

Package ‘bmlm’

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Title Bayesian Multilevel Mediation

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Description Easy estimation of Bayesian multilevel mediation models with Stan.

URL <https://github.com/mvuorre/bmlm/>

BugReports <https://github.com/mvuorre/bmlm/issues/>

License GPL (>= 3)

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Biarch true

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bmlm-package	<i>bmlm: Easy estimation of Bayesian multilevel mediation models with Stan.</i>
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Description

See <https://mvuorre.github.io/bmlm/> for a short tutorial.

BLch9	<i>Relationship between work stressors, work dissatisfaction, and relationship dissatisfaction.</i>
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Description

Simulated data from Intensive Longitudinal Methods: An Introduction to Diary and Experience Sampling Research. (Bolger, & Laurenceau, 2013, chapter 9; <http://www.intensivelongitudinal.com/index.html>).

Usage

```
data(BLch9)
```

Format

A data frame with 2100 rows and 8 variables:

id ID of study participant

time Time

fwkstrs Number of work stressors

fwkdis Work dissatisfaction rating

freldis Relationship dissatisfaction

x Subject-mean deviated number of work stressors

m Subject-mean deviated work dissatisfaction rating

y Subject-mean deviated relationship dissatisfaction

Source

<http://www.intensivelongitudinal.com/datasets.html>

isolate *Create isolated within- (and optionally between-) person variables.*

Description

Creates variables that represent pure within- and between-person predictors.

Usage

```
isolate(d = NULL, by = NULL, value = NULL, z = FALSE, which = "within")
```

Arguments

d	A data.frame.
by	A vector of values in d by which the data is clustered. i.e. a vector of unique participant IDs.
value	Names of columns in d to isolate. Multiple values can be given by value = c("var1", "var2", "var3")
z	Should the created values be standardized (defaults to FALSE).
which	Which component to return. "within" (default) returns within-person deviations only; "between" returns between-person means only; "both" returns both.

Value

A data.frame with additional columns for the within- and between-person variables. The new columns are labelled `_cw` for centered-within and `_cb` for centered-between.

Author(s)

Matti Vuorre <mv2521@columbia.edu>

Examples

```
# Create within-person deviations of work stressors in BLch9.
data(BLch9)
BLch9 <- isolate(BLch9, by = "id", value = "fwkstrs")
head(BLch9) # Now has new column for within-person work stressors.
```

MEC2010

Judgments of performance in a video game

Description

Data from an experiment where participants rated their performance in a video game in two conditions. (Experiment 1 in Metcalfe, Eich, & Castel, 2010; <https://www.sciencedirect.com/science/article/pii/S0010027710001113>).

Usage

```
data(MEC2010)
```

Format

A data frame with 344 rows and 4 variables:

subj Subject id number.

lag Lag condition (0 = no lag, 1 = 250ms lag).

hr Hit rate.

jop Judgment of Performance.

Source

Metcalfe, J., Eich, T. S., & Castel, A. D. (2010). Metacognition of agency across the lifespan. *Cognition*, 116(2), 267-282. doi:10.1016/j.cognition.2010.05.009

mlm

Estimate a multilevel mediation model

Description

Estimates a Bayesian multilevel mediation model using Stan.

Usage

```
mlm(  
  d = NULL,  
  id = "id",  
  x = "x",  
  m = "m",  
  y = "y",  
  priors = NULL,  
  binary_y = FALSE,  
  ...  
)
```

Arguments

<code>d</code>	A <code>data.frame</code> or a <code>data_frame</code> .
<code>id</code>	Column of participant IDs in data.
<code>x</code>	Column of X values in data.
<code>m</code>	Column of M values in data.
<code>y</code>	Column of Y values in data.
<code>priors</code>	A list of named values to be used as the prior scale parameters. See details.
<code>binary_y</code>	Set to <code>TRUE</code> if <code>y</code> is binary and should be modelled with logistic regression. Defaults to <code>FALSE</code> (<code>y</code> treated as continuous.) This feature is experimental.
<code>...</code>	Other optional parameters passed to <code>rstan::stan()</code> .

Details

Draw samples from the joint posterior distribution of a multilevel mediation model using Stan.

