Package 'BFF'

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Title Bayes Factor Functions

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Description

Bayes factors represent the ratio of probabilities assigned to data by competing scientific hypotheses. However, one drawback of Bayes factors is their dependence on prior specifications that define null and alternative hypotheses. Additionally, there are challenges in their computation. To address these issues, we define Bayes factor functions (BFFs) directly from common test statistics. BFFs express Bayes factors as a function of the prior densities used to define the alternative hypotheses. These prior densities are centered on standardized effects, which serve as indices for the BFF. Therefore, BFFs offer a summary of evidence in favor of alternative hypotheses that correspond to a range of scientifically interesting effect sizes. Such summaries remove the need for arbitrary thresholds to determine ``statistical significance." BFFs are available in closed form and can be easily computed from z, t, chi-squared, and F statistics. They depend on hyperparameters ``r" and ``tau^2", which determine the shape and scale of the prior distributions defining the alternative hypotheses. Plots of BFFs versus effect size provide informative summaries of hypothesis tests that can be easily aggregated across studies.

License GPL (>= 2)

URL https://github.com/rshudde/BFF

BugReports https://github.com/rshudde/BFF/issues

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Imports grDevices, ggplot2, Matrix, gsl, stats, rlang

Suggests testthat (>= 3.0.0), knitr, rmarkdown, BSDA, vdiffr

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Contents

`BFF.object` *BFF Object*

Description

The BFF object is a class that contains the results of a Bayes Factor Function. The BFF object contains the following fields:

`BFF`	the object containing the log_bf (log Bayes factor values) and corresponding omega values
`input`	the object containing the input values
`log_bf_h1`	maximized Bayes factor in favor of the alternative, or the corresponding Bayes factor if an omega is supplied
`omega_h1`	corresponding omega value for maximized Bayes factor in favor of the alternative, orthe corresponding omeg
`log_bf_h0`	minimized Bayes factor in favor of the null (for medium or large effect sizes, only returned if a specific omeg
`omega_h0`	corresponding omega value for minimized Bayes factor in favor of the null (for medium or large effect sizes,
`alternative`	alternative hypothesis used in calculations
`omega_set`	was an omega value provided?

r	r value (default is 1 if not provided by user)
test_type	type of BFF test
generic_test	FALSE

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chi2_test_BFF *chi2_test_BFF*

Description

chi2_test_BFF constructs BFFs based on the t test. BFFs depend on hyperparameters r and tau^2 which determine the shape and scale of the prior distributions which define the alternative hypotheses. By setting r > 1, we use higher-order moments for replicated studies. Fractional moments are set with r > 1 and r not an integer. All results are on the log scale.

Usage

```
chi2_test_BFF(
  chi2_stat,
  n,
  df,
  LRT = FALSE,
  omega = NULL,
  omega_sequence = if (is.null(omega)) seq(0.01, 1, by = 0.01),
  r = 1
)
```

Arguments

chi2_stat	chi-square statistic
n	sample size (if one sample test)
df	degrees of freedom
LRT	should LRT be performed? Default is FALSE
omega	standardized effect size. For the chi^2-test, this is often called Cohen's w (can be a single entry or a vector of values)
omega_sequence	sequence of standardized effect sizes. If no omega is provided, omega_sequence is set to be seq(0.01, 1, by = 0.01)
r	variable controlling dispersion of non-local priors. Default is 1. r must be >= 1

Value

Returns an S3 object of class 'BFF' (see 'BFF.object' for details).

Examples

```
chi2BFF = chi2_test_BFF(chi2_stat = 6.5, n = 10, df = 9)
chi2BFF
plot(chi2BFF)
```

---

f_test_BFF *f_test_BFF*

Description

f_test_BFF constructs BFFs based on the t test. BFFs depend on hyperparameters r and tau^2 which determine the shape and scale of the prior distributions which define the alternative hypotheses. By setting r > 1, we use higher-order moments for replicated studies. Fractional moments are set with r > 1 and r not an integer. All results are on the log scale.

Usage

```
f_test_BFF(
  f_stat,
  n,
  df1,
  df2,
  omega = NULL,
  omega_sequence = if (is.null(omega)) seq(0.01, 1, by = 0.01),
  r = 1
)
```

Arguments

f_stat	T statistic
n	sample size (if one sample test)
df1	sample size of group one for two sample test.
df2	sample size of group two for two sample test
omega	standardized effect size. For the f-test, this is often called Cohen's f (can be a single entry or a vector of values)
omega_sequence	sequence of standardized effect sizes. If no omega is provided, omega_sequence is set to be seq(0.01, 1, by = 0.01)
r	variable controlling dispersion of non-local priors. Default is 1. r must be >= 1

Value

Returns an S3 object of class 'BFF' (see 'BFF.object' for details).

