test.
- `n`: sample count.
- `statistic`: the value of Friedman's chi-squared statistic, used to compute the p-value.
- `p`: p-value.
- `method`: the statistical test used to compare groups.

Examples

```
# Load data
#:::::::::::::::::::::::::::::::::::::::
data("ToothGrowth")
df <- ToothGrowth %>%
    filter(supp == "VC") %>%
    mutate(id = rep(1:10, 3))
head(df)
```

```
# Friedman rank sum test
#:::::::::::::::::::::::::::::::::::::::::
df %>% friedman_test(len ~ dose | id)
```

`games_howell_test` *Games Howell Post-hoc Tests*

Description

Performs Games-Howell test, which is used to compare all possible combinations of group differences when the assumption of homogeneity of variances is violated. This post hoc test provides confidence intervals for the differences between group means and shows whether the differences are statistically significant.

The test is based on Welch's degrees of freedom correction and uses Tukey's studentized range distribution for computing the p-values. The test compares the difference between each pair of means with appropriate adjustment for the multiple testing. So there is no need to apply additional p-value corrections.

Usage

```
games_howell_test(data, formula, conf.level = 0.95, detailed = FALSE)
```

Arguments

`data`	a data.frame containing the variables in the formula.
`formula`	a formula of the form `x ~ group` where `x` is a numeric variable giving the data values and `group` is a factor with one or multiple levels giving the corresponding groups. For example, `formula = TP53 ~ cancer_group`.
`conf.level`	confidence level of the interval.
`detailed`	logical value. Default is FALSE. If TRUE, a detailed result is shown.

Details

The Games-Howell method is an improved version of the Tukey-Kramer method and is applicable in cases where the equivalence of variance assumption is violated. It is a t-test using Welch's degree of freedom. This method uses a strategy for controlling the type I error for the entire comparison and is known to maintain the preset significance level even when the size of the sample is different. However, the smaller the number of samples in each group, the it is more tolerant the type I error control. Thus, this method can be applied when the number of samples is six or more.

Value

return a data frame with some of the following columns:

- `.y.`: the y (outcome) variable used in the test.
- `group1,group2`: the compared groups in the pairwise tests.
- `n1,n2`: Sample counts.
- `estimate, conf.low, conf.high`: mean difference and its confidence intervals.
- `statistic`: Test statistic (t-value) used to compute the p-value.
- `df`: degrees of freedom calculated using Welch's correction.
- `p.adj`: adjusted p-value using Tukey's method.
- `method`: the statistical test used to compare groups.
- `p.adj.signif`: the significance level of p-values.

The **returned object has an attribute called args**, which is a list holding the test arguments.

References

- Aaron Schlege, https://rpubs.com/aaronsc32/games-howell-test.
- Sangseok Lee, Dong Kyu Lee. What is the proper way to apply the multiple comparison test?. Korean J Anesthesiol. 2018;71(5):353-360.

Examples

```
# Simple test
ToothGrowth %>% games_howell_test(len ~ dose)

# Grouped data
ToothGrowth %>%
  group_by(supp) %>%
  games_howell_test(len ~ dose)
```

`get_comparisons` *Create a List of Possible Comparisons Between Groups*

Description

Create a list of possible pairwise comparisons between groups. If a reference group is specified, only comparisons against reference will be kept.

Usage

```
get_comparisons(data, variable, ref.group = NULL)
```

Arguments

`data`	a data frame
`variable`	the grouping variable name. Can be unquoted.
`ref.group`	a character string specifying the reference group. Can be unquoted. If numeric, then it should be quoted. If specified, for a given grouping variable, each of the group levels will be compared to the reference group (i.e. control group). If `ref.group = "all"`, pairwise comparisons are performed between each grouping variable levels against all (i.e. basemean).

Value

a list of all possible pairwise comparisons.

Examples

```
# All possible pairwise comparisons
ToothGrowth %>%
  get_comparisons("dose")

# Comparisons against reference groups
ToothGrowth %>%
  get_comparisons("dose", ref.group = "0.5")

# Comparisons against  all (basemean)
ToothGrowth %>%
  get_comparisons("dose", ref.group = "all")
```

---

get_mode   *Compute Mode*

Description

Compute the mode in a given vector. Mode is the most frequent value.

Usage

```
get_mode(x)
```

Arguments

`x`	a vector. Can be numeric, factor or character vector.

Examples

```
# Mode of numeric vector
x <- c(1:5, 6, 6, 7:10)
get_mode(x)

# Bimodal
x <- c(1:5, 6, 6, 7, 8, 9, 9, 10)
get_mode(x)

# No mode
x <- c(1, 2, 3, 4, 5)
get_mode(x)

# Nominal vector
fruits <-  c(rep("orange", 10), rep("apple", 5), rep("lemon", 2))
get_mode(fruits)
```

---

get_pwc_label *Extract Label Information from Statistical Tests*

Description

Extracts label information from statistical tests. Useful for labelling plots with test outputs.

Usage

```
get_pwc_label(stat.test, type = c("expression", "text"))

get_test_label(
  stat.test,
  description = NULL,
  p.col = "p",
  type = c("expression", "text"),
  correction = c("auto", "GG", "HF", "none"),
  row = NULL,
  detailed = FALSE
)

create_test_label(
  statistic.text,
  statistic,
  p,
  parameter = NA,
  description = NULL,
  n = NA,
  effect.size = NA,
  effect.size.text = NA,
```

```
  type = c("expression", "text"),
  detailed = FALSE
)

get_n(stat.test)

get_description(stat.test)
```

Arguments

- `stat.test` — statistical test results returned by `rstatix` functions.
- `type` — the label type. Can be one of "text" and "expression". Partial match allowed. If you want to add the label onto a ggplot, it might be useful to specify `type = "expresion"`.
- `description` — the test description used as the prefix of the label. Examples of description are "ANOVA", "Two Way ANOVA". To remove the default description, specify `description = NULL`. If missing, we'll try to guess the statistical test default description.
- `p.col` — character specifying the column containing the p-value. Default is `"p"`, can be `"p.adj"`.
- `correction` — character, considered only in the case of ANOVA test. Which sphericity correction of the degrees of freedom should be reported for the within-subject factors (repeated measures). The default is set to `"GG"` corresponding to the Greenhouse-Geisser correction. Possible values are `"GG"`, `"HF"` (i.e., Hyunh-Feldt correction), `"none"` (i.e., no correction) and `"auto"` (apply automatically GG correction if the sphericity assumption is not for within-subject design.
- `row` — numeric, the row index to be considered. If NULL, the last row is automatically considered for ANOVA test.
- `detailed` — logical value. If TRUE, returns detailed label.
- `statistic.text` — character specifying the test statistic. For example `statistic.text = "F"` (for ANOVA test); `statistic.text = "t"` (for t-test).
- `statistic` — the numeric value of a statistic.
- `p` — the p-value of the test.
- `parameter` — string containing the degree of freedom (if exists). Default is `NA` to accommodate non-parametric tests. For example `parameter = "1,9"` (for ANOVA test. Two parameters exist: DFn and DFd); `sparameter = "9"` (for t-test).
- `n` — sample count, example: `n = 10`.
- `effect.size` — the effect size value
- `effect.size.text` — a character specifying the relevant effect size. For example, for `Cohens d` statistic, `effect.size.text = "d"`. You can also use plotmath expression as follow `quote(italic("d"))`.

Value

a text label or an expression to pass to a plotting function.

Functions

- `get_pwc_label`: Extract label from pairwise comparisons.
- `get_test_label`: Extract labels for statistical tests.
- `create_test_label`: Create labels from user specified test results.
- `get_n`: Extracts sample counts (n) from an rstatix test outputs. Returns a numeric vector.
- `get_description`: Extracts the description of an rstatix test outputs. Returns a character vector.

