

Package ‘ESTER’

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Title Efficient Sequential Testing with Evidence Ratios

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Description An implementation of sequential testing that uses evidence ratios computed from the weights of a set of models. These weights correspond either to Akaike weights computed from the Akaike Information Criterion (AIC) or the Bayesian Information Criterion (BIC) and following Burnham & Anderson (2004, <[doi:10.1177/0049124104268644](https://doi.org/10.1177/0049124104268644)>) recommendations, or to pseudo-BMA weights computed from the WAIC or the LOO-IC of models fitted with 'brms' and following Yao et al. (2017, <[doi:10.48550/arXiv.1704.02030v3](https://doi.org/10.48550/arXiv.1704.02030v3)>).

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LazyData yes

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Depends R (>= 3.3.0)

Imports brms, lme4, dplyr, magrittr, tidyr, ggplot2, rlang, foreach, doParallel, cowplot

URL <https://github.com/lNALborczyk/ESTER>

BugReports <https://github.com/lNALborczyk/ESTER/issues>

Suggests knitr, rmarkdown

VignetteBuilder knitr

NeedsCompilation no

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aic	<i>Computes the Akaike Information Criterion</i>
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Description

Computes the Akaike Information Criterion of a model. Except when the number of observations is much larger than the number of parameters (i.e., $n / k > 40$), we apply the second-order bias correction for small samples (AICc), as suggested by Burnham & Anderson (2002, 2004).

Usage

aic(mod)

Arguments

mod A fitted model of class lm or merMod.

Author(s)

Ladislav Nalborczyk <<ladislav.nalborczyk@gmail.com>>

References

Burnham, K. P., \& Anderson, D. R. (2002). Model Selection and Multimodel Inference: A Practical Information-Theoretical Approach. 2d ed. New York: Springer-Verlag.

Burnham, K. P., \& Anderson, D. R. (2004). Multimodel inference: Understanding AIC and BIC in model selection. Sociological Methods and Research, 33(2), 261-304.

See Also

[bic](#), [ictab](#)

Examples

```
data(mtcars)
mod1 <- lm(mpg ~ cyl, mtcars)
aic(mod1)
```

analysER*Analysing the results of simulations ran with simER*

Description

Analysing the results of simulations ran with `simER`. It computes the average sample number (ASN) at which the boundary is attained (either the lower or the upper one), the percentage of hits of the lower boundary as well as hits of the upper boundary, and the percentage of trajectories that did not hit none of the boundaries.

Usage

```
analysER(sim)
```

Arguments

`sim` A `simER` or a `compER` object.

Value

An object of class `data.frame`, which contains the average sample number (ASN) at which the boundary is attained (either the lower or the upper one), the percentage of hits of the lower boundary as well as hits of the upper boundary, and the percentage of trajectories that did not hit none of the boundaries (and thus end at `nmax`).

Author(s)

Ladislav Nalborczyk <<ladislav.nalborczyk@gmail.com>>

See Also

[simER](#)

Examples

```
## Not run:
library(ESTER)
sim <- simER(cohensd = 0.8, nmin = 20, nmax = 100, boundary = 10, nsims = 100, ic = bic)
analysER(sim)

## End(Not run)
```

bic	<i>Computes the Bayesian Information Criterion</i>
-----	----------------------------------------------------

Description

Computes the Bayesian Information Criterion of a model (Schwarz, 1978).

Usage

```
bic(mod)
```

Arguments

mod	A fitted model of class <code>lm</code> or <code>merMod</code> .
-----	------------------------------------------------------------------

Author(s)

Ladislav Nalborczyk <<ladislav.nalborczyk@gmail.com>>

References

Schwarz, G. (1978). Estimating the dimension of a model. *Annals of Statistics*, 6, 461-464.

See Also

[aic](#), [ictab](#)

Examples

```
data(mtcars)
mod1 <- lm(mpg ~ cyl, mtcars)
bic(mod1)
```

distER	<i>Simulating many sequential testing with evidence ratios and plotting their distribution</i>
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Description

Simulating many sequential evidence ratios using `simER`, keeps the last of each simulation, and plotting their distribution.

Usage

```
distER(cohensd, nmin, nmax, nsims, ic = bic)
```

Arguments

cohensd	Expected effect size
nmin	Minimum sample size from which start computing ERs
nmax	Maximum sample size at which stop computing ERs
nsims	Number of experiments to simulate.
ic	Indicates whether to use the aic or the bic

Author(s)

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See Also

[simER](#)

Examples

```
## Not run: distER(cohensd = 0.6, nmin = 20, nmax = 100, nsims = 100, ic = bic)
```

ESTER

Efficient Sequential Testing with Evidence Ratios

Description

The **ESTER** package implements sequential testing based on evidence ratios computed from the Akaike weights of a set of models. These weights are being computed using either the Akaike Information Criterion (AIC) or the Bayesian Information Criterion (BIC).