Examples

```
fBFF = f_test_BFF(f_stat = 1.5, n = 50, df1 = 25, df2 = 48)
fBFF
plot(fBFF)
```

`is.BFF` *Check whether x is a BFF object*

Description

Check whether x is a BFF object

Usage

```
is.BFF(x)
```

Arguments

`x`	an object to test

Value

returns a boolean.

`nlnm` *Non-local Normal Moment Distribution*

Description

Non-local Normal Moment Distribution

Usage

```
dnlnm(x, tau2, r, log = FALSE)
```

Arguments

`x`	vector of quantiles.
`tau2`	the tau2 parameter
`r`	the r parameter
`log`	logical; if `TRUE`, probabilities `p` are given as `log(p)`.

Value

`dnlnm` gives the density of non-local normal moment distribution

plot.BFF *Plot Bayes Factor Function*

Description

Creates a Bayes factor function plot of an BFF object. The BFF object needs to be specified with `omega = NULL` or .

Usage

```
## S3 method for class 'BFF'
plot(x, plot = TRUE, ...)
```

Arguments

`x`	a BFF object
`plot`	whether plot should be generated. Default to `TRUE`. If `FALSE` a data frame with the support, prior ordinates, and posterior ordinates is returned instead.
`...`	additional arguments to the plotting function. These include: **"title"** tile of the figure **"xlab"** x-axis label of the figure **"ylab"** y-axis label of the figure **"add_segments"** whether effect size segments should be added to the figure. Available only for standardized effect sizes. Defaults to `TRUE`

Value

either a ggplot2 object if `plot = TRUE` or a data.frame with a Bayes factor function if `plot = FALSE`

See Also

[z_test_BFF()], [t_test_BFF()], [chi2_test_BFF()], [f_test_BFF()]

posterior_plot *Plot Prior and Posterior Distribution*

Description

Creates a prior and posterior plot of an BFF object. If no specific omega was set when fitting the model, the omega resulting in maximum BF against the null hypothesis is selected.

Usage

```
posterior_plot(x, prior = FALSE, plot = TRUE, ...)
```

Arguments

x	a BFF object
prior	whether prior distribution should be added to the figure
plot	whether plot should be generated. Default to TRUE. If FALSE a data frame with the support, prior ordinates, and posterior ordinates is returned instead.
...	additional arguments to the plotting function. These include: **"x_limit"** vector defining the plotting range, defaults to c(-3, 3). **"color"** vector with color for the posterior and prior line. Defaults to c("black", "grey") **"linetype"** vector with linetype for the posterior and prior line. Defaults to c(2, 1) **"linewidth"** vector with linewidth for the posterior and prior line. Defaults to c(1, 1)

Value

either a ggplot2 object if plot = TRUE or a data.frame with prior and posterior densities if plot = FALSE

See Also

[z_test_BFF()], [t_test_BFF()], [chi2_test_BFF()], [f_test_BFF()]

---

print.BFF *Summarize BFF object*

Description

Summarize BFF object

Usage

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

Arguments

x	a BFF object
...	additional arguments (unused)

Value

prints summary of a BFF object.

See Also

[z_test_BFF()], [t_test_BFF()], [chi2_test_BFF()], [f_test_BFF()]

regression_test_BFF *regression_test_BFF*

Description

regression_test_BFF constructs BFFs based on the t test. BFFs depend on hyperparameters r and tau^2 which determine the shape and scale of the prior distributions which define the alternative hypotheses. By setting r > 1, we use higher-order moments for replicated studies. Fractional moments are set with r > 1 and r not an integer. All results are on the log scale.

Usage

```
regression_test_BFF(
  t_stat,
  n = NULL,
  k = NULL,
  alternative = "two.sided",
  omega = NULL,
  omega_sequence = if (is.null(omega)) seq(0.01, 1, by = 0.01),
  r = 1
)
```

Arguments

t_stat	T statistic
n	sample size (if one sample test)
k	number of predictors
alternative	is the alternative a one.sided or two.sided test? default is two.sided
omega	standadized effect size. For the regression test, this is also known as Cohen's f^@ (can be a single entry or a vector of values)
omega_sequence	sequence of standardized effect sizes. If no omega is provided, omega_sequence is set to be seq(0.01, 1, by = 0.01)
r	variable controlling dispersion of non-local priors. Default is 1. r must be >= 1

Value

Returns an S3 object of class 'BFF' (see 'BFF.object' for details).

Examples

```
regBFF = regression_test_BFF(t_stat = 1.5, n = 50, k = 3)
regBFF
plot(regBFF)
```

summary.BFF *Summarize BFF object*

Description

Summarize BFF object

Usage

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

Arguments

object	a BFF object
...	additional arguments (unused)

Value

prints summary of a BFF object.