Examples

```
# Load data
#:::::::::::::::::::::::::::::::::::::::
data("ToothGrowth")
df <- ToothGrowth

# One-way ANOVA test
#:::::::::::::::::::::::::::::::::::::::::
anov <- df %>% anova_test(len ~ dose)
get_test_label(anov, detailed = TRUE, type = "text")

# Two-way ANOVA test
#:::::::::::::::::::::::::::::::::::::::::
anov <- df %>% anova_test(len ~ supp*dose)
get_test_label(anov, detailed = TRUE, type = "text",
   description = "Two Way ANOVA")


# Kruskal-Wallis test
#:::::::::::::::::::::::::::::::::::::::::
kruskal<- df %>% kruskal_test(len ~ dose)
get_test_label(kruskal, detailed = TRUE, type = "text")

# Wilcoxon test
#:::::::::::::::::::::::::::::::::::::::::
# Unpaired test
wilcox <- df %>% wilcox_test(len ~ supp)
get_test_label(wilcox, detailed = TRUE, type = "text")
# Paired test
wilcox <- df %>% wilcox_test(len ~ supp, paired = TRUE)
get_test_label(wilcox, detailed = TRUE, type = "text")

# T test
#:::::::::::::::::::::::::::::::::::::::::
ttest <- df %>% t_test(len ~ dose)
get_test_label(ttest, detailed = TRUE, type = "text")


# Pairwise comparisons labels
#:::::::::::::::::::::::::::::::::::::::::
get_pwc_label(ttest, type = "text")
```

```
# Create test labels
#::::::::::::::::::::::::::::::::::::::::
create_test_label(
  statistic.text = "F", statistic = 71.82,
  parameter = "4, 294",
  p = "<0.0001",
  description = "ANOVA",
  type = "text"
)


# Extract infos
#::::::::::::::::::::::::::::::::::::::::
stat.test <- df %>% t_test(len ~ dose)
get_n(stat.test)
get_description(stat.test)
```

`get_summary_stats` *Compute Summary Statistics*

Description

Compute summary statistics for one or multiple numeric variables.

Usage

```
get_summary_stats(
  data,
  ...,
  type = c("full", "common", "robust", "five_number", "mean_sd", "mean_se", "mean_ci",
    "median_iqr", "median_mad", "quantile", "mean", "median", "min", "max"),
  show = NULL,
  probs = seq(0, 1, 0.25)
)
```

Arguments

`data`	a data frame
`...`	(optional) One or more unquoted expressions (or variable names) separated by commas. Used to select a variable of interest. If no variable is specified, then the summary statistics of all numeric variables in the data frame is computed.
`type`	type of summary statistics. Possible values include: `"full"`,`"common"`, `"robust"`, `"five_number"`, `"mean_sd"`, `"mean_se"`, `"mean_ci"`,`"median_iqr"`, `"median_mad"`, `"quantile"`, `"mean"`, `"median"`, `"min"`, `"max"`

show — a character vector specifying the summary statistics you want to show. Example: `show = c("n", "mean", "sd")`. This is used to filter the output after computation.

probs — numeric vector of probabilities with values in [0,1]. Used only when type = "quantile".

Value

A data frame containing descriptive statistics, such as:

- **n**: the number of individuals
- **min**: minimum
- **max**: maximum
- **median**: median
- **mean**: mean
- **q1, q3**: the first and the third quartile, respectively.
- **iqr**: interquartile range
- **mad**: median absolute deviation (see ?MAD)
- **sd**: standard deviation of the mean
- **se**: standard error of the mean
- **ci**: 95 percent confidence interval of the mean

Examples

```
# Full summary statistics
data("ToothGrowth")
ToothGrowth %>% get_summary_stats(len)

# Summary statistics of grouped data
# Show only common summary
ToothGrowth %>%
  group_by(dose, supp) %>%
  get_summary_stats(len, type = "common")

# Robust summary statistics
ToothGrowth %>% get_summary_stats(len, type = "robust")

# Five number summary statistics
ToothGrowth %>% get_summary_stats(len, type = "five_number")

# Compute only mean and sd
ToothGrowth %>% get_summary_stats(len, type = "mean_sd")

# Compute full summary statistics but show only mean, sd, median, iqr
ToothGrowth %>%
    get_summary_stats(len, show = c("mean", "sd", "median", "iqr"))
```

get_y_position *Autocompute P-value Positions For Plotting Significance*

Description

Compute p-value x and y positions for plotting significance levels. Many examples are provided at :

- How to Add P-Values onto a Grouped GGPLOT using the GGPUBR R Package
- How to Add Adjusted P-values to a Multi-Panel GGPlot
- How to Add P-Values Generated Elsewhere to a GGPLOT

Usage

```
get_y_position(
  data,
  formula,
  fun = "max",
  ref.group = NULL,
  comparisons = NULL,
  step.increase = 0.12,
  y.trans = NULL,
  stack = FALSE,
  scales = c("fixed", "free", "free_y")
)

add_y_position(
  test,
  fun = "max",
  step.increase = 0.12,
  data = NULL,
  formula = NULL,
  ref.group = NULL,
  comparisons = NULL,
  y.trans = NULL,
  stack = FALSE,
  scales = c("fixed", "free", "free_y")
)

add_x_position(test, x = NULL, group = NULL, dodge = 0.8)

add_xy_position(
  test,
  x = NULL,
  group = NULL,
  dodge = 0.8,
```

```
  stack = FALSE,
  fun = "max",
  step.increase = 0.12,
  scales = c("fixed", "free", "free_y"),
  ...
)
```

Arguments

data
: a data.frame containing the variables in the formula.

formula
: a formula of the form `x ~ group` where `x` is a numeric variable giving the data values and `group` is a factor with one or multiple levels giving the corresponding groups. For example, `formula = TP53 ~ cancer_group`.

fun
: summary statistics functions used to compute automatically suitable y positions of p-value labels and brackets. Possible values include: `"max"`, `"mean"`, `"mean_sd"`, `"mean_se"`, `"mean_ci"`, `"median"`, `"median_iqr"`, `"median_mad"`.

  For example, if `fun = "max"`, the y positions are guessed as follow:

  - 1. Compute the maximum of each group (groups.maximum)
  - 2. Use the highest groups maximum as the first bracket y position
  - 3. Add successively a step increase for remaining bracket y positions.

  When the main plot is a boxplot, you need the option `fun = "max"`, to have the p-value bracket displayed at the maximum point of the group.

  In some situations the main plot is a line plot or a barplot showing the `mean+/-error bars` of the groups, where error can be SE (standard error), SD (standard deviation) or CI (confidence interval). In this case, to correctly compute the bracket y position you need the option `fun = "mean_se"`, etc.

ref.group
: a character string specifying the reference group. If specified, for a given grouping variable, each of the group levels will be compared to the reference group (i.e. control group).

comparisons
: A list of length-2 vectors specifying the groups of interest to be compared. For example to compare groups "A" vs "B" and "B" vs "C", the argument is as follow: `comparisons = list(c("A", "B"), c("B","C"))`

step.increase
: numeric vector with the increase in fraction of total height for every additional comparison to minimize overlap.

y.trans
: a function for transforming y axis scale. Value can be `log2`, `log10` and `sqrt`. Can be also any custom function that can take a numeric vector as input and returns a numeric vector, example: `y.trans = function(x){log2(x+1)}`

stack
: logical. If TRUE, computes y position for a stacked plot. Useful when dealing with stacked bar plots.

scales
: Should scales be fixed (`"fixed"`, the default), free (`"free"`), or free in one dimension (`"free_y"`)?. This option is considered only when determining the y position. If the specified value is `"free"` or `"free_y"`, then the step increase of y positions will be calculated by plot panels. Note that, using `"free"` or `"free_y"` gives the same result. A global step increase is computed when `scales = "fixed"`.

test	an object of class rstatix_test as returned by t_test(), wilcox_test(), sign_test(), tukey_hsd(), dunn_test().
x	variable on x axis.
group	group variable (legend variable).
dodge	dodge width for grouped ggplot/test. Default is 0.8. Used only when x specified.
...	other arguments to be passed to the function t.test.

Functions

- get_y_position: compute the p-value y positions
- add_y_position: add p-value y positions to an object of class rstatix_test
- add_x_position: compute and add p-value x positions.
- add_xy_position: compute and add both x and y positions.

Examples

```
# Data preparation
#:::::::::::::::::::::::::::::::::::
df <- ToothGrowth
df$dose <- as.factor(df$dose)
df$group <- factor(rep(c(1, 2), 30))
head(df)

# Stat tests
#:::::::::::::::::::::::::::::::::::
stat.test <- df %>%
  t_test(len ~ dose)
stat.test

# Add the test into box plots
#:::::::::::::::::::::::::::::::::::
stat.test <- stat.test %>%
  add_y_position()

 if(require("ggpubr")){
   ggboxplot(df, x = "dose", y = "len") +
     stat_pvalue_manual(stat.test, label = "p.adj.signif", tip.length = 0.01)
  }
```

---

identify_outliers   *Identify Univariate Outliers Using Boxplot Methods*

Description

Detect outliers using boxplot methods. Boxplots are a popular and an easy method for identifying outliers. There are two categories of outlier: (1) outliers and (2) extreme points.

Values above `Q3 + 1.5xIQR` or below `Q1 - 1.5xIQR` are considered as outliers. Values above `Q3 + 3xIQR` or below `Q1 - 3xIQR` are considered as extreme points (or extreme outliers).