Details

See `vignette("ESTER")` for a general introduction and overview.

Author(s)

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See Also

[ictab](#), [simER](#), [seqER](#)

ictab	<i>Computes Akaike weights or pseudo-BMA weights for a set of models</i>
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Description

Returns a table with weights of a set of models, based on various information criteria. Currently, ictab supports the computation of Akaike weights from the aic or the bic computed on lm or merMod models, as well as the computation of pseudo-BMA weights, computed from the WAIC or LOOIC of brmsfit models.

Usage

```
ictab(mods, ic, ...)
```

Arguments

mods	Should be a named list of models, of class lm, merMod or brmsfit.
ic	Indicates which information criterion to use. Current supported information criteria include aic and bic for lm and merMod models, as well as WAIC and LOO for brmsfit models.
...	Additional parameters to be passed to brms::WAIC or brms::LOO functions.

Value

An object of class data.frame, which contains the value of the information criterion (either AIC, BIC, WAIC or LOOIC), the number of parameters (k for AIC and BIC or p for WAIC or LOOIC), the delta_IC (for AIC and BIC) or the elpd for models compared with WAIC or LOOIC, and the weight of each model (Akaike weights for AIC or BIC and pseudo-BMA weights for WAIC or LOOIC).

Author(s)

Ladislav Nalborczyk <<ladislav.nalborczyk@gmail.com>>

References

Burnham, K. P., \& Anderson, D. R. (2002). Model Selection and Multimodel Inference: A Practical Information-Theoretical Approach. 2d ed. New York: Springer-Verlag.

Burnham, K. P., \& Anderson, D. R. (2004). Multimodel inference: Understanding AIC and BIC in model selection. Sociological Methods and Research, 33(2), 261-304.

Yao, Y. P., Vehtari, A., Simpson, D., \& Gelman, A. (2017). Using stacking to average Bayesian predictive distributions.

See Also

[aic](#), [bic](#)

Examples

```

library(ESTER)
data(mtcars)
mod1 <- lm(mpg ~ cyl, mtcars)
mod2 <- lm(mpg ~ cyl + vs, mtcars)
mod3 <- lm(mpg ~ cyl + vs + I(vs^2), mtcars)
mod4 <- lm(mpg ~ cyl * vs, mtcars)
mods <- list(mod1 = mod1, mod2 = mod2, mod3 = mod3, mod4 = mod4)
ictab(mods, aic)
ictab(mods, bic)

## Not run:
library(brms)
mod1 <- brm(mpg ~ cyl, mtcars)
mod2 <- brm(mpg ~ cyl + vs, mtcars)
mods <- list(m1 = mod1, m2 = mod2)
ictab(mods, L00, relloo = TRUE, k_threshold = 0.6, cores = 2)

## End(Not run)

```

plot.simER

Plotting the results of simER

Description

Plotting the results of simER.

Usage

```

## S3 method for class 'simER'
plot(x, log = TRUE, hist = TRUE, ...)

```

Arguments

x	A simER object
log	Should the y-axis be log-transformed ?
hist	Should plot the histogram of simulations hitting either the lower, the upper boundary, or stopping at nmax ?
...	Further arguments passed to plot.default

Author(s)

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seqER

*Computes sequential evidence ratios***Description**

Computes sequential evidence ratios, either based on the AIC or the BIC. Supported models currently include `lm`, `merMod`, or `brmsfit` models. When data involve repeated measures (and so multiple lines per subject), a column indicating the subject "id" should be provided to the `id` argument. If nothing is passed to the `id` argument, `seqER` will suppose that there is only one observation (i.e., one line) per subject.

Usage

```
seqER(ic = bic, mod1, mod2, nmin = 10, id = NULL, boundary = Inf,
      blind = FALSE, nsims = NULL)
```

Arguments

<code>ic</code>	Indicates whether to use the <code>aic</code> or the <code>bic</code> .
<code>mod1</code>	A model of class <code>lm</code> or <code>lmerMod</code> .
<code>mod2</code>	A model of class <code>lm</code> or <code>lmerMod</code> (of the same class of <code>mod1</code>).
<code>nmin</code>	Minimum sample size from which start to compute sequential evidence ratios.
<code>id</code>	If applicable (i.e., repeated measures), name of the "id" column of your dataframe, in character string.
<code>boundary</code>	The Evidence Ratio (or its reciprocal) at which the run is stopped as well
<code>blind</code>	If true, the function only returns a "continue or stop" message
<code>nsims</code>	Number of permutation samples to evaluate (is ignored if <code>blind = TRUE</code>)

