

# Package ‘scdhlM’

July 8, 2022

**Title** Estimating Hierarchical Linear Models for Single-Case Designs

**Version** 0.6.0

**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](https://doi.org/10.1002/jrsm.1052)>; Hedges, Pustejovsky, and Shadish (2013) <[DOI:10.1002/jrsm.1086](https://doi.org/10.1002/jrsm.1086)>; and Pustejovsky, Hedges, and Shadish (2014) <[DOI:10.3102/1076998614547577](https://doi.org/10.3102/1076998614547577)>. Includes an interactive web interface.

**URL** <https://jepusto.github.io/scdhlM/>

**BugReports** <https://github.com/jepusto/scdhlM/issues>

**License** GPL-3

**VignetteBuilder** knitr

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AlberMorgan

*Alber-Morgan, et al. (2007)*

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**Description**

Data from a multiple baseline design conducted by Alber-Morgan, Ramp, Anderson, & Martin (2007). The variables are as follows:

- case Participant identifier
- condition Factor identifying the phase of the design (baseline or treatment)
- session Measurement occasion
- outcome Number of words read correctly per minute

**Format**

A data frame with 119 rows and 4 variables

**Source**

Alber-Morgan, S. R., Ramp, E. M., Anderson, L. L., & Martin, C. M. (2007). Effects of repeated readings, error correction, and performance feedback on the fluency and comprehension of middle school students with behavior problems. *Journal of Special Education*, 41(1), 17-30. doi:10.1177/00224669070410010201

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Anglesea

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

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**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.2008.41107

**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

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BartonArwood

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

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**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

---

 Bryant2018

*Bryant et al. (2018)*


---

### Description

Data from a multiple baseline across clusters design conducted by Bryant et al. (2018). The variables are as follows:

- Study\_ID. Study identifier.
- school. School identifier.
- case. Student identifier.
- treatment. Indicator for treatment phase.
- session. Measurement occasion.
- session\_trt. Measurement occasion times treatment phase.
- outcome. Texas Early Mathematics Inventory (TEMI-Aim Check) scores.
- session\_c. Measurement occasion centered at the follow-up time.

### Format

A data frame with 536 rows and 8 variables

### Source

Bryant, D. R., Bryant, B. R., Sorelle-Miner, D. A., Falcomata, T. S. & Nozari, M. (2018). Tier 3 intensified intervention for second grade students with severe mathematics difficulties. *Archives of Psychology*, 2(11), 1-24. doi:10.31296/aop.v2i11.86

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 Carson

*Carson (2008)*


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### 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 describing 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.

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CaseHarrisGraham      *Case, Harris, and Graham (1992)*

---

**Description**

Data from a multiple baseline design conducted by Case, Harris, and Graham (1992). The variables are as follows:

- case. Participant identifier.
- session. Measurement occasion.
- condition. Factor identifying the phase of the design (baseline or treatment).
- outcome. Number of subtraction equations and answers correct on each word problem probe.

**Format**

A data frame with 56 rows and 4 variables

**Source**

Case, L. P., Harris, K. R., & Graham, S. (1992). Improving the mathematical problem-solving skills of students with learning disabilities: Self-regulated strategy development. *The Journal of Special Education, 26*(1), 1-19. doi:[10.1177/002246699202600101](https://doi.org/10.1177/002246699202600101)

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CI\_g      *Calculates a confidence interval for a standardized mean difference effect size*

---

**Description**

Calculates a confidence interval given a `g_REML`, a `g_HPS`, or a `g_mlm` object using either a central t distribution (for a symmetric interval) or a non-central t distribution (for an asymmetric interval).

**Arguments**

<code>g</code>	an estimated effect size object of class <code>g_REML</code> , class <code>g_HPS</code> , or class <code>g_mlm</code> .
<code>cover</code>	confidence level
<code>bound</code>	numerical tolerance for non-centrality parameter in <code>qt</code> .
<code>symmetric</code>	If TRUE (the default), use a symmetric confidence interval. If FALSE, use a non-central t approximation to obtain an asymmetric confidence interval.

**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_REML <- suppressWarnings(
  g_REML(Laski_RML, p_const = c(0,1),
         r_const = c(1,0,1), returnModel = FALSE)
)
CI_g(Laski_g_REML, symmetric = TRUE)
CI_g(Laski_g_REML, symmetric = FALSE)

Laski_HPS <- with(Laski, effect_size_MB(outcome, treatment, case, time))
CI_g(Laski_HPS, symmetric = FALSE)

Laski_g_mlm <- g_mlm(mod = Laski_RML, p_const = c(0,1), r_const = c(1,0,1))
CI_g(Laski_g_mlm, symmetric = FALSE)
```

---

 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))
```

---

Datchuk

*Datchuk (2016)*

---

**Description**

Data from a multiple baseline design conducted by Datchuk (2016). The variables are as follows:

- case. Participant identifier.
- session. Measurement occasion.
- condition. Factor identifying the phase of the design (baseline or treatment).
- outcome. Correct word sequences per minute.

