Package 'bfpwr'

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Title Power and Sample Size Calculations for Bayes Factor Analysis

Description Provides functionality for performing power and sample size calculations for Bayes factor analysis.

License GPL-3

Encoding UTF-8

Suggests roxygen2, tinytest

NeedsCompilation no

RoxygenNote 7.3.1

URL https://github.com/SamCH93/bfpwr

BugReports https://github.com/SamCH93/bfpwr/issues

Contents

bf01 *Bayes factor under normality*

Description

This function computes the Bayes factor that quantifies the evidence that the data (in the form of an asympotically normally distributed parameter estimate with standard error) provide for a point null hypothesis with a normal prior assigned to the parameter under the alternative.

Usage

```
bf01(estimate, se, null = 0, pm, psd, log = FALSE)
```

Arguments

estimate	Parameter estimate
se	Standard error of the parameter estimate
null	Parameter value under the point null hypothesis. Defaults to 0
pm	Mean of the normal prior assigned to the parameter under the alternative
psd	Standard deviation of the normal prior assigned to the parameter under the alternative. Set to 0 to obtain a point prior at the prior mean
log	Logical indicating whether natural logarithm of the Bayes factor should be returned. Defaults to FALSE

Value

Bayes factor in favor of the null hypothesis over the alternative (BF > 1 indicates evidence for the null hypothesis, whereas BF < 1 indicates evidence for the alternative)

Author(s)

Samuel Pawel

Examples

```
bf01(estimate = 0.2, se = 0.05, null = 0, pm = 0, psd = 2)
```

nbf01 *Sample size determination for Bayes factor analysis*

Description

This function computes the required sample size to obtain a Bayes factor (bf01) less or greater than a threshold k with a specified target power.

Usage

```
nbf01(
  k,
  power,
  sd,
  null = 0,
  pm,
  psd,
  dpm = pm,
  dpsd = psd,
  nrange = c(1, 10^5),
  lower.tail = TRUE,
  integer = TRUE,
  analytical = TRUE,
  ...
)
```

Arguments

k	Bayes factor threshold
power	Target power
sd	Standard deviation of one unit
null	Parameter value under the point null hypothesis. Defaults to 0
pm	Mean of the normal prior assigned to the parameter under the alternative in the analysis
psd	Standard deviation of the normal prior assigned to the parameter under the alternative in the analysis. Set to 0 to obtain a point prior at the prior mean
dpm	Mean of the normal design prior assigned to the parameter. Defaults to the same value as specified for the analysis prior pm
dpsd	Standard deviation of the normal design prior assigned to the parameter. Set to 0 to obtain a point prior at the prior mean. Defaults to the same value as specified for the analysis prior psd
nrange	Sample size search range. Defaults to c(1, 10^5)
lower.tail	Logical indicating whether Pr(BF <= k) (TRUE) or Pr(BF > k) (FALSE) is the probability of interest. Defaults to TRUE

integer	Logical indicating whether only integer valued sample sizes should be returned. If TRUE the required sample size is rounded to the next larger integer. Defaults to TRUE
analytical	Logical indicating whether analytical (if available) or numerical method should be used. Defaults to TRUE
...	Other arguments passed to stats::uniroot

Value

The required sample size to achieve the specified power

Author(s)

Samuel Pawel

See Also

pbf01, powerbf01

Examples

```
## point alternative (analytical and numerical solution available)
nbf01(k = 1/10, power = 0.9, sd = 1, null = 0, pm = 0.5, psd = 0,
      analytical = c(TRUE, FALSE), integer = FALSE)
```

---

pbf01 *Cumulative distribution function of the Bayes factor under normality*

Description

This function computes the probability of obtaining a Bayes factor (bf01) smaller (or larger) than a threshold k with a specified sample size.

