Package ‘scdhlm’

December 20, 2016

Title Estimating Hierarchical Linear Models for Single-Case Designs

Version 0.3.1

Description Provides a set of tools for estimating hierarchical linear
models and effect sizes based on data from single-case designs.
Functions are provided for calculating standardized mean difference effect sizes that
are directly comparable to standardized mean differences estimated from between-
subjects randomized experiments,
as described in Hedges, Pustejovsky, and Shadish (2012) <DOI:10.1002/jrsm.1052>;
Hedges, Pustejovsky, and Shadish (2013) <DOI:10.1002/jrsm.1086>; and
Pustejovsky, Hedges, and Shadish (2014) <DOI:10.3102/1076998614547577>.
Includes an interactive web interface.

URL https://github.com/jepusto/scdhlm

BugReports https://github.com/jepusto/scdhlm/issues

License GPL-3

VignetteBuilder knitr

LazyData true

Imports stats

Depends nlme, R (>= 3.0.1)

Suggests knitr, markdown, rmarkdown, ggplot2, plyr, boot, parallel,
shiny, testthat

RoxygenNote 5.0.1

NeedsCompilation no

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Repository CRAN

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R topics documented:

`Anglesea` *Example 2 from Hedges, Pustejovsky, & Shadish (2012)*

Description

Data from an ABAB design conducted by Anglesea, Hoch, & Taylor (2008). The variables are as follows:

- `case` Case identifier.
- `condition` Factor indicating baseline or treatment condition
- `phase` Study phase (including both control and treatment condition)
- `session` Measurement occasion
- `outcome` Total seconds of eating time

Format

A data frame with 55 rows and 5 variables

Source

Anglesea, M. M., Hoch, H., & Taylor, B. A. (2008). Reducing rapid eating in teenagers with autism: Use of a pager prompt. *Journal of Applied Behavior Analysis, 41*(1), 107-111. doi:10.1901/jaba.2008.41-107

References

Hedges, L. V., Pustejovsky, J. E., & Shadish, W. R. (2012). A standardized mean difference effect size for single case designs. *Research Synthesis Methods, 3*, 224-239. doi:10.1002/jrsm.1052

`BartonArwood` *Barton-Arwood, Wehby, & Falk (2005)*

Description

Data from a multiple baseline design conducted by Barton-Arwood, Wehby, and Falk (2005). The variables are as follows:

- `case` Participant identifier
- `condition` Factor identifying the phase of the design (A or B)
- `session` Measurement occasion
- `outcome` Oral reading fluency score (words per minute)

Format

A data frame with 143 rows and 4 variables

Source

Barton-Arwood, S. M., Wehby, J. H., & Falk, K. B. (2005). Reading instruction for elementary-age students with emotional and behavioral disorders: Academic and behavioral outcomes. *Exceptional Children, 72*(1), 7-27. doi:10.1177/001440290507200101

Carson — *Carson (2008)*

Description

Data from a BAB design conducted by Carson, Gast, & Ayres (2008). The variables are as follows:

- `case` Participant identifier
- `treatment` Factor describing the treatment condition
- `phase` Numeric descibing the phase of the study design for each case
- `outcome` Outcome scores
- `time` Measurement occasion

Format

A data frame with 47 rows and 5 variables

Source

Carson, K. D., Gast, D. L., & Ayres, K. M. (2008). Effects of a photo activity schedule book on independent task changes by students with intellectual disabilities in community and school job sites. *European Journal of Special Needs Education, 23*, 269-279.

CI_g — *Approximate confidence interval for BC-SMD effect size estimates*

Description

Calculates an approximate confidence interval given a `g_REML` or `g_HPS` object, based on a non-central t approximation.

Usage

```
CI_g(g, cover = 0.95, bound = 35)
```

Arguments

`g`	an estimated effect size object of class `g_REML` or `g_HPS`
`cover`	confidence level
`bound`	numerical tolerance for non-centrality parameter in `qt`.

Value

A vector of upper and lower confidence bounds.