**Format**

A data frame with 74 rows and 4 variables

**Source**

Datchuk, S. M. (2016). Writing simple sentences and descriptive paragraphs: Effects of an intervention on adolescents with writing difficulties. *Journal of Behavioral Education*, 25(2), 166-188. doi:10.1007/s108640159236x



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DelemereDounavi      *Delemere & Dounavi (2018)*

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### Description

Data from a multiple baseline design conducted by Delemere & Dounavi (2018). The variables are as follows:

- `intervention`. Type of intervention received: bedtime fading or positive routines.
- `case`. Participant identifier.
- `session`. Measurement occasion.
- `condition`. Factor identifying the phase of the design (baseline or treatment).
- `outcome`. Total sleep onset latency in minutes across nights.

### Format

A data frame with 187 rows and 5 variables

### Source

Delemere, E., & Dounavi, K. (2018). Parent-implemented bedtime fading and positive routines for children with autism spectrum disorders. *Journal of Autism and Developmental Disorders*, 48(4), 1002-1019. doi:[10.1007/s1080301733984](https://doi.org/10.1007/s1080301733984)

---

`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

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

**Value**

A design matrix

**Examples**

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

---

effect_size_ABk	<i>Calculates HPS effect size</i>
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**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,
  data = NULL,
  phi = NULL,
  rho = NULL
)
```

**Arguments**

outcome	vector of outcome data or name of variable within data. May not contain any missing values.
treatment	vector of treatment indicators or name of variable within data. Must be the same length as outcome.
id	factor vector indicating unique cases or name of variable within data. Must be the same length as outcome.
phase	factor vector indicating unique phases (each containing one contiguous control condition and one contiguous treatment condition) or name of variable within data. Must be the same length as outcome.
time	vector of measurement occasion times or name of variable within data. Must be the same length as outcome.
data	(Optional) dataset to use for analysis. Must be data.frame.
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)
effect_size_ABk(outcome = outcome, treatment = treatment, id = case,
                phase = phase, time = time, data = Lambert)

data(Anglesea)
effect_size_ABk(outcome = outcome, treatment = condition, id = case,
                phase = phase, time = session, data = Anglesea)
```

---

effect_size_MB	<i>Calculates HPS effect size</i>
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---

**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,
  data = NULL,
  phi = NULL,
  rho = NULL
)
```

**Arguments**

outcome	vector of outcome data or name of variable within data. May not contain any missing values.
treatment	vector of treatment indicators or name of variable within data. Must be the same length as outcome.
id	factor vector indicating unique cases or name of variable within data. Must be the same length as outcome.
time	vector of measurement occasion times or name of variable within data. Must be the same length as outcome.
data	(Optional) dataset to use for analysis. Must be data.frame.
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)
effect_size_MB(outcome = outcome, treatment = treatment, id = case,
               time = time, data = subset(Saddler, measure=="writing quality"))

data(Laski)
effect_size_MB(outcome = outcome, treatment = treatment, id = case,
               time = time, data = Laski)
```

---

graph\_SCD

*Graph Single Case Design Data*

---

## Description

Graphs single case design data for treatment reversal and multiple baseline designs.

## Usage

```
graph_SCD(
  design,
  case,
  phase,
  session,
  outcome,
  cluster = NULL,
  series = NULL,
  treatment_name = NULL,
  model_fit = NULL,
  data = NULL
)
```

## Arguments

design	Character string to specify whether data comes from a treatment reversal ("TR"), multiple baseline across participants ("MBP"), replicated multiple baseline across behaviors ("RMBB"), or clustered multiple baseline across participants ("CMB").
case	vector of case indicators or name of a character or factor vector within data indicating unique cases.
phase	vector of treatment indicators or name of a character or factor vector within data indicating unique treatment phases.

session	vector of measurement occasions or name of numeric vector within data of measurement times.
outcome	vector of outcome data or name of numeric vector of outcome data within data.
cluster	(Optional) vector of cluster indicators or name of a character or factor vector within data indicating clusters.
series	(Optional) vector of series indicators or name of a character or factor vector within data indicating series.
treatment_name	(Optional) character string corresponding to the name of the treatment phase.
model_fit	(Optional) lme fitted model that adds predicted values to graph
data	(Optional) dataset to use for analysis. Must be a data.frame.