Usage

```
pbf01(k, n, sd, null = 0, pm, psd, dpm = pm, dpsd = psd, lower.tail = TRUE)
```

Arguments

k	Bayes factor threshold
n	Sample size
sd	Standard deviation of one unit
null	Parameter value under the point null hypothesis. Defaults to 0
pm	Mean of the normal prior assigned to the parameter under the alternative in the analysis

psd	Standard deviation of the normal prior assigned to the parameter under the alternative in the analysis. Set to 0 to obtain a point prior at the prior mean
dpm	Mean of the normal design prior assigned to the parameter. Defaults to the same value as the analysis prior pm
dpsd	Standard deviation of the normal design prior assigned to the parameter. Defaults to the same value as the analysis prior psd
lower.tail	Logical indicating whether Pr(BF $\leq$ k) (TRUE) or Pr(BF $>$ k) (FALSE) should be computed. Defaults to TRUE

Value

The probability that the Bayes factor is less or greater (depending on the specified lower.tail) than the specified threshold k

Author(s)

Samuel Pawel

See Also

nbf01, powerbf01

Examples

```
## point alternative (psd = 0)
pbf01(k = 1/10, n = 200, sd = 2, null = 0, pm = 0.5, psd = 0)

## normal alternative (psd > 0)
pbf01(k = 1/10, n = 100, sd = 2, null = 0, pm = 0.5, psd = 2)

## design prior is the null hypothesis (dpm = 0, dpsd = 0)
pbf01(k = 10, n = 1000, sd = 2, null = 0, pm = 0.3, psd = 2, dpm = 0, dpsd = 0, lower.tail = FALSE)

## draw a power curve
nseq <- round(exp(seq(log(10), log(10000), length.out = 100)))
plot(nseq, pbf01(k = 1/10, n = nseq, sd = 2, null = 0, pm = 0.3, psd = 0), type = "l",
     xlab = "n", ylab = bquote("Pr(BF"["01"] <= 1/10 * ")"), ylim = c(0, 1),
     log = "x", las = 1)
```

---

plot.power.bftest *Plot method for class* "power.bftest"

Description

Plot method for class "power.bftest"

Usage

```
## S3 method for class 'power.bftest'
plot(x, nlim = c(1, 500), plot = TRUE, nullplot = TRUE, ...)
```

Arguments

x	Object of class "power.bftest"
nlim	Range of samples sizes over which the power should be computed. Defaults to c(1, 500)
plot	Logical indicating whether data should be plotted. If FALSE only the data used for plotting are returned.
nullplot	Logcal indicating whether a second plot with the power in favor of the null (using a Bayes factor threshold of 1/k) should be created. Defaults to TRUE
...	Other arguments (for consistency with the generic)

Value

Plots power curves (if specified) and invisibly returns a list of data frames containing the data underlying the power curves

Author(s)

Samuel Pawel

See Also

powerbf01

Examples

```
ssd1 <- powerbf01(k = 1/6, power = 0.95, pm = 0, psd = 1/sqrt(2), dpm = 0.5, dpsd = 0)
plot(ssd1, nlim = c(1, 8000))

power1 <- powerbf01(k = 1/2, n = 120, pm = 0, psd = 1/sqrt(2), dpm = 0.5, dpsd = 0)
plot(power1, nlim = c(1, 1000))
```

---

powerbf01 *Power and sample size calculations for Bayes factor under normality*

Description

Compute probability that Bayes factor under normality is smaller than a specified threshold (the power), or determine sample size to obtain a target power

Usage

```
powerbf01(
  n = NULL,
  power = NULL,
  k = 1/10,
  sd = 1,
  null = 0,
  pm,
  psd,
  dpm = pm,
  dpsd = psd,
  nrange = c(1, 10^5),
  type = c("two.sample", "one.sample", "paired")
)
```

Arguments

n	Sample size. Has to be NULL if power is specified. Defaults to NULL
power	Target power. Has to be NULL if n is specified. Defaults to NULL
k	Bayes factor threshold. Defaults to 1/10, Jeffreys' threshold for 'strong evidence' against the null hypothesis
sd	Standard deviation of one observation (for type = "two.sample" or type = "one.sample") or of one difference within a pair of observations (type = "paired"). Is assumed to be known
null	Mean difference under the point null hypothesis. Defaults to 0
pm	Mean of the normal prior assigned to the mean difference under the alternative in the analysis
psd	Standard deviation of the normal prior assigned to the mean difference under the alternative in the analysis. Set to 0 to obtain a point prior at the prior mean
dpm	Mean of the normal design prior assigned to the mean difference. Defaults to the same value as the analysis prior pm
dpsd	Standard deviation of the normal design prior assigned to the mean difference. Defaults to the same value as the analysis prior psd
nrange	Sample size search range (only taken into account when n is NULL). Defaults to c(1, 10^5)
type	The type of test. One of "two.sample", "one.sample", "paired". Defaults to "two.sample"