Examples

```
data(Laski)
Laski_RML <- lme(fixed = outcome ~ treatment,
                 random = ~ 1 | case,
                 correlation = corAR1(0, ~ time | case),
                 data = Laski)
Laski_g <- g_REML(Laski_RML, p_const = c(0,1),
                  r_const = c(1,0,1), returnModel=FALSE)
CI_g(Laski_g)

Laski_HPS <- with(Laski, effect_size_MB(outcome, treatment, case, time))
CI_g(Laski_HPS)
```

---

compare_RML_HPS *Run simulation comparing REML and HPS estimates*

Description

Simulates data from a simple linear mixed effects model, then calculates REML and HPS effect size estimators as described in Pustejovsky, Hedges, & Shadish (2014).

Usage

```
compare_RML_HPS(iterations, beta, rho, phi, design, m, n, MB = TRUE)
```

Arguments

`iterations`	number of independent iterations of the simulation
`beta`	vector of fixed effect parameters
`rho`	intra-class correlation parameter
`phi`	autocorrelation parameter
`design`	design matrix. If not specified, it will be calculated based on `m`, `n`, and `MB`.
`m`	number of cases. Not used if `design` is specified.
`n`	number of measurement occasions. Not used if `design` is specified.
`MB`	If true, a multiple baseline design will be used; otherwise, an AB design will be used. Not used if `design` is specified.

Value

A matrix reporting the mean and variance of the effect size estimates and various associated statistics.

References

Pustejovsky, J. E., Hedges, L. V., & Shadish, W. R. (2014). Design-comparable effect sizes in multiple baseline designs: A general modeling framework. *Journal of Educational and Behavioral Statistics, 39*(4), 211-227. doi:10.3102/1076998614547577

Examples

```
compare_RML_HPS(iterations=10, beta = c(0,1,0,0), rho = 0.3,
                phi = 0.5, design=design_matrix(m=3,n=8))
```

---

design_matrix *Create a design matrix for a single-case design*

Description

Create a design matrix containing a linear trend, a treatment effect, and a trend-by-treatment interaction for a single-case design with `m` cases and `n` measurement occasions.

Usage

```
design_matrix(m, n, treat_times = n/2 + 1, center = 0)
```

Arguments

`m`	number of cases
`n`	number of time points
`treat_times`	(Optional) vector of length `m` listing treatment introduction times for each case.
`center`	centering point for time trend.

Value

A design matrix

Examples

```
design_matrix(3, 16, c(5,9,13))
```

effect_size_ABk — *Calculates HPS effect size*

Description

Calculates the HPS effect size estimator based on data from an (AB)^k design, as described in Hedges, Pustejovsky, & Shadish (2012). Note that the data must contain one row per measurement occasion per subject.

Usage

```
effect_size_ABk(outcome, treatment, id, phase, time, phi, rho)
```

Arguments

`outcome`	Vector of outcome data. May not contain any missing values.
`treatment`	Vector of treatment indicators. Must be the same length as `outcome`.
`id`	factor vector indicating unique cases. Must be the same length as `outcome`.
`phase`	factor vector indicating unique phases (each containing one contiguous control condition and one contiguous treatment condition). Must be the same length as `outcome`.
`time`	vector of measurement occasion times. Must be the same length as `outcome`.
`phi`	Optional value of the auto-correlation nuisance parameter, to be used in calculating the small-sample adjusted effect size
`rho`	Optional value of the intra-class correlation nuisance parameter, to be used in calculating the small-sample adjusted effect size

Value

A list with the following components

`M_a`	Matrix reporting the total number of time points with data for all ids, by phase and treatment condition
`M_dot`	Total number of time points used to calculate the total variance (the sum of `M_a`)
`D_bar`	numerator of effect size estimate
`S_sq`	sample variance, pooled across time points and treatment groups
`delta_hat_unadj`	unadjusted effect size estimate
`phi`	corrected estimate of first-order auto-correlation
`sigma_sq_w`	corrected estimate of within-case variance
`rho`	estimated intra-class correlation
`theta`	estimated scalar constant
`nu`	estimated degrees of freedom
`delta_hat`	corrected effect size estimate
`V_delta_hat`	estimated variance of the effect size

Note

If phi or rho is left unspecified (or both), estimates for the nuisance parameters will be calculated.