Q1 and Q3 are the first and third quartile, respectively. IQR is the interquartile range (IQR = Q3 - Q1).

Generally speaking, data points that are labelled outliers in boxplots are not considered as troublesome as those considered extreme points and might even be ignored. Note that, any `NA` and `NaN` are automatically removed before the quantiles are computed.

Usage

```
identify_outliers(data, ..., variable = NULL)

is_outlier(x, coef = 1.5)

is_extreme(x)
```

Arguments

`data`	a data frame
`...`	One unquoted expressions (or variable name). Used to select a variable of interest. Alternative to the argument `variable`.
`variable`	variable name for detecting outliers
`x`	a numeric vector
`coef`	coefficient specifying how far the outlier should be from the edge of their box. Possible values are 1.5 (for outlier) and 3 (for extreme points only). Default is 1.5

Value

- `identify_outliers()`. Returns the input data frame with two additional columns: "is.outlier" and "is.extreme", which hold logical values.
- `is_outlier()` and `is_extreme()`. Returns logical vectors.

Functions

- `identify_outliers`: takes a data frame and extract rows suspected as outliers according to a numeric column. The following columns are added "is.outlier" and "is.extreme".
- `is_outlier`: detect outliers in a numeric vector. Returns logical vector.
- `is_extreme`: detect extreme points in a numeric vector. An alias of `is_outlier()`, where coef = 3. Returns logical vector.

Examples

```
# Generate a demo data
set.seed(123)
demo.data <- data.frame(
  sample = 1:20,
  score = c(rnorm(19, mean = 5, sd = 2), 50),
  gender = rep(c("Male", "Female"), each = 10)
)

# Identify outliers according to the variable score
demo.data %>%
  identify_outliers(score)

# Identify outliers by groups
demo.data %>%
  group_by(gender) %>%
  identify_outliers("score")
```

---

kruskal_effsize *Kruskal-Wallis Effect Size*

Description

Compute the effect size for Kruskal-Wallis test as the eta squared based on the H-statistic: `eta2[H] = (H - k + 1)/(n - k)`; where `H` is the value obtained in the Kruskal-Wallis test; `k` is the number of groups; `n` is the total number of observations.

The eta-squared estimate assumes values from 0 to 1 and multiplied by 100 indicates the percentage of variance in the dependent variable explained by the independent variable. The interpretation values commonly in published litterature are: `0.01- < 0.06` (small effect), `0.06 - < 0.14` (moderate effect) and `>= 0.14` (large effect).

Confidence intervals are calculated by bootstap.

Usage

```
kruskal_effsize(
  data,
  formula,
  ci = FALSE,
  conf.level = 0.95,
  ci.type = "perc",
  nboot = 1000
)
```

Arguments

data	a data.frame containing the variables in the formula.

formula	a formula of the form x ~ group where x is a numeric variable giving the data values and group is a factor with one or multiple levels giving the corresponding groups. For example, formula = TP53 ~ cancer_group.
ci	If TRUE, returns confidence intervals by bootstrap. May be slow.
conf.level	The level for the confidence interval.
ci.type	The type of confidence interval to use. Can be any of "norm", "basic", "perc", or "bca". Passed to boot::boot.ci.
nboot	The number of replications to use for bootstrap.

Value

return a data frame with some of the following columns:

- .y.: the y variable used in the test.
- n: Sample counts.
- effsize: estimate of the effect size.
- magnitude: magnitude of effect size.
- conf.low,conf.high: lower and upper bound of the effect size confidence interval.

References

Maciej Tomczak and Ewa Tomczak. The need to report effect size estimates revisited. An overview of some recommended measures of effect size. Trends in Sport Sciences. 2014; 1(21):19-25.

http://imaging.mrc-cbu.cam.ac.uk/statswiki/FAQ/effectSize

http://www.psy.gla.ac.uk/~steve/best/effect.html

Examples

```
# Load data
#:::::::::::::::::::::::::::::::::::::::
data("ToothGrowth")
df <- ToothGrowth

# Kruskal-wallis rank sum test
#:::::::::::::::::::::::::::::::::::::::::
df %>% kruskal_effsize(len ~ dose)

# Grouped data
df %>%
  group_by(supp) %>%
  kruskal_effsize(len ~ dose)
```

kruskal_test *Kruskal-Wallis Test*

Description

Provides a pipe-friendly framework to perform Kruskal-Wallis rank sum test. Wrapper around the function `kruskal.test()`.

Usage

```
kruskal_test(data, formula, ...)
```

Arguments

`data`	a data.frame containing the variables in the formula.
`formula`	a formula of the form `x ~ group` where `x` is a numeric variable giving the data values and `group` is a factor with one or multiple levels giving the corresponding groups. For example, `formula = TP53 ~ cancer_group`.
`...`	other arguments to be passed to the function `kruskal.test`.

Value

return a data frame with the following columns:

- `.y.`: the y variable used in the test.
- `n`: sample count.
- `statistic`: the kruskal-wallis rank sum statistic used to compute the p-value.
- `p`: p-value.
- `method`: the statistical test used to compare groups.

Examples

```
# Load data
#:::::::::::::::::::::::::::::::::::::::
data("ToothGrowth")
df <- ToothGrowth

# Kruskal-wallis rank sum test
#:::::::::::::::::::::::::::::::::::::::::
df %>% kruskal_test(len ~ dose)

# Grouped data
df %>%
  group_by(supp) %>%
  kruskal_test(len ~ dose)
```

levene_test *Levene's Test*

Description

Provide a pipe-friendly framework to easily compute Levene's test for homogeneity of variance across groups.

Wrapper around the function leveneTest(), which can additionally handles a grouped data.

Usage

```
levene_test(data, formula, center = median)
```

Arguments

data	a data frame for evaluating the formula or a model
formula	a formula
center	The name of a function to compute the center of each group; mean gives the original Levene's test; the default, median, provides a more robust test.

Value

a data frame with the following columns: df1, df2 (df.residual), statistic and p.

Examples

```
# Prepare the data
data("ToothGrowth")
df <- ToothGrowth
df$dose <- as.factor(df$dose)
# Compute Levene's Test
df %>% levene_test(len ~ dose)

# Grouped data
df %>%
  group_by(supp) %>%
  levene_test(len ~ dose)
```

mahalanobis_distance *Compute Mahalanobis Distance and Flag Multivariate Outliers*

Description

Pipe-friendly wrapper around to the function mahalanobis(), which returns the squared Mahalanobis distance of all rows in x. Compared to the base function, it automatically flags multivariate outliers.

Mahalanobis distance is a common metric used to identify multivariate outliers. The larger the value of Mahalanobis distance, the more unusual the data point (i.e., the more likely it is to be a multivariate outlier).

The distance tells us how far an observation is from the center of the cloud, taking into account the shape (covariance) of the cloud as well.

To detect outliers, the calculated Mahalanobis distance is compared against a chi-square (X^2) distribution with degrees of freedom equal to the number of dependent (outcome) variables and an alpha level of 0.001.

The threshold to declare a multivariate outlier is determined using the function `qchisq(0.999, df)` , where df is the degree of freedom (i.e., the number of dependent variable used in the computation).

Usage

```
mahalanobis_distance(data, ...)
```

Arguments

`data`	a data frame. Columns are variables.
`...`	One unquoted expressions (or variable name). Used to select a variable of interest. Can be also used to ignore a variable that are not needed for the computation. For example specify `-id` to ignore the id column.

Value

Returns the input data frame with two additional columns: 1) "mahal.dist": Mahalanobis distance values; and 2) "is.outlier": logical values specifying whether a given observation is a multivariate outlier

Examples

```
# Compute mahalonobis distance and flag outliers if any
iris %>%
  doo(~mahalanobis_distance(.))

# Compute distance by groups and filter outliers
iris %>%
 group_by(Species) %>%
```

```
doo(~mahalanobis_distance(.)) %>%
filter(is.outlier == TRUE)
```

---

make_clean_names *Make Clean Names*

Description

Pipe-friendly function to make syntactically valid names out of character vectors.

Usage

```
make_clean_names(data)
```

Arguments

data	a data frame or vector

Value

a data frame or a vector depending on the input data

Examples

```
# Vector
make_clean_names(c("a and b", "a-and-b"))
make_clean_names(1:10)

# data frame
df <- data.frame(
`a and b` = 1:4,
`c and d` = 5:8,
 check.names = FALSE
)
df
make_clean_names(df)
```

mcnemar_test *McNemar's Chi-squared Test for Count Data*

Description

Performs McNemar chi-squared test to compare paired proportions.