Priors:

Users may pass a list of named values for the `priors` argument. The values will be used to define the scale parameter of the respective prior distributions. This list may specify some or all of the following parameters:

dy, dm Regression intercepts (for Y and M as outcomes, respectively.)

a, b, cp Regression slopes.

tau_x Varying effects SDs for above parameters (e.g replace `x` with `a`.)

lkj_shape Shape parameter for the LKJ prior.

See examples for specifying the following: Gaussian distributions with $SD = 10$ as priors for the intercepts, Gaussians with $SD = 2$ for the slopes, Half-Cauchy distributions with scale parameters 1 for the varying effects SDs, and an LKJ prior of 2.

Value

An object of S4 class `stanfit`, with all its available methods.

Author(s)

Matti Vuorre <mv2521@columbia.edu>

Examples

```
## Not run:
## Run example from Bolger and Laurenceau (2013)
data(BLch9)
fit <- mlm(BLch9)
mlm_summary(fit)

### With priors
Priors <- list(dy = 10, dm = 10, a = 2, b = 2, cp = 2,
              tau_dy = 1, tau_dm = 1, tau_a = 1, tau_b = 1, tau_cp = 1,
```

```

      lkj_shape = 2)
fit <- mlm(BLch9, priors = Priors)

## End(Not run)

```

mlm_pars_plot

Plot estimated parameters of multilevel mediation model

Description

Plot the model's estimated parameters as histograms or a coefficient plot.

Usage

```

mlm_pars_plot(
  mod = NULL,
  type = "hist",
  color = "black",
  p_shape = 15,
  p_size = 1.2,
  level = 0.95,
  nrow = 3,
  pars = c("a", "b", "cp", "covab", "me", "c", "pme")
)

```

Arguments

mod	A Stanfit model estimated with <code>mlm()</code> .
type	Type of the plot, <code>hist</code> , <code>coef</code> , or <code>violin</code> .
color	Color (and fill) for plots.
p_shape	Shape of points for <code>coefplot</code> .
p_size	Size of points for <code>coefplot</code> .
level	X level for Credible Intervals. (Defaults to <code>.95</code> .)
nrow	Number of rows for multiple histograms.
pars	Which parameters to plot.

Details

The point estimate for the coefficient plot is the posterior mean.

Value

A `ggplot2` object.

Author(s)

Matti Vuorre <mv2521@columbia.edu>

mlm_path_plot	<i>Plot bmlm's mediation model as a path diagram</i>
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Description

Plots a path diagram for an estimated multilevel mediation model.

Usage

```
mlm_path_plot(
  mod = NULL,
  xlab = "X",
  ylab = "Y",
  mlab = "M",
  level = 0.95,
  random = TRUE,
  text = FALSE,
  id = NULL,
  digits = 2,
  ...
)
```

Arguments

mod	A Stanfit model estimated with <code>mlm()</code> .
xlab	Label for X
ylab	Label for Y
mlab	Label for M
level	"Confidence" level for credible intervals. (Defaults to .95.)
random	Should the "random" effects SDs be displayed? (Default = TRUE)
text	Should additional parameter values be displayed? (Defaults to FALSE.)
id	Plot an individual-level path diagram by specifying ID number.
digits	Number of significant digits to show on graph. (Default = 2.)
...	Other arguments passed on to <code>qgraph::qgraph()</code> .

Details

Plots a path diagram of the mediation model, with estimated parameter values and credible intervals. Can also be used to draw a template diagram of the mediation model by not specifying input to the `mod` argument.

To modify various settings of the underlying `qgraph` object, see [qgraph](#).

Value

A `qgraph` object.

Author(s)

Matti Vuorre <mv2521@columbia.edu>

Examples

```
# Draw a template path diagram of the mediation model
mlm_path_plot()
```

mlm_spaghetti_plot *Plot fitted values of M and Y from multilevel mediation model*

Description

Plot population-level fitted values and X values, for M and Y.