References

Hedges, L. V., Pustejovsky, J. E., & Shadish, W. R. (2012). A standardized mean difference effect size for single case designs. *Research Synthesis Methods, 3*, 224-239. doi:10.1002/jrsm.1052

Examples

```
data(Lambert)
with(Lambert, effect_size_ABk(outcome, treatment, case, phase, time))

data(Anglesea)
with(Anglesea, effect_size_ABk(outcome, condition, case, phase, session))
```

---

effect_size_MB *Calculates HPS effect size*

Description

Calculates the HPS effect size estimator based on data from a multiple baseline design, as described in Hedges, Pustejovsky, & Shadish (2013). Note that the data must contain one row per measurement occasion per subject.

Usage

```
effect_size_MB(outcome, treatment, id, time, phi, rho)
```

Arguments

`outcome`	Vector of outcome data. May not contain any missing values.
`treatment`	Vector of treatment indicators. Must be the same length as `outcome`.
`id`	factor vector indicating unique cases. Must be the same length as `outcome`.
`time`	vector of measurement occasion times. Must be the same length as `outcome`.
`phi`	Optional value of the auto-correlation nuisance parameter, to be used in calculating the small-sample adjusted effect size
`rho`	Optional value of the intra-class correlation nuisance parameter, to be used in calculating the small-sample adjusted effect size

Value

A list with the following components

g_dotdot	total number of non-missing observations
K	number of time-by-treatment groups containing at least one observation
D_bar	numerator of effect size estimate
S_sq	sample variance, pooled across time points and treatment groups
delta_hat_unadj	unadjusted effect size estimate
phi	corrected estimate of first-order auto-correlation
sigma_sq_w	corrected estimate of within-case variance
rho	estimated intra-class correlation
theta	estimated scalar constant
nu	estimated degrees of freedom
delta_hat	corrected effect size estimate
V_delta_hat	estimated variance of delta_hat

Note

If phi or rho is left unspecified (or both), estimates for the nuisance parameters will be calculated.

References

Hedges, L. V., Pustejovsky, J. E., & Shadish, W. R. (2013). A standardized mean difference effect size for multiple baseline designs across individuals. *Research Synthesis Methods, 4*(4), 324-341. doi:10.1002/jrsm.1086

Examples

```
data(Saddler)
with(subset(Saddler, measure=="writing quality"), effect_size_MB(outcome, treatment, case, time))

data(Laski)
with(Laski, effect_size_MB(outcome, treatment, case, time))
```

---

g_REML *Calculates adjusted REML effect size*

Description

Estimates a design-comparable standardized mean difference effect size based on data from a multiple baseline design, using adjusted REML method as described in Pustejovsky, Hedges, & Shadish (2014). Note that the data must contain one row per measurement occasion per case.

Usage

```
g_REML(m_fit, p_const, r_const, X_design = model.matrix(m_fit, data =
  m_fit$data), Z_design = model.matrix(m_fit$modelStruct$reStruct, data =
  m_fit$data), block = nlme::getGroups(m_fit),
  times = attr(m_fit$modelStruct$corStruct, "covariate"),
  returnModel = TRUE)
```

Arguments

m_fit	Fitted model of class lme, with AR(1) correlation structure at level 1.
p_const	Vector of constants for calculating numerator of effect size. Must be the same length as fixed effects in m_fit.
r_const	Vector of constants for calculating denominator of effect size. Must be the same length as the number of variance component parameters in m_fit.
X_design	(Optional) Design matrix for fixed effects. Will be extracted from m_fit if not specified.
Z_design	(Optional) Design matrix for random effects. Will be extracted from m_fit if not specified.
block	(Optional) Factor variable describing the blocking structure. Will be extracted from m_fit if not specified.
times	(Optional) list of times used to describe AR(1) structure. Will be extracted from m_fit if not specified.
returnModel	(Optional) If true, the fitted input model is included in the return.

Value

A list with the following components

p_beta	Numerator of effect size
r_theta	Squared denominator of effect size
delta_AB	Unadjusted (REML) effect size estimate
nu	Estimated denominator degrees of freedom
kappa	Scaled standard error of numerator
g_AB	Corrected effect size estimate
V_g_AB	Approximate variance estimate
cnvg_warn	Indicator that model did not converge
sigma_sq	Estimated level-1 variance
phi	Estimated autocorrelation
Tau	Vector of level-2 variance components
I_E_inv	Expected information matrix

References

Pustejovsky, J. E., Hedges, L. V., & Shadish, W. R. (2014). Design-comparable effect sizes in multiple baseline designs: A general modeling framework. *Journal of Educational and Behavioral*