See Also

[z_test_BFF()], [t_test_BFF()], [chi2_test_BFF()], [f_test_BFF()]

t_test_BFF *t_test_BFF*

Description

t_test_BFF constructs BFFs based on the t test. BFFs depend on hyperparameters r and tau^2 which determine the shape and scale of the prior distributions which define the alternative hypotheses. By setting r > 1, we use higher-order moments for replicated studies. Fractional moments are set with r > 1 and r not an integer. All results are on the log scale.

Usage

```
t_test_BFF(
  t_stat,
  n = NULL,
  n1 = NULL,
  n2 = NULL,
  one_sample = FALSE,
  alternative = "two.sided",
  omega = NULL,
  omega_sequence = if (is.null(omega)) seq(0.01, 1, by = 0.01),
  r = 1
)
```

Arguments

t_stat	t statistic
n	sample size (if one sample test)
n1	sample size of group one for two sample test. Must be provided if one_sample = FALSE
n2	sample size of group two for two sample test. Must be provided if one_sample = FALSE
one_sample	is test one sided? Default is FALSE
alternative	the alternative. options are "two.sided" or "less" or "greater"
omega	standardized effect size. For the t-test, this is often called Cohen's d (can be a single entry or a vector of values)
omega_sequence	sequence of standardized effect sizes. If no omega is provided, omega_sequence is set to be seq(0.01, 1, by = 0.01)
r	variable controlling dispersion of non-local priors. Default is 1. r must be >= 1

Value

Returns an S3 object of class 'BFF' (see 'BFF.object' for details).

Examples

```
tBFF = t_test_BFF(t_stat = 2.5, n = 50, one_sample = TRUE)
tBFF
plot(tBFF)
```

---

t_test_BFF_invm *t_test_BFF_invm*

Description

t_test_BFF constructs BFFs based on the t test using the inverse moment prior. BFFs depend on hyperparameters r and tau^2 which determine the shape and scale of the prior distributions which define the alternative hypotheses. By setting r > 1, we use higher-order moments for replicated studies. Fractional moments are set with r > 1 and r not an integer. All results are on the log scale.

Usage

```
t_test_BFF_invm(
  t_stat,
  n = NULL,
  nu = 1,
  n1 = NULL,
  n2 = NULL,
  one_sample = FALSE,
  alternative = "two.sided",
```

```
  omega = NULL,
  omega_sequence = if (is.null(omega)) seq(0.01, 1, by = 0.01),
  default_max = 700
)
```

Arguments

t_stat	t statistic
n	sample size (if one sample test)
nu	hyperparemeter for the inverse moment prior
n1	sample size of group one for two sample test. Must be provided if one_sample = FALSE
n2	sample size of group two for two sample test. Must be provided if one_sample = FALSE
one_sample	is test one sided? Default is FALSE
alternative	the alternative. options are "two.sided" or "less" or "greater"
omega	standardized effect size. For the t-test, this is often called Cohen's d (can be a single entry or a vector of values)
omega_sequence	sequence of standardized effect sizes. If no omega is provided, omega_sequence is set to be seq(0.01, 1, by = 0.01)
default_max	set to 700, required for integration to correctly calculate. Authors do not suggest changing this value, as it is for computation only

Value

Returns an S3 object of class 'BFF' (see 'BFF.object' for details).

Examples

```
tBFF = t_test_BFF_invm(t_stat = 0.5, n = 50, nu = 1, one_sample = TRUE)
tBFF
plot(tBFF)
```

---

z_test_BFF *z_test_BFF*

Description

z_test_BFF constructs BFFs based on the z test. BFFs depend on hyperparameters r and tau^2 which determine the shape and scale of the prior distributions which define the alternative hypotheses. By setting r > 1, we use higher-order moments for replicated studies. Fractional moments are set with r > 1 and r not an integer. All results are on the log scale.

Usage

```
z_test_BFF(
  z_stat,
  n = NULL,
  n1 = NULL,
  n2 = NULL,
  one_sample = FALSE,
  alternative = "two.sided",
  omega = NULL,
  omega_sequence = if (is.null(omega)) seq(0.01, 1, by = 0.01),
  r = 1
)
```

Arguments

z_stat	Z statistic
n	sample size (if one sample test)
n1	sample size of group one for two sample test. Must be provided if one_sample = FALSE
n2	sample size of group two for two sample test. Must be provided if one_sample = FALSE
one_sample	is test one sided? Default is FALSE
alternative	the alternative. options are "two.sided" or "less" or "greater"
omega	standardized effect size. For the z-test, this is often called Cohen's d (can be a single entry or a vector of values)
omega_sequence	sequence of standardized effect sizes. If no omega is provided, omega_sequence is set to be seq(0.01, 1, by = 0.01)
r	variable controlling dispersion of non-local priors. Default is 1. r must be >= 1

Value

Returns an S3 object of class 'BFF' (see 'BFF.object' for details).

Examples

```
zBFF = z_test_BFF(z_stat = 2.5, n = 50, one_sample = TRUE)
zBFF
plot(zBFF)
```

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