Wrappers around the R base function mcnemar.test(), but provide pairwise comparisons between multiple groups

Usage

```
mcnemar_test(x, y = NULL, correct = TRUE)

pairwise_mcnemar_test(
  data,
  formula,
  type = c("mcnemar", "exact"),
  correct = TRUE,
  p.adjust.method = "bonferroni"
)
```

Arguments

x	either a two-dimensional contingency table in matrix form, or a factor object.
y	a factor object; ignored if x is a matrix.
correct	a logical indicating whether to apply continuity correction when computing the test statistic.
data	a data frame containing the variables in the formula.
formula	a formula of the form a ~ b | c, where a is the outcome variable name; b is the within-subjects factor variables; and c (factor) is the column name containing individuals/subjects identifier. Should be unique per individual.
type	type of statistical tests used for pairwise comparisons. Allowed values are one of c("mcnemar", "exact").
p.adjust.method	method to adjust p values for multiple comparisons. Used when pairwise comparisons are performed. Allowed values include "holm", "hochberg", "hommel", "bonferroni", "BH", "BY", "fdr", "none". If you don't want to adjust the p value (not recommended), use p.adjust.method = "none".

Value

return a data frame with the following columns:

- n: the number of participants.
- statistic: the value of McNemar's statistic.

- df the degrees of freedom of the approximate chi-squared distribution of the test statistic.
- p: p-value.
- p.adj: the adjusted p-value.
- method: the used statistical test.
- p.signif: the significance level of p-values.

The **returned object has an attribute called args**, which is a list holding the test arguments.

Functions

- mcnemar_test: performs McNemar's chi-squared test for comparing two paired proportions
- pairwise_mcnemar_test: performs pairwise McNemar's chi-squared test between multiple groups. Could be used for post-hoc tests following a significant Cochran's Q test.

Examples

```
# Comparing two paired proportions
#%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
# Data: frequencies of smokers before and after interventions
xtab <- as.table(
  rbind(c(25, 6), c(21,10))
)
dimnames(xtab) <- list(
  before = c("non.smoker", "smoker"),
  after = c("non.smoker", "smoker")
)
xtab

# Compare the proportion of smokers
mcnemar_test(xtab)

# Comparing multiple related proportions
# %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
# Generate a demo data
mydata <- data.frame(
  outcome = c(0,1,1,0,0,1,0,1,1,1,1,1,0,0,1,1,0,1,0,1,1,0,0,1,0,1,1,0,0,1),
  treatment = gl(3,1,30,labels=LETTERS[1:3]),
  participant = gl(10,3,labels=letters[1:10])
)
mydata$outcome <- factor(
  mydata$outcome, levels = c(1, 0),
  labels = c("success", "failure")
  )
# Cross-tabulation
xtabs(~outcome + treatment, mydata)

# Compare the proportion of success between treatments
cochran_qtest(mydata, outcome ~ treatment|participant)

# pairwise comparisons between groups
```

```
pairwise_mcnemar_test(mydata, outcome ~ treatment|participant)
```

---

multinom_test *Exact Multinomial Test*

Description

Performs an exact multinomial test. Alternative to the chi-square test of goodness-of-fit-test when the sample size is small.

Usage

```
multinom_test(x, p = rep(1/length(x), length(x)), detailed = FALSE)
```

Arguments

x	numeric vector containing the counts.
p	a vector of probabilities of success. The length of p must be the same as the number of groups specified by x, and its elements must be greater than 0 and less than 1.
detailed	logical value. Default is FALSE. If TRUE, a detailed result is shown.

Value

return a data frame containing the p-value and its significance.

The **returned object has an attribute called args**, which is a list holding the test arguments.

See Also

binom_test

Examples

```
# Data
tulip <- c(red = 81, yellow = 50, white = 27)

# Question 1: are the color equally common ?
#%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
# this is a test of homogeneity
res <- multinom_test(tulip)
res

attr(res, "descriptives")

# Pairwise comparisons between groups
pairwise_binom_test(tulip, p.adjust.method = "bonferroni")
```

```
# Question 2: comparing observed to expected proportions
#%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
# this is a goodness-of-fit test
expected.p <- c(red = 0.5, yellow = 0.33, white = 0.17)
res <- multinom_test(tulip, expected.p)
res
attr(res, "descriptives")

# Pairwise comparisons against a given probabilities
pairwise_binom_test_against_p(tulip, expected.p)
```

---

prop_test *Proportion Test*

Description

Performs proportion tests to either evaluate the homogeneity of proportions (probabilities of success) in several groups or to test that the proportions are equal to certain given values.

Wrappers around the R base function `prop.test()` but have the advantage of performing pairwise and row-wise z-test of two proportions, the post-hoc tests following a significant chi-square test of homogeneity for 2xc and rx2 contingency tables.

Usage

```
prop_test(
  x,
  n,
  p = NULL,
  alternative = c("two.sided", "less", "greater"),
  correct = TRUE,
  conf.level = 0.95,
  detailed = FALSE
)

pairwise_prop_test(xtab, p.adjust.method = "holm", ...)

row_wise_prop_test(xtab, p.adjust.method = "holm", detailed = FALSE, ...)
```

Arguments

x	a vector of counts of successes, a one-dimensional table with two entries, or a two-dimensional table (or matrix) with 2 columns, giving the counts of successes and failures, respectively.
n	a vector of counts of trials; ignored if x is a matrix or a table.
p	a vector of probabilities of success. The length of p must be the same as the number of groups specified by x, and its elements must be greater than 0 and less than 1.

`alternative`	a character string specifying the alternative hypothesis, must be one of `"two.sided"` (default), `"greater"` or `"less"`. You can specify just the initial letter. Only used for testing the null that a single proportion equals a given value, or that two proportions are equal; ignored otherwise.
`correct`	a logical indicating whether Yates' continuity correction should be applied where possible.
`conf.level`	confidence level of the returned confidence interval. Must be a single number between 0 and 1. Only used when testing the null that a single proportion equals a given value, or that two proportions are equal; ignored otherwise.
`detailed`	logical value. Default is FALSE. If TRUE, a detailed result is shown.
`xtab`	a cross-tabulation (or contingency table) with two columns and multiple rows (rx2 design). The columns give the counts of successes and failures respectively.
`p.adjust.method`	method to adjust p values for multiple comparisons. Used when pairwise comparisons are performed. Allowed values include "holm", "hochberg", "hommel", "bonferroni", "BH", "BY", "fdr", "none". If you don't want to adjust the p value (not recommended), use p.adjust.method = "none".
`...`	Other arguments passed to the function `prop_test()`.

Value

return a data frame with some the following columns:

- `n`: the number of participants.
- `group`: the categories in the row-wise proportion tests.
- `statistic`: the value of Pearson's chi-squared test statistic.
- `df`: the degrees of freedom of the approximate chi-squared distribution of the test statistic.
- `p`: p-value.
- `p.adj`: the adjusted p-value.
- `method`: the used statistical test.
- `p.signif, p.adj.signif`: the significance level of p-values and adjusted p-values, respectively.
- `estimate`: a vector with the sample proportions x/n.
- `estimate1, estimate2`: the proportion in each of the two populations.
- `alternative`: a character string describing the alternative hypothesis.
- `conf.low,conf.high`: Lower and upper bound on a confidence interval. a confidence interval for the true proportion if there is one group, or for the difference in proportions if there are 2 groups and p is not given, or NULL otherwise. In the cases where it is not NULL, the returned confidence interval has an asymptotic confidence level as specified by conf.level, and is appropriate to the specified alternative hypothesis.

The **returned object has an attribute called args**, which is a list holding the test arguments.

Functions

- prop_test: performs one-sample and two-samples z-test of proportions. Wrapper around the function prop.test().
- pairwise_prop_test: pairwise comparisons between proportions, a post-hoc tests following a significant chi-square test of homogeneity for 2xc design. Wrapper around pairwise.prop.test()
- row_wise_prop_test: performs row-wise z-test of two proportions, a post-hoc tests following a significant chi-square test of homogeneity for rx2 contingency table. The z-test of two proportions is calculated for each category (row).