Statistics, 39(4), 211-227. doi:10.3102/1076998614547577

Examples

```
data(Laski)
Laski_RML <- lme(fixed = outcome ~ treatment,
                 random = ~ 1 | case,
                 correlation = corAR1(0, ~ time | case),
                 data = Laski)
summary(Laski_RML)
g_REML(Laski_RML, p_const = c(0,1), r_const = c(1,0,1), returnModel=FALSE)

data(Schutte)
Schutte$trt.week <- with(Schutte, unlist(tapply((treatment=="treatment") * week,
         list(treatment,case), function(x) x - min(x))) + (treatment=="treatment"))
Schutte$week <- Schutte$week - 9
Schutte_RML <- lme(fixed = fatigue ~ week + treatment + trt.week,
                   random = ~ week | case,
                   correlation = corAR1(0, ~ week | case),
                   data = subset(Schutte, case != 4))
summary(Schutte_RML)
Schutte_g <- g_REML(Schutte_RML, p_const = c(0,0,1,7), r_const = c(1,0,1,0,0))
summary(Schutte_g)
```

`Info_Expected_lmeAR1` *Calculate expected information matrix*

Description

Calculates the expected information matrix from a fitted linear mixed effects model with AR(1) correlation structure in the level-1 errors.

Usage

```
Info_Expected_lmeAR1(m_fit)
```

Arguments

`m_fit`	Fitted model of class lme, with AR(1) correlation structure at level 1.

Value

Expected Information matrix corresponding to variance components of `m_fit`.

Examples

```
data(Laski)
Laski_RML <- lme(fixed = outcome ~ treatment,
                 random = ~ 1 | case,
                 correlation = corAR1(0, ~ time | case),
                 data = Laski)
Info_Expected_lmeAR1(Laski_RML)
```

Lambert   *Example 1 from Hedges, Pustejovsky, & Shadish (2012)*

Description

Data from an ABAB design conducted by Lambert, Cartledge, Heward, & Lo (2008). The variables are as follows:

- `case`. Student identifier.
- `treatment`. Factor indicating treatment or control condition. SSR = single-subject responding. RC = response cards.
- `phase`. Study phase (including both control and treatment condition)
- `time`. Measurement occasion.
- `outcome`. Intervals with disruptive behavior, as measured by a partial interval recording procedure with 10 ten-second intervals per session.

Format

A data frame with 264 rows and 5 variables

Source

Lambert, M. C., Cartledge, G., Heward, W. L., & Lo, Y. (2006). Effects of response cards on disruptive behavior and academic responding during math lessons by fourth-grade urban students. *Journal of Positive Behavior Interventions, 8*(2), 88-99.

References

Hedges, L. V., Pustejovsky, J. E., & Shadish, W. R. (2012). A standardized mean difference effect size for single case designs. *Research Synthesis Methods, 3*, 224-239. doi:10.1002/jrsm.1052

Laski *Example 2 from Hedges, Pustejovsky, & Shadish (2013)*

Description

Data from a multiple baseline design conducted by Laski, Charlop, & Schreibman (1988). The variables are as follows:

- `case`. Child identifier.
- `outcome`. Frequency of child vocalization, as measured by a partial interval recording procedure with 60 ten-second intervals per session.
- `time`. Measurement occasion.
- `treatment`. Indicator for treatment phase.

Format

A data frame with 128 rows and 4 variables

Source

Laski, K. E., Charlop, M. H., & Schreibman, L. (1988). Training parents to use the natural language paradigm to increase their autistic children's speech. *Journal of Applied Behavior Analysis, 21*(4), 391-400.

References

Hedges, L. V., Pustejovsky, J. E., & Shadish, W. R. (2013). A standardized mean difference effect size for multiple baseline designs across individuals. *Research Synthesis Methods, 4*(4), 324-341. doi:10.1002/jrsm.1086

MB1results *MB1 simulation results*

Description

Simulation results for model MB1 from Pustejovsky, Hedges, & Shadish (2014).