**Value**

A ggplot graph

**Note**

If treatment\_name is left null it will choose the second level of the phase variable to be the treatment phase.

**Examples**

```
if (requireNamespace("ggplot2", quietly = TRUE)) {

data(Anglesea)
graph_SCD(design="TR",
          case=case, phase=condition,
          session=session, outcome=outcome,
          treatment_name = "treatment",
          data=Anglesea)

data(BartonArwood)
graph_SCD(design="MBP",
          case=case, phase=condition,
          session=session, outcome=outcome,
          treatment_name = "B",
          data=BartonArwood)

data(Thiemann2001)
graph_SCD(design="RMBB",
          case=case, series = series, phase=treatment,
          session=time, outcome=outcome,
          treatment_name = "treatment",
          data=Thiemann2001)

data(Bryant2018)
graph_SCD(design="CMB",
          cluster=school, case=case, phase=treatment,
          session=session, outcome=outcome,
```

```

    treatment_name = "treatment",
    data=Bryant2018)
}

```

GunningEspie

*Gunning & Espie (2003)***Description**

Data from a multiple baseline design conducted by Gunning & Espie (2003). The variables are as follows:

- case. Participant identifier.
- session. Measurement occasion.
- condition. Factor identifying the phase of the design (baseline or treatment).
- outcome. Sleep onset latency in minutes.

**Format**

A data frame with 301 rows and 4 variables

**Source**

Gunning, M. J., & Espie, C.A. (2003). Psychological treatment of reported sleep disorder in adults with intellectual disability using a multiple baseline design. *Journal of Intellectual Disability Research*, 47(3), 191-202. doi:10.1046/j.13652788.2003.00461.x

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

---

lmeInfo

*lmeInfo*

---

**Description**

Functions imported from the lmeInfo package.

- [extract\\_varcomp](#)
- [g\\_mlm](#)
- [varcomp\\_vcov](#)

---

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	<i>MB1 simulation time</i>
---------	----------------------------

---

**Description**

MB1 simulation time

**Format**

A data frame

---

MB2results	<i>MB2 simulation results</i>
------------	-------------------------------

---

**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	<i>MB2 simulation time</i>
---------	----------------------------

---

**Description**

MB2 simulation time

**Format**

A data frame

---

MB4results	<i>MB4 simulation results</i>
------------	-------------------------------

---

**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](https://doi.org/10.3102/1076998614547577)

---

MB4time	<i>MB4 simulation time</i>
---------	----------------------------

---

**Description**

MB4 simulation time

**Format**

A data frame

---

Musser	<i>Musser (2001)</i>
--------	----------------------

---

**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.

---

Peltier

*Peltier et al. (2020)*

---

**Description**

Data from a multiple baseline design conducted by Peltier, Sinclair, Pulos, & Suk (2020). The variables are as follows:

- case. Participant identifier.
- session. Measurement occasion.
- condition. Factor identifying the phase of the design (baseline or treatment).
- outcome. Mathematical problem-solving performance (percentage).

**Format**

A data frame with 232 rows and 4 variables

**Source**

Peltier, C., Sinclair, T. E., Pulos, J. M., & Suk, A. (2020). Effects of schema-based instruction on immediate, generalized, and combined structured word problems. *The Journal of Special Education*, 54(2), 101-112. doi:10.1177/0022466919883397

---

phase\_pairs

*Calculate phase-pairs for a unique case*

---

**Description**

Calculate phase-pairs based on phases and session numbering.

**Usage**

```
phase_pairs(phase, session = seq_along(phase))
```

**Arguments**

phase	vector of treatment indicators or a character or factor vector indicating unique treatment phases.
session	numeric vector of measurement occasions.

**Examples**

```

phases <- rep(c("A","B","A","B"), each = 4)
sessions <- 1:length(phases)

phase_pairs(phases, sessions)

phases <- rep(c("A","B","C","A","B","C","D"), each = 4)
phase_pairs(phases)

phases <- rep(c("B","A","C","B","A","B","C","A"), each = 4)
phase_pairs(phases)

```

---

```

preprocess_SCD      Clean Single Case Design Data

```

---

**Description**

Clean single case design data for treatment reversal and multiple baseline designs.