Examples

```
# Comparing an observed proportion to an expected proportion
#%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
prop_test(x = 95, n = 160, p = 0.5, detailed = TRUE)

# Comparing two proportions
#%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
# Data: frequencies of smokers between two groups
xtab <- as.table(rbind(c(490, 10), c(400, 100)))
dimnames(xtab) <- list(
  group = c("grp1", "grp2"),
  smoker = c("yes", "no")
)
xtab
# compare the proportion of smokers
prop_test(xtab, detailed = TRUE)

# Homogeneity of proportions between groups
#%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
# H0: the proportion of smokers is similar in the four groups
# Ha:  this proportion is different in at least one of the populations.
#
# Data preparation
grp.size <- c( 106, 113, 156, 102 )
smokers  <- c( 50, 100, 139, 80 )
no.smokers <- grp.size - smokers
xtab <- as.table(rbind(
  smokers,
  no.smokers
))
dimnames(xtab) <- list(
  Smokers = c("Yes", "No"),
  Groups = c("grp1", "grp2", "grp3", "grp4")
)
xtab

# Compare the proportions of smokers between groups
prop_test(xtab, detailed = TRUE)

# Pairwise comparison between groups
pairwise_prop_test(xtab)
```

```
# Pairwise proportion tests
#%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
# Data: Titanic
xtab <- as.table(rbind(
  c(122, 167, 528, 673),
  c(203, 118, 178, 212)
))
dimnames(xtab) <- list(
  Survived = c("No", "Yes"),
  Class = c("1st", "2nd", "3rd", "Crew")
)
xtab
# Compare the proportion of survived between groups
pairwise_prop_test(xtab)

# Row-wise proportion tests
#%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
# Data: Titanic
xtab <- as.table(rbind(
  c(180, 145), c(179, 106),
  c(510, 196), c(862, 23)
))
dimnames(xtab) <- list(
  Class = c("1st", "2nd", "3rd", "Crew"),
  Gender = c("Male", "Female")
)
xtab
# Compare the proportion of males and females in each category
row_wise_prop_test(xtab)
```

---

prop_trend_test *Test for Trend in Proportions*

Description

Performs chi-squared test for trend in proportion. This test is also known as Cochran-Armitage trend test.

Wrappers around the R base function `prop.trend.test()` but returns a data frame for easy data visualization.

Usage

```
prop_trend_test(xtab, score = NULL)
```

Arguments

xtab	a cross-tabulation (or contingency table) with two columns and multiple rows (rx2 design). The columns give the counts of successes and failures respectively.
score	group score. If NULL, the default is group number.

Value

return a data frame with some the following columns:

- `n`: the number of participants.
- `statistic`: the value of Chi-squared trend test statistic.
- `df`: the degrees of freedom.
- `p`: p-value.
- `method`: the used statistical test.
- `p.signif`: the significance level of p-values and adjusted p-values, respectively.

The **returned object has an attribute called args**, which is a list holding the test arguments.

Examples

```
# Proportion of renal stone (calculi) across age
#%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
# Data
xtab <- as.table(rbind(
  c(384, 536, 335),
  c(951, 869, 438)
))
dimnames(xtab) <- list(
  stone = c("yes", "no"),
  age = c("30-39", "40-49", "50-59")
)
xtab
# Compare the proportion of survived between groups
prop_trend_test(xtab)
```

---

pull_triangle *Pull Lower and Upper Triangular Part of a Matrix*

Description

Returns the lower or the upper triangular part of a (correlation) matrix.

Usage

```
pull_triangle(x, triangle = c("lower", "upper"), diagonal = FALSE)

pull_upper_triangle(x, diagonal = FALSE)

pull_lower_triangle(x, diagonal = FALSE)
```

Arguments

x	a (correlation) matrix
triangle	the triangle to pull. Allowed values are one of "upper" and "lower".
diagonal	logical. Default is FALSE. If TRUE, the matrix diagonal is included.

Value

an object of class cor_mat_tri, which is a data frame

Functions

- pull_triangle: returns either the lower or upper triangular part of a matrix.
- pull_upper_triangle: returns an object of class upper_tri, which is a data frame containing the upper triangular part of a matrix.
- pull_lower_triangle: returns an object of class lower_tri, which is a data frame containing the lower triangular part of a matrix.

See Also

replace_triangle()

Examples

```
# Data preparation
#:::::::::::::::::::::::::::::::::::::::::::
mydata <- mtcars %>%
  select(mpg, disp, hp, drat, wt, qsec)
head(mydata, 3)

# Compute correlation matrix and pull triangles
#:::::::::::::::::::::::::::::::::::::::::::
# Correlation matrix
cor.mat <- cor_mat(mydata)
cor.mat

# Pull lower triangular part
cor.mat %>% pull_lower_triangle()

# Pull upper triangular part
cor.mat %>% pull_upper_triangle()
```

p_round *Rounding and Formatting p-values*

Description

Round and format p-values. Can also mark significant p-values with stars.

Usage

```
p_round(x, ..., digits = 3)

p_format(
  x,
  ...,
  new.col = FALSE,
  digits = 2,
  accuracy = 1e-04,
  decimal.mark = ".",
  leading.zero = TRUE,
  trailing.zero = FALSE,
  add.p = FALSE,
  space = FALSE
)

p_mark_significant(
  x,
  ...,
  new.col = FALSE,
  cutpoints = c(0, 1e-04, 0.001, 0.01, 0.05, 1),
  symbols = c("****", "***", "**", "*", "")
)

p_detect(data, type = c("all", "p", "p.adj"))

p_names()

p_adj_names()
```

Arguments

`x`	a numeric vector of p-values or a data frame containing a p value column. If data frame, the p-value column(s) will be automatically detected. Known p-value column names can be obtained using the functions `p_names()` and `p_adj_names()`
`...`	column names to manipulate in the case where `x` is a data frame. P value columns are automatically detected if not specified.
`digits`	the number of significant digits to be used.

new.col	logical, used only when x is a data frame. If TRUE, add a new column to hold the results. The new column name is created by adding, to the p column, the suffix "format" (for p_format()), "signif" (for p_mak_significant()).
accuracy	number to round to, that is the threshold value above wich the function will replace the pvalue by "<0.0xxx".
decimal.mark	the character to be used to indicate the numeric decimal point.
leading.zero	logical. If FALSE, remove the leading zero.
trailing.zero	logical. If FALSE (default), remove the training extra zero.
add.p	logical value. If TRUE, add "p=" before the value.
space	logical. If TRUE (default) use space as separator between different elements and symbols.
cutpoints	numeric vector used for intervals
symbols	character vector, one shorter than cutpoints, used as significance symbols.
data	a data frame
type	the type of p-value to detect. Can be one of c("all", "p", "p.adj").

Value

a vector or a data frame containing the rounded/formatted p-values.

Functions

- p_round: round p-values
- p_format: format p-values. Add a symbol "<" for small p-values.
- p_mark_significant: mark p-values with significance levels
- p_detect: detects and returns p-value column names in a data frame.
- p_names: returns known p-value column names
- p_adj_names: returns known adjust p-value column names

Examples

```
# Round and format a vector of p-values
# ::::::::::::::::::::::::::::::::::::::::::
# Format
p <- c(0.5678, 0.127, 0.045, 0.011, 0.009, 0.00002, NA)
p_format(p)

# Specify the accuracy
p_format(p, accuracy = 0.01)

# Add p and remove the leading zero
p_format(p, add.p = TRUE, leading.zero = FALSE)

# Remove space before and after "=" or "<".
p_format(p, add.p = TRUE, leading.zero = FALSE, space = FALSE)
```

```
# Mark significant p-values
# :::::::::::::::::::::::::::::::::::::::::::
p_mark_significant(p)

# Round, the mark significant
p %>% p_round(digits = 2) %>% p_mark_significant()

# Format, then mark significant
p %>% p_format(digits = 2) %>% p_mark_significant()

# Perform stat test, format p and mark significant
# :::::::::::::::::::::::::::::::::::::::::::
ToothGrowth %>%
  group_by(dose) %>%
  t_test(len ~ supp) %>%
  p_format(digits = 2, leading.zero = FALSE) %>%
  p_mark_significant()
```

`remove_ns` *Remove Non-Significant from Statistical Tests*

Description

Filter out non-significant (NS) p-values from a statistical test. Can detect automatically p-value columns

Usage

```
remove_ns(stat.test, col = NULL, signif.cutoff = 0.05)
```

Arguments

`stat.test`	statistical test results returned by `rstatix` functions or any data frame containing a p-value column.
`col`	(optional) character specifying the column containing the p-value or the significance information, to be used for the filtering step. Possible values include: `"p"`, `"p.adj"`, `"p.signif"`, `"p.adj.signif"`. If missing, the function will automatically look for p.adj.signif, p.adj, p.signif, p in this order.
`signif.cutoff`	the significance cutoff; default is 0.05. Significance is declared at `p-value <= signif.cutoff`

Value

a data frame

Examples

```
# Statistical test
stat.test <- PlantGrowth %>% wilcox_test(weight ~ group)
# Remove ns: automatic detection of p-value columns
stat.test %>% remove_ns()
# Remove ns by the column p
stat.test %>% remove_ns(col ="p")
```

`replace_triangle` *Replace Lower and Upper Triangular Part of a Matrix*

Description

Replace the lower or the upper triangular part of a (correlation) matrix.