Format

A data frame

References

Pustejovsky, J. E., Hedges, L. V., & Shadish, W. R. (2014). Design-comparable effect sizes in multiple baseline designs: A general modeling framework. *Journal of Educational and Behavioral Statistics, 39*(4), 211-227. doi:10.3102/1076998614547577

`MB1time` *MB1 simulation time*

Description

MB1 simulation time

Format

A data frame

`MB2results` *MB2 simulation results*

Description

Simulation results for model MB2 from Pustejovsky, Hedges, & Shadish (2014).

Format

A data frame

References

Pustejovsky, J. E., Hedges, L. V., & Shadish, W. R. (2014). Design-comparable effect sizes in multiple baseline designs: A general modeling framework. *Journal of Educational and Behavioral Statistics, 39*(4), 211-227. doi:10.3102/1076998614547577

`MB2time` *MB2 simulation time*

Description

MB2 simulation time

Format

A data frame

MB4results — *MB4 simulation results*

Description

Simulation results for model MB4 from Pustejovsky, Hedges, & Shadish (2014).

Format

A data frame

References

Pustejovsky, J. E., Hedges, L. V., & Shadish, W. R. (2014). Design-comparable effect sizes in multiple baseline designs: A general modeling framework. *Journal of Educational and Behavioral Statistics, 39*(4), 211-227. doi:10.3102/1076998614547577

MB4time — *MB4 simulation time*

Description

MB4 simulation time

Format

A data frame

Musser — *Musser (2001)*

Description

Data from a multiple baseline design conducted by Musser, Bray, Kehle, and Jenson (2001). The variables are as follows:

- `student` Participant identifier
- `session` Measurement occasion
- `outcome` Percentage of disruptive intervals
- `treatment` Factor indicating baseline, treatment, or follow-up phase

Format

A data frame with 136 rows and 4 variables

Source

Musser, E. H., Bray, M. A., Kehle, T. J., & Jenson, W. R. (2001). Reducing disruptive behaviors in students with serious emotional disturbance. School Psychology Review, 30(2), 294-304.

`Rodriguez` *Rodriguez & Anderson (2014)*

Description

Data from a multiple baseline design conducted by Rodriguez and Anderson (2014). The variables are as follows:

- `case` Participant identifier
- `condition` Factor identifying the phase of the design (A or B)
- `session` Measurement occasion
- `outcome` Percentage of intervals with problem behavior

Format

A data frame with 148 rows and 4 variables

Source

Rodriguez, B. J., & Anderson, C. M. (2014). Integrating a social behavior intervention during small group academic instruction using a total group criterion intervention. *Journal of Positive Behavior Interventions, 16*(4), 234-245. doi:10.1177/1098300713492858

`Romaniuk` *Romaniuk (2002)*

Description

Data from a treatment reversal design conducted by Romaniuk and colleagues (2002). The variables are as follows:

- `case` Participant identifier
- `phase` Factor identifying the phase of the design
- `condition` Factor identifying the treatment condition
- `session` Measurement occasion
- `outcome` Problem behavior
- `measurement` Character string describing how problem behavior was measured

Format

A data frame with 148 rows and 4 variables

Source

Romaniuk, C., Miltenberger, R., Conyers, C., Jenner, N., Jurgens, M., & Ringenberg, C. (2002). The influence of activity choice on problem behaviors maintained by escape versus attention. *Journal of Applied Behavior Analysis, 35*(4), 349-62. doi:10.1901/jaba.2002.35-349

`Saddler` *Example 1 from Hedges, Pustejovsky, & Shadish (2013)*

Description

Data from a multiple baseline design conducted by Saddler, Behforooz, & Asaro, (2008). The variables are as follows:

- `case` Student identifier
- `measure` Factor indicating the outcome measure (writing quality, T-unit length, number of constructions)
- `outcome` Value of outcome measure.
- `time`. Measurement occasion.
- `treatment`. Factor indicating the treatment phase.

Format

A data frame with 124 rows and 5 variables

Source

Saddler, B., Behforooz, B., & Asaro, K. (2008). The effects of sentence-combining instruction on the writing of fourth-grade students with writing difficulties. *The Journal of Special Education, 42*(2), 79-90. doi:10.1177/0022466907310371

References

Hedges, L. V., Pustejovsky, J. E., & Shadish, W. R. (2013). A standardized mean difference effect size for multiple baseline designs across individuals. *Research Synthesis Methods, 4*(4), 324-341. doi:10.1002/jrsm.1086

scdhlm	*scdhlm*

Description

Standardize mean difference effect size estimation based on hierarchical models for single-case designs.