**Usage**

```

preprocess_SCD(
  design,
  case,
  phase,
  session,
  outcome,
  cluster = NULL,
  series = NULL,
  center = 0,
  round_session = TRUE,
  treatment_name = NULL,
  data = NULL
)

```

**Arguments**

design	Character string to specify whether data comes from a treatment reversal ("TR"), multiple baseline across participants ("MBP"), replicated multiple baseline across behaviors ("RMBB"), or clustered multiple baseline across participants ("CMB").
case	vector of case indicators or name of a character or factor vector within data indicating unique cases.
phase	vector of treatment indicators or name of a character or factor vector within data indicating unique treatment phases.

<code>session</code>	vector of measurement occasions or name of numeric vector within data of measurement times.
<code>outcome</code>	vector of outcome data or name of numeric vector of outcome data within data.
<code>cluster</code>	(Optional) vector of cluster indicators or name of a character or factor vector within data indicating clusters.
<code>series</code>	(Optional) vector of series indicators or name of a character or factor vector within data indicating series.
<code>center</code>	Numeric value for the centering value for session. Default is 0.
<code>round_session</code>	Logical indicating whether to round session to the nearest integer. Defaults to TRUE.
<code>treatment_name</code>	(Optional) character string corresponding to the name of the treatment phase.
<code>data</code>	(Optional) dataset to use for analysis. Must be a <code>data.frame</code> .

**Value**

A cleaned SCD dataset that can be used for model fitting and effect size calculation.

**Note**

If `treatment_name` is left null it will choose the second level of the phase variable to be the treatment phase.

**Examples**

```
data(Laski)
preprocess_SCD(design = "MBP",
               case = case, phase = treatment,
               session = time, outcome = outcome,
               center = 4, data = Laski)
```

```
data(Anglesea)
preprocess_SCD(design="TR",
               case=case, phase=condition,
               session=session, outcome=outcome,
               treatment_name = "treatment",
               data=Anglesea)
```

```
data(Thiemann2001)
preprocess_SCD(design = "RMBB",
               case = case, series = series, phase = treatment,
               session = time, outcome = outcome,
               data = Thiemann2001)
```



---

Rodgers

*Rodgers et al. (2021)*

---

### Description

Data from a multiple baseline design conducted by Rodgers, Datchuk, & Rila (2021). The variables are as follows:

- case. Participant identifier.
- session. Measurement occasion.
- condition. Factor identifying the phase of the design (baseline or treatment).
- outcome. The number of correct writing sequences in 1 minute.

### Format

A data frame with 83 rows and 4 variables

### Source

Rodgers, D. B., Datchuk, S. M., & Rila, A. L. (2021). Effects of a text-writing fluency intervention for postsecondary students with intellectual and developmental disabilities. *Exceptionality*, 29(4), 310-325. doi:10.1080/09362835.2020.1850451

---

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.2002.35349

---

 Ruiz

*Ruiz, et al. (2020)*


---

### Description

Data from a multiple baseline design conducted by Ruiz, Luciano, Florez, Suarez-Falcon, & Cardona-Betancourt (2020). The variables are as follows:

- case. Participant identifier.
- measure. Outcome measure description (AAQ-II, ANXIETY, CFQ, DASS-TOTAL, DEPRESSION, PSWQ, PTQ, STRESS, VQ-OBSTRUCTION, or VQ-PROGRESS).
- treatment Factor indicating baseline, treatment, post, or follow-up phase.
- time. Measurement occasion.
- outcome. Outcome scores.

### Format

A data frame with 840 rows and 5 variables

**Source**

Ruiz, F., Luciano, C., Florez, C., Suarez-Falcon, J., & Cardona-Betancourt, V. (2020). A Multiple-Baseline Evaluation of Acceptance and Commitment Therapy Focused on Repetitive Negative Thinking for Comorbid Generalized Anxiety Disorder and Depression. *Frontiers in Psychology*, 11. doi:10.3389/fpsyg.2020.00356

---

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

---

Salazar

*Salazar, et al. (2020)*

---

### Description

Data from a multiple baseline design conducted by Salazar, Ruiz, Ramírez1, & Cardona-Betancourt (2020). The variables are as follows:

- case. Participant identifier.
- measure. Outcome measure description (AFQ-Y, PTQ-C, or GPQ-C).
- treatment Factor indicating baseline, treatment, post, or follow-up phase.
- time. Measurement occasion.
- outcome. Outcome scores.

