Package 'multilevelcoda'

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Title Estimate Bayesian Multilevel Models for Compositional Data

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https://github.com/florale/multilevelcoda

BugReports https://github.com/florale/multilevelcoda/issues

Description Implement Bayesian Multilevel Modelling for compositional data in a multilevel framework. Compute multilevel compositional data and Isometric log ratio (ILR) at between and within-person levels, fit Bayesian multilevel models for compositional predictors and outcomes, and run post-hoc analyses such as isotemporal substitution models.

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R topics documented:

`basesub` *Base Pairwise Substitution*

Description

Makes a data set of all possible pairwise substitution of a composition which can be used as the base for substitution models.

Usage

```
basesub(parts)
```

Arguments

`parts`	A character vector specifying the names of compositional variables to be used.

Value

A data table of all possible pairwise substitution.

Examples

```
data(mcompd)

ps <- basesub(parts = c("TST", "WAKE", "MVPA", "LPA", "SB"))
ps2 <- basesub(c("WAKE", "MVPA", "LPA", "SB"))

print(ps2)

## cleanup
rm(mcompd, ps1, ps2)
```

brmcoda *Fit Bayesian generalised (non-)linear multilevel compositional model via full Bayesian inference using brms,*

Description

This function fits a brm model with multilevel ILR coordinates.

Usage

```
brmcoda(compilr, formula, ...)
```

Arguments

compilr	A compilr object containing data of composition, ILR coordinates, and other variables used in the model.
formula	A object of class formula, brmsformula: A symbolic description of the model to be fitted. Details of the model specification can be found in brmsformula.
...	Further arguments passed to brm.

Value

A list with two elements

- CompIlr An object of class compilr used in the brm model.
- Model An object of class brmsfit, which contains the posterior draws along with many other useful information about the model.

Examples

```
data(mcompd)
data(sbp)
cilr <- compilr(data = mcompd, sbp = sbp,
        parts = c("TST", "WAKE", "MVPA", "LPA", "SB"), idvar = "ID")

# inspects ILRs before passing to brmcoda
names(cilr$BetweenILR)
names(cilr$WithinILR)
names(cilr$TotalILR)

# model with compositional predictor at between and within-person levels
m1 <- brmcoda(compilr = cilr,
 formula = STRESS ~ bilr1 + bilr2 + bilr3 + bilr4 +
 wilr1 + wilr2 + wilr3 + wilr4 + (1 | ID),
             chain = 1, iter = 500)

# model with compositional outcome
```

```
m2 <- brmcoda(compilr = cilr,
 formula = mvbind(ilr1, ilr2, ilr3, ilr4) ~ STRESS + Female + (1 | ID),
 chain = 1, iter = 500)
```

---

bsub *Between-person Basic Substitution Model.*

Description

Estimate the difference in outcomes when compositional parts are substituted for specific unit(s) at between-person level. The bsub output encapsulates the substitution results for all compositional parts present in the brmcoda object.

Notes: The reference composition for substitution model is the compositional mean of the dataset provided. For average marginal effect, use bsubmargins.

Usage

```
bsub(
  object,
  delta,
  basesub,
  regrid = NULL,
  summary = TRUE,
  level = "between",
  type = "conditional",
  ...
)
```

Arguments

object	A fitted brmcoda object. Required.
delta	A integer, numeric value or vector indicating the amount of substituted change between compositional parts.
basesub	A data.frame or data.table of the base possible substitution of compositional parts. This data set can be computed using function basesub. If NULL, all possible pairwise substitution of compositional parts are used.
regrid	If non-NULL, a data.table of reference grid consisting of combinations of covariates over which predictions are made. If NULL, the reference grid is constructed via ref_grid.
summary	A logical value. Should the estimate at each level of the reference grid (FALSE) or their average (TRUE) be returned? Default to TRUE.
level	A character string or vector. Should the estimate be at the between-person and/or within-person level? Required.

type	A character string or vector. Should the estimate be conditional mean or average marginal mean? Required.
...	Additional arguments to be passed to describe_posterior.

Value

A list containing the result of multilevel compositional substitution model. Each element of the list is the estimation for a compositional part and include at least six elements.

- Mean Posterior means.
- CI_low and
- CI_high 95% credible intervals.
- Delta Amount substituted across compositional parts.
- From Compositional part that is substituted from.
- To Compositional parts that is substituted to.
- LevelLevel where changes in composition takes place.
- EffectTypeEither estimated conditional or average marginal changes.

Examples

```
data(mcompd)
data(sbp)
data(psub)
cilr <- compilr(data = mcompd, sbp = sbp,
                parts = c("TST", "WAKE", "MVPA", "LPA", "SB"), idvar = "ID")

# model with compositional predictor at between and between-person levels
m <- brmcoda(compilr = cilr,
             formula = STRESS ~ bilr1 + bilr2 + bilr3 + bilr4 +
                                wilr1 + wilr2 + wilr3 + wilr4 + (1 | ID),
             chain = 1, iter = 500)

subm <- bsub(object = m, basesub = psub, delta = 5)
```

---

bsubmargins *Between-person Average Marginal Substitution Model.*

Description

Using a fitted model object, estimates the average marginal difference when compositional parts are substituted for specific unit(s) at between-person level. The bsubmargins output encapsulates the substitution results for all compositional parts present in the brmcoda object.