Details

scdhlm implements methods for estimating a design-comparable standardized mean difference effect size based on data from a single-case design. The following functions are available:

- `g_REML` implements the corrected REML estimator for a fitted `lme` model, as described in Pustejovsky, Hedges, and Shadish (2014).
- `effect_size_MB` implements the HPS estimator for the multiple baseline design, as described in Hedges, Pustejovsky, and Shadish (2013).
- `effect_size_ABk` implements the HPS estimator for the (AB)^k design, as described in Hedges, Pustejovsky, and Shadish (2012).

The package also includes the data used in the examples from each paper, as well as a few other datasets:

- `Lambert`
- `Anglesea`
- `Saddler`
- `Laski`
- `Schutte`
- `Thorne`
- `Carson`

Author(s)

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References

Hedges, L. V., Pustejovsky, J. E., & Shadish, W. R. (2012). A standardized mean difference effect size for single case designs. *Research Synthesis Methods, 3*, 224-239. doi:10.1002/jrsm.1052

Hedges, L. V., Pustejovsky, J. E., & Shadish, W. R. (2013). A standardized mean difference effect size for multiple baseline designs across individuals. *Research Synthesis Methods, 4*(4), 324-341. doi:10.1002/jrsm.1086

Pustejovsky, J. E., Hedges, L. V., & Shadish, W. R. (2014). Design-comparable effect sizes in multiple baseline designs: A general modeling framework. *Journal of Educational and Behavioral Statistics, 39*(4), 211-227. doi:10.3102/1076998614547577

`Schutte` *Example from Pustejovsky, Hedges, & Shadish (2014)*

Description

Data from a multiple baseline design conducted by Schutte, Malouff, & Brown (2008). The variables are as follows:

- `case`. Participant identifier.
- `week`. Measurement occasion.
- `treatment`. Factor indicating baseline or treatment phase.
- `fatigue`. Fatigue severity scale scores.

Format

A data frame with 136 rows and 4 variables

Source

Schutte, N. S., Malouff, J. M., & Brown, R. F. (2008). Efficacy of an emotion-focused treatment for prolonged fatigue. *Behavior Modification, 32*(5), 699-713. doi:10.1177/0145445508317133

References

Pustejovsky, J. E., Hedges, L. V., & Shadish, W. R. (2014). Design-comparable effect sizes in multiple baseline designs: A general modeling framework. *Journal of Educational and Behavioral Statistics, 39*(4), 211-227. doi:10.3102/1076998614547577

`shine_scd` *A shiny interface for the scdhlm package*

Description

An interactive shiny interface for estimating design-comparable standardized mean difference effect sizes from single-case designs. Estimation methods for multiple baseline and treatment reversal designs are available.

Usage

```
shine_scd()
```

simulate.g_REML *Simulate data from a fitted* g_REML *object*

Description

Simulates data from the linear mixed effects model used to estimate the specified standardized mean difference effect size. Suitable for parametric bootstrapping.

Usage

```
## S3 method for class 'g_REML'
simulate(object, nsim = 1, seed = NULL, parallel = FALSE,
  ...)
```

Arguments

object	a g_REML object
nsim	number of models to simulate
seed	seed value. See documentation for simulate
parallel	if TRUE, run in parallel using foreach backend.
...	additional optional arguments

Value

A matrix with one row per simulation, with columns corresponding to the output of g_REML.

Examples

```
data(Laski)
Laski_RML <- lme(fixed = outcome ~ treatment,
                 random = ~ 1 | case,
                 correlation = corAR1(0, ~ time | case),
                 data = Laski)
Laski_g <- g_REML(Laski_RML, p_const = c(0,1), r_const = c(1,0,1))
simulate(Laski_g, nsim = 20)
```

simulate_MB2 *Simulate Model MB2 from Pustejovsky, Hedges, & Shadish (2014)*

Description

Simulates data from a linear mixed effects model, then calculates REML effect size estimator as described in Pustejovsky, Hedges, & Shadish (2014).