Author(s)

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See Also

[simER](#)

Examples

```
## Not run:
data(mtcars)
mod1 <- lm(mpg ~ cyl, mtcars)
mod2 <- lm(mpg ~ cyl + disp, mtcars)
seqER(ic = bic, mod1, mod2, nmin = 10)

# Example with ten permutation samples
data(mtcars)
```



```

mod1 <- lm(mpg ~ cyl, mtcars)
mod2 <- lm(mpg ~ cyl + disp, mtcars)
seqER(ic = bic, mod1, mod2, nmin = 10, nsims = 10)

# Example with blinding
data(mtcars)
mod1 <- lm(mpg ~ cyl, mtcars)
mod2 <- lm(mpg ~ cyl + disp, mtcars)
seqER(ic = bic, mod1, mod2, nmin = 10, boundary = 10, blind = TRUE)

# Example with repeated measures
library(lme4)
data(sleepstudy)
mod1 <- lmer(Reaction ~ Days + (1|Subject), sleepstudy)
mod2 <- lmer(Reaction ~ Days + I(Days^2) + (1|Subject), sleepstudy)
seqER(ic = bic, mod1, mod2, nmin = 10, id = "Subject", nsims = 10)

# Example with brmsfit models
library(brms)
mod1 <- brm(Reaction ~ Days + (1|Subject), sleepstudy)
mod2 <- brm(Reaction ~ Days + I(Days^2) + (1|Subject), sleepstudy)
seqER(ic = WAIC, mod1, mod2, nmin = 10, id = "Subject", nsims = 10)

## End(Not run)

```

seqERboot

Computes sequential evidence ratios for a given data set and permutation samples

Description

Computes sequential evidence ratios for a given data set as well as for `order_nb` random permutations of this dataset. When data involve repeated measures (and so multiple lines per subject), a column indicating the subject "id" should be provided to the `id` argument. If nothing is passed to the `id` argument, `seqERboot` will suppose that there is only one observation (i.e., one line) per subject.

Usage

```
seqERboot(ic, mod1, mod2, nmin, id = NULL, order_nb)
```

Arguments

<code>ic</code>	Indicates whether to use the <code>aic</code> or the <code>bic</code> .
<code>mod1</code>	A model of class <code>lm</code> or <code>lmerMod</code> .
<code>mod2</code>	A model of class <code>lm</code> or <code>lmerMod</code> (of the same class of <code>mod1</code>).
<code>nmin</code>	Minimum sample size from which start to compute sequential evidence ratios.

id	If applicable (i.e., repeated measures), name of the "id" column of your dataframe, in character string.
order_nb	Number of permutation samples to evaluate.

Author(s)

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See Also

[seqER](#)

Examples

```
## Not run:
data(mtcars)
mod1 <- lm(mpg ~ cyl, mtcars)
mod2 <- lm(mpg ~ cyl + disp, mtcars)
seqERboot(ic = bic, mod1, mod2, nmin = 10, order_nb = 20)
## End(Not run)
```

simER

Simulates sequential testing with evidence ratios

Description

Simulates one or many sequential testing with evidence ratios from independent two-groups comparisons, as a function of sample size and standardized mean difference. Evidence ratios are computed from the so-called Akaike weights from either the Akaike Information Criterion or the Bayesian Information Criterion.

Usage

```
simER(cohensd = 0, nmin = 20, nmax = 100, boundary = 10, nsims = 20,
      ic = bic, cores = 2, verbose = FALSE)
```

Arguments

cohensd	Expected effect size
nmin	Minimum sample size from which start computing ERs
nmax	Maximum sample size at which stop computing ERs
boundary	The Evidence Ratio (or its reciprocal) at which the run is stopped as well
nsims	Number of simulated samples (should be dividable by cores)
ic	Indicates whether to use the aic or the bic
cores	Number of parallel processes. If cores is set to 1, no parallel framework is used (default is two cores).
verbose	Show output about progress

Value

An object of class `data.frame`, which contains...

Author(s)

Ladislav Nalborczyk <<ladislav.nalborczyk@gmail.com>>

See Also

[ictab](#), [analysER](#)

Examples

```
## Not run:
sim <- simER(cohensd = 0.8, nmin = 20, nmax = 100, boundary = 10,
  nsims = 100, ic = bic, cores = 2, verbose = TRUE)
plot(sim, log = TRUE, hist = TRUE)

## End(Not run)
```

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