Value

Object of class "power.bftest", a list of the arguments (including the computed one) augmented with method and note elements

Note

An error message will be displayed in case that the specified target power is not achievable under the specified analysis and design priors.

Author(s)

Samuel Pawel

See Also

plot.power.bftest, nbf01, pbf01

Examples

```
## determine power
powerbf01(n = 100, pm = 0, psd = 1, dpm = 0.5, dpsd = 0)

## determine sample size
powerbf01(power = 0.99, pm = 0, psd = 1, dpm = 0.5, dpsd = 0)
```

---

print.power.bftest *Print method for class* "power.bftest"

Description

Print method for class "power.bftest"

Usage

```
## S3 method for class 'power.bftest'
print(x, digits = getOption("digits"), ...)
```

Arguments

x	Object of class "power.bftest"
digits	Number of digits for formatting of numbers
...	Other arguments (for consistency with the generic)

Value

Prints text summary in the console and invisibly returns the "power.bftest" object

Note

Function adapted from stats:::print.power.htest written by Peter Dalgaard

Author(s)

Samuel Pawel

See Also

powerbf01

Examples

```
powerbf01(power = 0.95, pm = 0, psd = 1, dpm = 0.5, dpsd = 0)
powerbf01(power = 0.95, pm = 0, psd = 1, dpm = 0.5, dpsd = 0, type = "one.sample")
powerbf01(power = 0.95, pm = 0, psd = 1, dpm = 0.5, dpsd = 0, type = "paired")
powerbf01(power = 0.95, pm = 1, psd = 0, dpm = 0.8, dpsd = 0, type = "paired")
```

---

ptbf01 *Cumulative distribution function of the t-test Bayes factor*

Description

This function computes the probability of obtaining a t-test Bayes factor (tbf01) smaller (or larger) than a threshold k with a specified sample size.

Usage

```
ptbf01(
  k = 1/10,
  n,
  n1 = n,
  n2 = n,
  null = 0,
  plocation = 0,
  pscale = 1/sqrt(2),
  pdf = 1,
  dpm = plocation,
  dpsd = pscale,
  type = c("two.sample", "one.sample", "paired"),
  alternative = c("two.sided", "less", "greater"),
  lower.tail = TRUE,
  strict = FALSE
)
```

Arguments

k	Bayes factor threshold. Defaults to 1/10, Jeffreys' threshold for 'strong evidence' against the null hypothesis
n	Sample size (per group)
n1	Sample size in group 1 (only required for two-sample t-test with unequal group sizes)
n2	Sample size in group 2 (only required for two-sample t-test with unequal group sizes)

null	Standardized mean difference under the point null hypothesis. Defaults to 0
plocation	Analysis t prior location. Defaults to 0
pscale	Analysis t prior scale. Defaults to 1/sqrt(2)
pdf	Analysis t prior degrees of freedom. Defaults to 1
dpm	Mean of the normal design prior assigned to the standardized mean difference. Defaults to the analysis prior location
dpsd	Standard deviation of the normal design prior assigned to the standardized mean difference. Set to 0 to obtain a point prior at the design prior mean. Defaults to the analysis prior scale
type	The type of test. One of "two.sample", "one.sample", "paired". Defaults to "two.sample"
alternative	Direction of the test. Can be either "two.sided" (default), "less", or "greater"
lower.tail	Logical indicating whether Pr(BF $\leq$ k) (TRUE) or Pr(BF $>$ k) (FALSE) should be computed. Defaults to TRUE
strict	Logical indicating whether in case of one-sided alternatives the power should be computed also in the opposite direction. Defaults to FALSE