Usage

```
simulate_MB2(iterations, beta, rho, phi, tau1_ratio, tau_corr, design, m, n,
  MB = TRUE)
```

Arguments

iterations	number of independent iterations of the simulation
beta	vector of fixed effect parameters
rho	intra-class correlation parameter
phi	autocorrelation parameter
tau1_ratio	ratio of treatment effect variance to intercept variance
tau_corr	correlation between case-specific treatment effects and intercepts
design	design matrix. If not specified, it will be calculated based on `m`, `n`, and `MB`.
m	number of cases. Not used if `design` is specified.
n	number of measurement occasions. Not used if `design` is specified.
MB	If true, a multiple baseline design will be used; otherwise, an AB design will be used. Not used if `design` is specified.

Value

A matrix reporting the mean and variance of the effect size estimates and various associated statistics.

References

Pustejovsky, J. E., Hedges, L. V., & Shadish, W. R. (2014). Design-comparable effect sizes in multiple baseline designs: A general modeling framework. *Journal of Educational and Behavioral Statistics, 39*(4), 211-227. doi:10.3102/1076998614547577

Examples

```
set.seed(8)
simulate_MB2(iterations = 10, beta = c(0,1,0,0), rho = 0.4, phi = 0.5,
             tau1_ratio = 0.5, tau_corr = -0.4, design = design_matrix(m=3, n=8))
set.seed(8)
simulate_MB2(iterations = 10, beta = c(0,1,0,0), rho = 0.4, phi = 0.5,
             tau1_ratio = 0.5, tau_corr = -0.4, m = 3, n = 8, MB = FALSE)
```

simulate_MB4 *Simulate Model MB4 from Pustejovsky, Hedges, & Shadish (2014)*

Description

Simulates data from a linear mixed effects model, then calculates REML effect size estimator as described in Pustejovsky, Hedges, & Shadish (2014).

Usage

```
simulate_MB4(iterations, beta, rho, phi, tau2_ratio, tau_corr, p_const, r_const,
  design, m, n, MB = TRUE)
```

Arguments

`iterations`	number of independent iterations of the simulation
`beta`	vector of fixed effect parameters
`rho`	intra-class correlation parameter
`phi`	autocorrelation parameter
`tau2_ratio`	ratio of trend variance to intercept variance
`tau_corr`	correlation between case-specific trends and intercepts
`p_const`	vector of constants for calculating numerator of effect size
`r_const`	vector of constants for calculating denominator of effect size
`design`	design matrix. If not specified, it will be calculated based on `m`, `n`, and `MB`.
`m`	number of cases. Not used if `design` is specified.
`n`	number of measurement occasions. Not used if `design` is specified.
`MB`	If true, a multiple baseline design will be used; otherwise, an AB design will be used. Not used if `design` is specified.

Value

A matrix reporting the mean and variance of the effect size estimates and various associated statistics.

References

Pustejovsky, J. E., Hedges, L. V., & Shadish, W. R. (2014). Design-comparable effect sizes in multiple baseline designs: A general modeling framework. *Journal of Educational and Behavioral Statistics, 39*(4), 211-227. doi:10.3102/1076998614547577

Examples

```
simulate_MB4(iterations = 10, beta = c(0,1,0,0), rho = 0.8, phi = 0.5,
             tau2_ratio = 0.5, tau_corr = 0,
             p_const = c(0,1,0,7), r_const = c(1,0,1,0,0),
             design = design_matrix(3, 16, treat_times=c(5,9,13), center = 12))
simulate_MB4(iterations = 10, beta = c(0,1,0,0), rho = 0.8, phi = 0.5,
             tau2_ratio = 0.5, tau_corr = 0, m = 6, n = 8)
```

`Thorne` *Thorne (2005)*

Description

Data from an ABAB design conducted by Thorne and Kamps (2008). The variables are as follows:

- `case`. Participant identifier.
- `outcome_desc`. Outcome measure description (academic engagement or inappropriate verbalizations).
- `session`. Measurement occasion.
- `phase_id`. Factor descibing the phase of the study design for each case.
- `phase_indicator`. Indicator variable equal to 1 during intervention phases.
- `outcome`. Outcome scores

Format

A data frame with 776 rows and 6 variables

Source

Thorne, S., & Kamps, D. (2008). The effects of a group contingency intervention on academic engagement and problem behavior of at-risk students. *Behavior Analysis in Practice, 1*(2), 12-18.

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