### Format

A data frame with 324 rows and 5 variables

### Source

Salazar, D., Ruiz, F., Ramírez, E., & Cardona-Betancourt, V. (2020). Acceptance and Commitment Therapy Focused on Repetitive Negative Thinking for Child Depression: A Randomized Multiple-Baseline Evaluation. *The Psychological Record*. doi:10.1007/s40732019003625

---

Schutte

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

---

### Description

Data from a multiple baseline design conducted by Schutte, Malouff, & Brown (2008). Case 4 is excluded because nearly all of these measurements are at the upper extreme of the scale. 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

---

session\_by\_treatment    *Calculate session-by-treatment interactions for a unique case*

---

**Description**

Calculate session-by-treatment interactions based on phases and session numbering.

**Usage**

```
session_by_treatment(phase, session, trt_phase)
```

**Arguments**

phase	vector of treatment indicators or a character or factor vector indicating unique treatment phases.
session	numeric vector of measurement occasions.
trt_phase	character string indicating the phase value corresponding to the treatment condition.

---

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(dataset = NULL, ...)
```

**Arguments**

`dataset`            Optionally, a data.frame or path to a file from which to read data. If specified, the app will open with the data loaded. Default is NULL. If `dataset` is a data.frame, then it will be passed directly. If a file path with a `.xlsx` extension is specified, it will be read using `read_excel`. If a file path with a `.csv` extension is specified, it will be read using `read.csv`. If a file path with a different extension is specified, it will be read using `read.table`.

`...`                Further arguments passed to `read_excel`, `read.csv`, or `read.table`.

**Examples**

```
## Not run:
shine_scd()
data(Laski)
shine_scd(dataset = Laski)
shine_scd(dataset = "SCD_data.xlsx", sheet = "Laski")
shine_scd(dataset = "Laski.csv")

## End(Not run)
```

---

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)

suppressWarnings(
  Laski_g <- g_REML(Laski_RML, p_const = c(0,1), r_const = c(1,0,1))
)

if (requireNamespace("plyr", quietly = TRUE)) {
  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 = 5, 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 = 5, 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 = 5, 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 = 5, beta = c(0,1,0,0), rho = 0.8, phi = 0.5,
             tau2_ratio = 0.5, tau_corr = 0, m = 6, n = 8)

```

---

Thiemann2001

*Thiemann & Goldstein (2001)*

---

### Description

Data from a multiple baseline across behaviors design conducted by Thiemann & Goldstein (2001). The variables are as follows:

- Study\_ID. Study identifier.
- case. Student identifier.
- series. Series identifier.
- outcome. Frequency of coded social communication skills, as measured by a direct observation coding system with 15-second intervals recoding for the occurrence of any of the four social measures: contingent responses, securing attention, initiating comments, and initiating requests.
- time. Measurement occasion.
- treatment. Indicator for treatment phase.
- trt\_time. Measurement occasion times treatment phase.
- time\_c. Measurement occasion centered at the follow-up time.

### Format

A data frame with 363 rows and 8 variables

### Source

Thiemann, K.S., & Goldstein, H. (2001). Social stories, written text cues, and video feedback: effects on social communication of children with Autism. *Journal of Applied Behavior Analysis*, 34(4), 425-446. doi:10.1901/jaba.2001.34425

---

Thiemann2004

*Thiemann & Goldstein (2004)*

---

### Description

Data from a multiple baseline across behaviors design conducted by Thiemann & Goldstein (2004). The variables are as follows:

- Study\_ID. Study identifier.
- case. Student identifier.
- series. Series identifier.

- `outcome`. Frequency of unprompted targeted social communication skills, as measured by a direct observation, paper and pencil coding system during the 10-minute social activity for each behavior for all sessions.
- `time`. Measurement occasion.
- `treatment`. Indicator for treatment phase.
- `trt_time`. Measurement occasion times treatment phase.
- `time_c`. Measurement occasion centered at the follow-up time.

### Format

A data frame with 408 rows and 8 variables

### Source

Thiemann, K.S., & Goldstein, H. (2004). Effects of peer training and written text cueing on social communication of school-age children with pervasive developmental disorder. *Journal of Speech Language and Hearing Research*, 47(1), 126-144. doi:10.1044/10924388(2004/012)

---

Thorne

*Thorne (2005)*

---

### Description

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

- `case`. Participant identifier.
- `measure`. Outcome measure description (academic engagement or inappropriate verbalizations).
- `session`. Measurement occasion.
- `phase_id`. Categorical variable describing the phase of the study design for each case.
- `condition`. Categorical variable describing whether each phase is a baseline (A) phase or intervention (B) phase.
- `phase_indicator`. Indicator variable equal to 1 during intervention phases.
- `outcome`. Outcome scores

### Format

A data frame with 776 rows and 7 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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