Usage

```
replace_triangle(x, triangle = c("lower", "upper"), by = "", diagonal = FALSE)

replace_upper_triangle(x, by = "", diagonal = FALSE)

replace_lower_triangle(x, by = "", diagonal = FALSE)
```

Arguments

`x`	a (correlation) matrix
`triangle`	the triangle to replace. Allowed values are one of "upper" and "lower".
`by`	a replacement argument. Appropriate values are either "" or NA. Used to replace the upper, lower or the diagonal part of the matrix.
`diagonal`	logical. Default is FALSE. If TRUE, the matrix diagonal is included.

Value

an object of class `cor_mat_tri`, which is a data frame

Functions

- `replace_triangle`: replaces the specified triangle by empty or NA.
- `replace_upper_triangle`: replaces the upper triangular part of a matrix. Returns an object of class `lower_tri`.
- `replace_lower_triangle`: replaces the lower triangular part of a matrix. Returns an object of class `lower_tri`

See Also

`pull_triangle()`

Examples

```
# Compute correlation matrix and pull triangles
#::::::::::::::::::::::::::::::::::::::::::
# Correlation matrix
 cor.mat <- mtcars %>%
   select(mpg, disp, hp, drat, wt, qsec) %>%
   cor_mat()
 cor.mat

 # Replace upper triangle by NA
#::::::::::::::::::::::::::::::::::::::::::
cor.mat %>% replace_upper_triangle(by = NA)


# Replace upper triangle by NA and reshape the
# correlation matrix to have unique combinations of variables
#::::::::::::::::::::::::::::::::::::::::::
cor.mat %>%
  replace_upper_triangle(by = NA) %>%
  cor_gather()
```

`sample_n_by` *Sample n Rows By Group From a Table*

Description

sample n rows by group from a table using the `sample_n()` function.

Usage

```
sample_n_by(data, ..., size = 1, replace = FALSE)
```

Arguments

`data`	a data frame
`...`	Variables to group by
`size`	the number of rows to select
`replace`	with or without replacement?

Examples

```
ToothGrowth %>% sample_n_by(dose, supp, size = 2)
```

shapiro_test *Shapiro-Wilk Normality Test*

Description

Provides a pipe-friendly framework to performs Shapiro-Wilk test of normality. Support grouped data and multiple variables for multivariate normality tests. Wrapper around the R base function `shapiro.test()`. Can handle grouped data. Read more: Normality Test in R.

Usage

```
shapiro_test(data, ..., vars = NULL)

mshapiro_test(data)
```

Arguments

`data`	a data frame. Columns are variables.
`...`	One or more unquoted expressions (or variable names) separated by commas. Used to select a variable of interest.
`vars`	optional character vector containing variable names. Ignored when dot vars are specified.

Value

a data frame containing the value of the Shapiro-Wilk statistic and the corresponding p.value.

Functions

- `shapiro_test`: univariate Shapiro-Wilk normality test
- `mshapiro_test`: multivariate Shapiro-Wilk normality test. This is a modified copy of the `mshapiro.test()` function of the package mvnormtest, for internal convenience.

Examples

```
# Shapiro Wilk normality test for one variable
iris %>% shapiro_test(Sepal.Length)

# Shapiro Wilk normality test for two variables
iris %>% shapiro_test(Sepal.Length, Petal.Width)

# Multivariate normality test
mshapiro_test(iris[, 1:3])
```

sign_test *Sign Test*

Description

Performs one-sample and two-sample sign tests. Read more: Sign Test in R.

Usage

```
sign_test(
  data,
  formula,
  comparisons = NULL,
  ref.group = NULL,
  p.adjust.method = "holm",
  alternative = "two.sided",
  mu = 0,
  conf.level = 0.95,
  detailed = FALSE
)

pairwise_sign_test(
  data,
  formula,
  comparisons = NULL,
  ref.group = NULL,
  p.adjust.method = "holm",
  detailed = FALSE,
  ...
)
```

Arguments

`data`	a data.frame containing the variables in the formula.
`formula`	a formula of the form `x ~ group` where `x` is a numeric variable giving the data values and `group` is a factor with one or multiple levels giving the corresponding groups. For example, `formula = TP53 ~ treatment`.
`comparisons`	A list of length-2 vectors specifying the groups of interest to be compared. For example to compare groups "A" vs "B" and "B" vs "C", the argument is as follow: `comparisons = list(c("A", "B"), c("B","C"))`
`ref.group`	a character string specifying the reference group. If specified, for a given grouping variable, each of the group levels will be compared to the reference group (i.e. control group).
`p.adjust.method`	method to adjust p values for multiple comparisons. Used when pairwise comparisons are performed. Allowed values include "holm", "hochberg", "hommel",

	"bonferroni", "BH", "BY", "fdr", "none". If you don't want to adjust the p value (not recommended), use p.adjust.method = "none".
`alternative`	a character string specifying the alternative hypothesis, must be one of `"two.sided"` (default), `"greater"` or `"less"`. You can specify just the initial letter.
`mu`	a single number representing the value of the population median specified by the null hypothesis.
`conf.level`	confidence level of the interval.
`detailed`	logical value. Default is FALSE. If TRUE, a detailed result is shown.
`...`	other arguments passed to the function `sign_test()`

Value

return a data frame with some the following columns:

- `.y.`: the y variable used in the test.
- `group1,group2`: the compared groups in the pairwise tests.
- `n,n1,n2`: Sample counts.
- `statistic`: Test statistic used to compute the p-value. That is the S-statistic (the number of positive differences between the data and the hypothesized median), with names attribute `"S"`.
- `df, parameter`: degrees of freedom. Here, the total number of valid differences.
- `p`: p-value.
- `method`: the statistical test used to compare groups.
- `p.signif, p.adj.signif`: the significance level of p-values and adjusted p-values, respectively.
- `estimate`: estimate of the effect size. It corresponds to the median of the differences.
- `alternative`: a character string describing the alternative hypothesis.
- `conf.low,conf.high`: Lower and upper bound on a confidence interval of the estimate.

The **returned object has an attribute called args**, which is a list holding the test arguments.

Functions

- `sign_test`: Sign test
- `pairwise_sign_test`: performs pairwise two sample Wilcoxon test.

Note

This function is a reimplementation of the function `SignTest()` from the `DescTools` package.

Examples

```
# Load data
#:::::::::::::::::::::::::::::::::::::::
data("ToothGrowth")
df <- ToothGrowth

# One-sample test
#:::::::::::::::::::::::::::::::::::::::::
df %>% sign_test(len ~ 1, mu = 0)


# Two-samples paired test
#:::::::::::::::::::::::::::::::::::::::::
df %>% sign_test(len ~ supp)


# Compare supp levels after grouping the data by "dose"
#::::::::::::::::::::::::::::::::::::::::
df %>%
  group_by(dose) %>%
  sign_test(data =., len ~ supp) %>%
  adjust_pvalue(method = "bonferroni") %>%
  add_significance("p.adj")

# pairwise comparisons
#::::::::::::::::::::::::::::::::::::::::
# As dose contains more than two levels ==>
# pairwise test is automatically performed.
df %>% sign_test(len ~ dose)

# Comparison against reference group
#::::::::::::::::::::::::::::::::::::::::
# each level is compared to the ref group
df %>% sign_test(len ~ dose, ref.group = "0.5")
```

`tukey_hsd` *Tukey Honest Significant Differences*

Description

Provides a pipe-friendly framework to performs Tukey post-hoc tests. Wrapper around the function `TukeyHSD()`. It is essentially a t-test that corrects for multiple testing.

Can handle different inputs formats: aov, lm, formula.

Usage

```
tukey_hsd(x, ...)
```

```
## Default S3 method:
tukey_hsd(x, ...)

## S3 method for class 'lm'
tukey_hsd(x, ...)

## S3 method for class 'data.frame'
tukey_hsd(x, formula, ...)
```

Arguments

x — an object of class aov, lm or data.frame containing the variables used in the formula.

... — other arguments passed to the function TukeyHSD(). These include:

- **which**: A character vector listing terms in the fitted model for which the intervals should be calculated. Defaults to all the terms.
- **ordered**: A logical value indicating if the levels of the factor should be ordered according to increasing average in the sample before taking differences. If ordered is true then the calculated differences in the means will all be positive. The significant differences will be those for which the lwr end point is positive.

formula — a formula of the form x ~ group where x is a numeric variable giving the data values and group is a factor with one or multiple levels giving the corresponding groups. For example, formula = TP53 ~ cancer_group.

data — a data.frame containing the variables in the formula.