Usage

```
mlm_spaghetti_plot(
  mod = NULL,
  d = NULL,
  id = "id",
  x = "x",
  m = "m",
  y = "y",
  level = 0.95,
  n = 12,
  binary_y = FALSE,
  mx = "fitted",
  fixed = TRUE,
  random = TRUE,
  h_jitter = 0,
  v_jitter = 0,
  bar_width = 0.2,
  bar_size = 0.75,
  n_samples = NA
)
```

Arguments

mod	A multilevel mediation model estimated with <code>mlm()</code> .
d	A <code>data.frame</code> or a <code>data_frame</code> used in fitting model.
id	Name of id variable (identifying subjects) in data (d).
x	Name of X variable in data.
m	Name of M variable in data.
y	Name of Y variable in data.

level	X level for Credible Intervals. (Defaults to .95.)
n	Number of points along X to evaluate fitted values on. See details.
binary_y	Set to TRUE if the outcome variable (Y) is 0/1.
mx	Should the X axis of the M-Y figure be "fitted" values, or "data" values. Defaults to "fitted".
fixed	Should the population-level ("fixed") fitted values be shown?
random	Should the subject-level ("random") fitted values be shown?
h_jitter	Horizontal jitter of points. Defaults to 0.
v_jitter	Vertical jitter of points. Defaults to 0.
bar_width	Width of the error bars. Defaults to 0.2.
bar_size	Thickness of the error bars. Defaults to 0.75.
n_samples	Number of MCMC samples to use in calculating fitted values. See details.

Details

If $n = 2$, the fitted values will be represented as points with X line with a Confidence Ribbon instead. If a very large model is fitted with a large number of MCMC iterations, the function might take a long time to run. In these cases, users can set `n_samples` to a smaller value (e.g. 1000), in which case the fitted values (and the CIs) will be based on a random subset of `n_samples` MCMC samples. The default value is NA, meaning that all MCMC samples are used.

Value

A list of two ggplot2 objects.

Author(s)

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mlm_summary

Print a summary of the estimated multilevel mediation model

Description

Prints the estimated parameters (numerical summaries of the marginal posterior distributions).

Usage

```
mlm_summary(
  mod = NULL,
  level = 0.95,
  pars = c("a", "b", "cp", "me", "c", "pme"),
  digits = 2
)
```

Arguments

<code>mod</code>	A <code>stanfit</code> object obtained from <code>mlm()</code>
<code>level</code>	"Confidence" level; Defines the limits of the credible intervals. Defaults to .95 (i.e. displays 95% CIs.)
<code>pars</code>	Parameters to summarize. Defaults to main average-level parameters. See Details for more information.
<code>digits</code>	How many decimal points to display in the output. Defaults to 2.

Details

After estimating a model (drawing samples from the joint posterior probability distribution) with `mlm()`, show the estimated results by using `mlm_summary(fit)`, where `fit` is an object containing the fitted model.

The function shows, for each parameter specified with `pars`, the posterior mean, and limits of the Credible Interval as specified by `level`. For example, `level = .91` shows a 91% Credible Interval, which summarizes the central 91% mass of the marginal posterior distribution.

Parameters: By default, `mlm()` estimates and returns a large number of parameters, including the varying effects, and their associated standard deviations. However, `mlm_summary()` by default only displays a subset of the estimated parameters:

- a** Regression slope of the X -> M relationship.
- b** Regression slope of the M -> Y relationship.
- cp** Regression slope of the X -> Y relationship. (Direct effect.)
- me** Mediated effect ($a * b + \sigma_{a_j b_j}$).
- c** Total effect of X on Y. ($cp + me$)
- pme** Percent mediated effect.

The user may specify `pars = NULL` to display all estimated parameters. Other options include e.g. `pars = "tau"` to display the varying effects' standard deviations. To display all the group-level parameters (also known as random effects) only, specify `pars = "random"`. With this argument, `mlm_summary()` prints the following parameters:

- tau_a** Standard deviation of subject-level `a_js`.
- tau_b** Standard deviation of subject-level `b_js`.
- tau_cp** Standard deviation of subject-level `c\ '_js`.
- covab** Estimated covariance of `a_j` and `b_js`.
- corrab** Estimated correlation of `a_j` and `b_js`.

To learn more about the additional parameters, refer to the Stan code (`cat(get_stancode(fit))`).

Value

A data.frame summarizing the estimated multilevel mediation model:

- Parameter** Name of parameter
- Mean** Mean of parameter's posterior distribution.
- Median** Median of parameter's posterior distribution.

SE Standard deviation of parameter's posterior distribution.

ci_lwr The lower limit of Credible Intervals.

ci_upr The upper limit of Credible Intervals.

n_eff Number of efficient samples.

Rhat Should be 1.00.

Author(s)

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