Value

The probability that the Bayes factor is less or greater (depending on the specified lower.tail) than the specified threshold k

Author(s)

Samuel Pawel

See Also

tbf01

Examples

```
## example from Schönbrodt and Wagenmakers (2018, p.135)
ptbf01(k = 1/6, n = 146, dpm = 0.5, dpsd = 0, alternative = "greater")
ptbf01(k = 6, n = 146, dpm = 0, dpsd = 0, alternative = "greater",
       lower.tail = FALSE)
```

tbf01 *t-test Bayes factor*

Description

This function computes the Bayes factor that forms the basis of the informed Bayesian t-test from Gronau et al. (2020). The Bayes factor quantifies the evidence that the data provide for the null hypothesis that the standardized mean difference (SMD) is zero against the alternative that the SMD is non-zero. A t-distribution is assumed for the SMD under the alternative. The Jeffreys-Zellner-Siow (JZS) Bayes factor (Rouder et al., 2009) is obtained as a special case by setting the location of the prior to zero and the prior degrees of freedom to one, which is the default.

The data are summarized by t-statistics and sample sizes. The following types of t-statistics are accepted:

- Two-sample t-test where the SMD represents the standardized mean difference between two group means (assuming equal variances in both groups)
- One-sample t-test where the SMD represents the standardized mean difference to the null value
- Paired t-test where the SMD represents the standardized mean change score

Usage

```
tbf01(
  t,
  n,
  n1 = n,
  n2 = n,
  plocation = 0,
  pscale = 1/sqrt(2),
  pdf = 1,
  type = c("two.sample", "one.sample", "paired"),
  alternative = c("two.sided", "less", "greater"),
  log = FALSE,
  ...
)
```

Arguments

t	t-statistic
n	Sample size (per group)
n1	Sample size in group 1 (only required for two-sample t-test with unequal group sizes)
n2	Sample size in group 2 (only required for two-sample t-test with unequal group sizes)
plocation	t prior location. Defaults to 0

pscale	t prior scale. Defaults to 1/sqrt(2)
pdf	t prior degrees of freedom. Defaults to 1
type	Type of t-test associated with t-statistic. Can be "two.sample" (default), "one.sample", or "paired"
alternative	Direction of the test. Can be either "two.sided" (default), "less", or "greater"
log	Logical indicating whether natural logarithm of the Bayes factor should be returned. Defaults to FALSE
...	Additional arguments passed to stats::integrate

Details

The Bayes factor is implemented as in equation (5) in Gronau et al. (2020), and using suitable truncation in case of one-sided alternatives. Integration is performed numerically with stats::integrate.

Value

Bayes factor in favor of the null hypothesis over the alternative (BF > 1 indicates evidence for the null hypothesis, whereas BF < 1 indicates evidence for the alternative)

Author(s)

Samuel Pawel

References

Rouder, J. N., Speckman, P. L., Sun, D., Morey, R. D., Iverson, G. (2014). Bayesian t tests for accepting and rejecting the null hypothesis. Psychonomic Bulletin & Review, 16(2):225-237. doi:10.3758/PBR.16.2.225

Gronau, Q. F., Ly., A., Wagenmakers, E.J. (2020). Informed Bayesian t-Tests. The American Statistician, 74(2):137-143. doi:10.1080/00031305.2018.1562983

Examples

```
## analyses from Rouder et al. (2009):
## values from Table 1
tbf01(t = c(0.69, 3.20), n = 100, pscale = 1, type = "one.sample")
## examples from p. 232
tbf01(t = c(2.24, 2.03), n = 80, pscale = 1, type = "one.sample")

## analyses from Gronau et al. (2020) section 3.2:
## informed prior
tbf01(t = -0.90, n1 = 53, n2 = 57, plocation = 0.350, pscale = 0.102, pdf = 3,
      alternative = "greater", type = "two.sample")
## default (one-sided) prior
tbf01(t = -0.90, n1 = 53, n2 = 57, plocation = 0, pscale = 1/sqrt(2), pdf = 1,
      alternative = "greater", type = "two.sample")
```

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