Value

a tibble data frame containing the results of the different comparisons.

Methods (by class)

- default: performs tukey post-hoc test from aov() results.
- lm: performs tukey post-hoc test from lm() model.
- data.frame: performs tukey post-hoc tests using data and formula as inputs. ANOVA will be automatically performed using the function aov()

Examples

```
# Data preparation
df <- ToothGrowth
df$dose <- as.factor(df$dose)
# Tukey HSD from ANOVA results
aov(len ~ dose, data = df) %>% tukey_hsd()

# two-way anova with interaction
aov(len ~ dose*supp, data = df) %>% tukey_hsd()
```

```
# Tukey HSD from lm() results
lm(len ~ dose, data = df) %>% tukey_hsd()

# Tukey HSD from data frame and formula
tukey_hsd(df, len ~ dose)

# Tukey HSD using grouped data
df %>%
  group_by(supp) %>%
  tukey_hsd(len ~ dose)
```

---

t_test *T-test*

Description

Provides a pipe-friendly framework to performs one and two sample t-tests. Read more: T-test in R.

Usage

```
t_test(
  data,
  formula,
  comparisons = NULL,
  ref.group = NULL,
  p.adjust.method = "holm",
  paired = FALSE,
  var.equal = FALSE,
  alternative = "two.sided",
  mu = 0,
  conf.level = 0.95,
  detailed = FALSE
)

pairwise_t_test(
  data,
  formula,
  comparisons = NULL,
  ref.group = NULL,
  p.adjust.method = "holm",
  paired = FALSE,
  pool.sd = !paired,
  detailed = FALSE,
  ...
)
```

Arguments

data	a data.frame containing the variables in the formula.
formula	a formula of the form x ~ group where x is a numeric variable giving the data values and group is a factor with one or multiple levels giving the corresponding groups. For example, formula = TP53 ~ cancer_group.
comparisons	A list of length-2 vectors specifying the groups of interest to be compared. For example to compare groups "A" vs "B" and "B" vs "C", the argument is as follow: comparisons = list(c("A", "B"), c("B","C"))
ref.group	a character string specifying the reference group. If specified, for a given grouping variable, each of the group levels will be compared to the reference group (i.e. control group). If ref.group = "all", pairwise two sample tests are performed for comparing each grouping variable levels against all (i.e. basemean).
p.adjust.method	method to adjust p values for multiple comparisons. Used when pairwise comparisons are performed. Allowed values include "holm", "hochberg", "hommel", "bonferroni", "BH", "BY", "fdr", "none". If you don't want to adjust the p value (not recommended), use p.adjust.method = "none".
paired	a logical indicating whether you want a paired test.
var.equal	a logical variable indicating whether to treat the two variances as being equal. If TRUE then the pooled variance is used to estimate the variance otherwise the Welch (or Satterthwaite) approximation to the degrees of freedom is used.
alternative	a character string specifying the alternative hypothesis, must be one of "two.sided" (default), "greater" or "less". You can specify just the initial letter.
mu	a number specifying an optional parameter used to form the null hypothesis.
conf.level	confidence level of the interval.
detailed	logical value. Default is FALSE. If TRUE, a detailed result is shown.
pool.sd	logical value used in the function pairwise_t_test(). Switch to allow/disallow the use of a pooled SD. The pool.sd = TRUE (default) calculates a common SD for all groups and uses that for all comparisons (this can be useful if some groups are small). This method does not actually call t.test, so extra arguments are ignored. Pooling does not generalize to paired tests so pool.sd and paired cannot both be TRUE. If pool.sd = FALSE the standard two sample t-test is applied to all possible pairs of groups. This method calls the t.test(), so extra arguments, such as var.equal are accepted.
...	other arguments to be passed to the function t.test.

Details

- If a list of comparisons is specified, the result of the pairwise tests is filtered to keep only the comparisons of interest. The p-value is adjusted after filtering.

- For a grouped data, if pairwise test is performed, then the p-values are adjusted for each group level independently.

Value

return a data frame with some the following columns:

- `.y.`: the y variable used in the test.
- `group1,group2`: the compared groups in the pairwise tests.
- `n,n1,n2`: Sample counts.
- `statistic`: Test statistic used to compute the p-value.
- `df`: degrees of freedom.
- `p`: p-value.
- `p.adj`: the adjusted p-value.
- `method`: the statistical test used to compare groups.
- `p.signif, p.adj.signif`: the significance level of p-values and adjusted p-values, respectively.
- `estimate`: estimate of the effect size. It corresponds to the estimated mean or difference in means depending on whether it was a one-sample test or a two-sample test.
- `estimate1, estimate2`: show the mean values of the two groups, respectively, for independent samples t-tests.
- `alternative`: a character string describing the alternative hypothesis.
- `conf.low,conf.high`: Lower and upper bound on a confidence interval.

The **returned object has an attribute called args**, which is a list holding the test arguments.

Functions

- `t_test`: t test
- `pairwise_t_test`: performs pairwise two sample t-test. Wrapper around the R base function `pairwise.t.test`.

Examples

```
# Load data
#:::::::::::::::::::::::::::::::::::::::
data("ToothGrowth")
df <- ToothGrowth

# One-sample test
#:::::::::::::::::::::::::::::::::::::::::
df %>% t_test(len ~ 1, mu = 0)


# Two-samples unpaired test
#:::::::::::::::::::::::::::::::::::::::::
df %>% t_test(len ~ supp)

# Two-samples paired test
#:::::::::::::::::::::::::::::::::::::::::
```

```
df %>% t_test (len ~ supp, paired = TRUE)

# Compare supp levels after grouping the data by "dose"
#::::::::::::::::::::::::::::::::::::::::
df %>%
  group_by(dose) %>%
  t_test(data =., len ~ supp) %>%
  adjust_pvalue(method = "bonferroni") %>%
  add_significance("p.adj")

# pairwise comparisons
#::::::::::::::::::::::::::::::::::::::::
# As dose contains more than two levels ==>
# pairwise test is automatically performed.
df %>% t_test(len ~ dose)

# Comparison against reference group
#::::::::::::::::::::::::::::::::::::::::
# each level is compared to the ref group
df %>% t_test(len ~ dose, ref.group = "0.5")

# Comparison against all
#::::::::::::::::::::::::::::::::::::::::
df %>% t_test(len ~ dose, ref.group = "all")
```

`welch_anova_test` *Welch One-Way ANOVA Test*

Description

Tests for equal means in a one-way design (not assuming equal variance). A wrapper around the base function `oneway.test()`. This is is an alternative to the standard one-way ANOVA in the situation where the homogeneity of variance assumption is violated.

Usage

```
welch_anova_test(data, formula)
```

Arguments

`data`	a data frame containing the variables in the formula.
`formula`	a formula specifying the ANOVA model similar to aov. Can be of the form y ~ group where y is a numeric variable giving the data values and group is a factor with one or multiple levels giving the corresponding groups. For example, formula = TP53 ~ cancer_group.

Value

return a data frame with the following columns:

- `.y.`: the y variable used in the test.
- `n`: sample count.
- `statistic`: the value of the test statistic.
- `p`: p-value.
- `method`: the statistical test used to compare groups.

Examples

```
# Load data
#:::::::::::::::::::::::::::::::::::::::
data("ToothGrowth")
df <- ToothGrowth
df$dose <- as.factor(df$dose)

# Welch one-way ANOVA test (not assuming equal variance)
#:::::::::::::::::::::::::::::::::::::::::
df %>% welch_anova_test(len ~ dose)

# Grouped data
#:::::::::::::::::::::::::::::::::::::::::
df %>%
  group_by(supp) %>%
  welch_anova_test(len ~ dose)
```

`wilcox_effsize` *Wilcoxon Effect Size*

Description

Compute Wilcoxon effect size (`r`) for:

- one-sample test (Wilcoxon one-sample signed-rank test);
- paired two-samples test (Wilcoxon two-sample paired signed-rank test) and
- independent two-samples test (Mann-Whitney, two-sample rank-sum test).

It can also returns confidence intervals by bootstap.

The effect size `r` is calculated as `Z` statistic divided by square root of the sample size (N) ($Z/\sqrt{N}$). The `Z` value is extracted from either `coin::wilcoxsign_test()` (case of one- or paired-samples test) or `coin::wilcox_test()` (case of independent two-samples test).

Note that `N` corresponds to total sample size for independent samples test and to total number of pairs for paired samples test.

The `r` value varies from 0 to close to 1. The interpretation values for r commonly in published litterature and on the internet are: `0.10 - < 0.3` (small effect), `0.30 - < 0.5` (moderate effect) and `>= 0.5` (large effect).

Usage

```
wilcox_effsize(
  data,
  formula,
  comparisons = NULL,
  ref.group = NULL,
  paired = FALSE,
  alternative = "two.sided",
  mu = 0,
  ci = FALSE,
  conf.level = 0.95,
  ci.type = "perc",
  nboot = 1000,
  ...
)
```

Arguments

`data`	a data.frame containing the variables in the formula.
`formula`	a formula of the form `x ~ group` where `x` is a numeric variable giving the data values and `group` is a factor with one or multiple levels giving the corresponding groups. For example, `formula = TP53 ~ cancer_group`.
`comparisons`	A list of length-2 vectors specifying the groups of interest to be compared. For example to compare groups "A" vs "B" and "B" vs "C", the argument is as follow: `comparisons = list(c("A", "B"), c("B","C"))`
`ref.group`	a character string specifying the reference group. If specified, for a given grouping variable, each of the group levels will be compared to the reference group (i.e. control group). If `ref.group = "all"`, pairwise two sample tests are performed for comparing each grouping variable levels against all (i.e. basemean).
`paired`	a logical indicating whether you want a paired test.
`alternative`	a character string specifying the alternative hypothesis, must be one of `"two.sided"` (default), `"greater"` or `"less"`. You can specify just the initial letter.
`mu`	a number specifying an optional parameter used to form the null hypothesis.
`ci`	If TRUE, returns confidence intervals by bootstrap. May be slow.
`conf.level`	The level for the confidence interval.
`ci.type`	The type of confidence interval to use. Can be any of "norm", "basic", "perc", or "bca". Passed to `boot::boot.ci`.
`nboot`	The number of replications to use for bootstrap.
`...`	Additional arguments passed to the functions `coin::wilcoxsign_test()` (case of one- or paired-samples test) or `coin::wilcox_test()` (case of independent two-samples test).

Value

return a data frame with some of the following columns:

- `.y.`: the y variable used in the test.
- `group1,group2`: the compared groups in the pairwise tests.
- `n,n1,n2`: Sample counts.
- `effsize`: estimate of the effect size (`r` value).
- `magnitude`: magnitude of effect size.
- `conf.low,conf.high`: lower and upper bound of the effect size confidence interval.

References

Maciej Tomczak and Ewa Tomczak. The need to report effect size estimates revisited. An overview of some recommended measures of effect size. Trends in Sport Sciences. 2014; 1(21):19-25.

Examples

```
if(require("coin")){

# One-sample Wilcoxon test effect size
ToothGrowth %>% wilcox_effsize(len ~ 1, mu = 0)

# Independent two-samples wilcoxon effect size
ToothGrowth %>% wilcox_effsize(len ~ supp)


# Paired-samples wilcoxon effect size
ToothGrowth %>% wilcox_effsize(len ~ supp, paired = TRUE)

# Pairwise comparisons
ToothGrowth %>% wilcox_effsize(len ~ dose)

# Grouped data
ToothGrowth %>%
  group_by(supp) %>%
  wilcox_effsize(len ~ dose)

}
```

`wilcox_test` *Wilcoxon Tests*

Description

Provides a pipe-friendly framework to performs one and two sample Wilcoxon tests. Read more: Wilcoxon in R.

Usage

```
wilcox_test(
  data,
  formula,
  comparisons = NULL,
  ref.group = NULL,
  p.adjust.method = "holm",
  paired = FALSE,
  exact = NULL,
  alternative = "two.sided",
  mu = 0,
  conf.level = 0.95,
  detailed = FALSE
)

pairwise_wilcox_test(
  data,
  formula,
  comparisons = NULL,
  ref.group = NULL,
  p.adjust.method = "holm",
  detailed = FALSE,
  ...
)
```

Arguments

`data`	a data.frame containing the variables in the formula.
`formula`	a formula of the form `x ~ group` where `x` is a numeric variable giving the data values and `group` is a factor with one or multiple levels giving the corresponding groups. For example, `formula = TP53 ~ cancer_group`.
`comparisons`	A list of length-2 vectors specifying the groups of interest to be compared. For example to compare groups "A" vs "B" and "B" vs "C", the argument is as follow: `comparisons = list(c("A", "B"), c("B","C"))`
`ref.group`	a character string specifying the reference group. If specified, for a given grouping variable, each of the group levels will be compared to the reference group (i.e. control group). If `ref.group = "all"`, pairwise two sample tests are performed for comparing each grouping variable levels against all (i.e. basemean).
`p.adjust.method`	method to adjust p values for multiple comparisons. Used when pairwise comparisons are performed. Allowed values include "holm", "hochberg", "hommel", "bonferroni", "BH", "BY", "fdr", "none". If you don't want to adjust the p value (not recommended), use p.adjust.method = "none".
`paired`	a logical indicating whether you want a paired test.
`exact`	a logical indicating whether an exact p-value should be computed.

alternative	a character string specifying the alternative hypothesis, must be one of "two.sided" (default), "greater" or "less". You can specify just the initial letter.
mu	a number specifying an optional parameter used to form the null hypothesis.
conf.level	confidence level of the interval.
detailed	logical value. Default is FALSE. If TRUE, a detailed result is shown.
...	other arguments to be passed to the function wilcox.test.

Details

- pairwise_wilcox_test() applies the standard two sample Wilcoxon test to all possible pairs of groups. This method calls the wilcox.test(), so extra arguments are accepted.

- If a list of comparisons is specified, the result of the pairwise tests is filtered to keep only the comparisons of interest.The p-value is adjusted after filtering.

- For a grouped data, if pairwise test is performed, then the p-values are adjusted for each group level independently.

- a nonparametric confidence interval and an estimator for the pseudomedian (one-sample case) or for the difference of the location parameters x-y is computed, where x and y are the compared samples or groups. The column estimate and the confidence intervals are displayed in the test result when the option detailed = TRUE is specified in the wilcox_test() and pairwise_wilcox_test() functions. Read more about the calculation of the estimate in the details section of the R base function wilcox.test() documentation by typing ?wilcox.test in the R console.

Value

return a data frame with some of the following columns:

- .y.: the y variable used in the test.
- group1,group2: the compared groups in the pairwise tests.
- n,n1,n2: Sample counts.
- statistic: Test statistic used to compute the p-value.
- p: p-value.
- p.adj: the adjusted p-value.
- method: the statistical test used to compare groups.
- p.signif, p.adj.signif: the significance level of p-values and adjusted p-values, respectively.
- estimate: an estimate of the location parameter (Only present if argument detailed = TRUE). This corresponds to the pseudomedian (for one-sample case) or to the difference of the location parameter (for two-samples case).
  - The pseudomedian of a distribution F is the median of the distribution of (u+v)/2, where u and v are independent, each with distribution F. If F is symmetric, then the pseudomedian and median coincide.
  - Note that in the two-sample case the estimator for the difference in location parameters does not estimate the difference in medians (a common misconception) but rather the median of the difference between a sample from x and a sample from y.

- `conf.low`, `conf.high`: a confidence interval for the location parameter. (Only present if argument conf.int = TRUE.)

The **returned object has an attribute called args**, which is a list holding the test arguments.

Functions

- `wilcox_test`: Wilcoxon test
- `pairwise_wilcox_test`: performs pairwise two sample Wilcoxon test.

Examples

```
# Load data
#:::::::::::::::::::::::::::::::::::::::
data("ToothGrowth")
df <- ToothGrowth

# One-sample test
#:::::::::::::::::::::::::::::::::::::::::
df %>% wilcox_test(len ~ 1, mu = 0)


# Two-samples unpaired test
#:::::::::::::::::::::::::::::::::::::::::
df %>% wilcox_test(len ~ supp)

# Two-samples paired test
#:::::::::::::::::::::::::::::::::::::::::
df %>% wilcox_test (len ~ supp, paired = TRUE)

# Compare supp levels after grouping the data by "dose"
#::::::::::::::::::::::::::::::::::::::::
df %>%
  group_by(dose) %>%
  wilcox_test(data =., len ~ supp) %>%
  adjust_pvalue(method = "bonferroni") %>%
  add_significance("p.adj")

# pairwise comparisons
#::::::::::::::::::::::::::::::::::::::::
# As dose contains more than two levels ==>
# pairwise test is automatically performed.
df %>% wilcox_test(len ~ dose)

# Comparison against reference group
#::::::::::::::::::::::::::::::::::::::::
# each level is compared to the ref group
df %>% wilcox_test(len ~ dose, ref.group = "0.5")

# Comparison against all
#::::::::::::::::::::::::::::::::::::::::
df %>% wilcox_test(len ~ dose, ref.group = "all")
```

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