Usage

```
bsubmargins(object, delta, basesub, level = "between", type = "marginal", ...)
```

Arguments

object	A fitted brmcoda object. Required.
delta	A integer, numeric value or vector indicating the amount of substituted change between compositional parts.
basesub	A data.frame or data.table of the base possible substitution of compositional parts. This data set can be computed using function basesub. If NULL, all possible pairwise substitution of compositional parts are used.
level	A character string or vector. Should the estimate be at the between-person and/or within-person level? Required.
type	A character string or vector. Should the estimate be conditional mean or average marginal mean? Required.
...	Additional arguments to be passed to describe_posterior.

Value

A list containing the result of multilevel compositional substitution model. Each element of the list is the estimation for a compositional part and include at least six elements.

- Mean Posterior means.
- CI_low and
- CI_high 95% credible intervals.
- Delta Amount substituted across compositional parts.
- From Compositional part that is substituted from.
- To Compositional parts that is substituted to.
- LevelLevel where changes in composition takes place.
- EffectTypeEither estimated conditional or average marginal changes.

Examples

```
data(psub)
data(mcompd)
data(psub)
cilr <- compilr(data = mcompd[ID %in% 1:10, .SD[1:3], by = ID], sbp = sbp,
                parts = c("TST", "WAKE", "MVPA", "LPA", "SB"), idvar = "ID")

m <- brmcoda(compilr = cilr,
             formula = STRESS ~ bilr1 + bilr2 + bilr3 + bilr4 + wilr1 +
             wilr2 + wilr3 + wilr4 + Female + (1 | ID), chains = 1, iter = 500)

subm <- bsubmargins(object = m, basesub = psub, delta = 5)
```

compilr *Compute useful indices from a (dataset of) multilevel composition(s)*

Description

Computes sets of compositions and IRLs for Multilevel Compositional Data models.

Usage

```
compilr(data, sbp, parts, total = 1440, idvar = "ID")
```

Arguments

data	A data.frame or data.table containing data of all variables used in the analysis. It must include a composition and a ID variable. Required.
sbp	A signary matrix indicating sequential binary partition. Required.
parts	A character vector specifying the names of compositional variables to be used.
total	A numeric value of the total amount to which the compositions should be closed. Default to 1440.
idvar	A character string specifying the name of the variable containing IDs. Default to ID.

Value

A list with twelve elements.

- BetweenComp A vector of class acomp representing one closed between-person composition or a matrix of class acomp representing multiple closed between-person compositions each in one row.
- WithinComp A vector of class acomp representing one closed within-person composition or a matrix of class acomp representing multiple closed within-person compositions each in one row.
- TotalComp A vector of class acomp representing one closed total composition or a matrix of class acomp representing multiple closed total compositions each in one row.
- BetweenILR Isometric log ratio transform of between-person composition.
- WithinILR Isometric log ratio transform of within-person composition.
- TotalILR Isometric log ratio transform of total composition.
- data The user's dataset or imputed dataset if the input data contains zeros.
- psi A ILR matrix associated with user-defined partition structure.
- sbp The user-defined sequential binary partition matrix.
- parts Names of compositional variables.
- idvar Name of the variable containing IDs.
- total Total amount to which the compositions is closed.

Examples

```
data(mcompd)
data(sbp)
cilr1 <- compilr(data = mcompd, sbp = sbp,
                 parts = c("TST", "WAKE", "MVPA", "LPA", "SB"), idvar = "ID")
str(cilr1)

## cleanup
rm(cilr1, mcompd, sbp)
```

---

mcompd *Multilevel Compositional Data*

Description

A simulated dataset containing multiple days of compositional data.

Usage

```
mcompd
```

Format

A data table containing 9 variables.

TST Total Sleep Time (minutes) — repeated measure

WAKE Wake time while in bed, trying to sleep (minutes) — repeated measure

MVPA Moderate to Vigorous Physical Activity (minutes) — repeated measure

LPA Light Physical Activity (minutes) — repeated measure

SB Sedentary Behavior (minutes) — repeated measure

ID A unique identifier for each individual

Age Age in years — baseline measure only

Female Binary: whether participants identified as female (1) or not (0) — baseline measure only

STRESS Self report stress measures on a 0 to 10 scale — repeated measure

plotsub *Substitution plot*

Description

This function is useful for visualising the estimated differences in outcomes when compositional variables are substituted for a specific period of time.

Usage

```
plotsub(data, x, y, ...)
```

Arguments

data	A dataset to use for plot. It must be a component of a list resulted from one of the following functions: wsub, bsub, wsubmargins, bsubmargins.
x	A character string specifying name of the compostional predictor variable.
y	A character string specifying the name of the outcome variable.
...	Further arguments passed to ggplot.

Value

A ggplot graph object showing the estimated difference in outcome when each pair of compositional variables are substituted for a specific time.

psub *Possible Pairwise Substitutions*

Description

A dataset containing possible pairwise subsitutions.

Usage

```
psub
```

Format

A data table containing 5 variables.

V1 first compositional variable

V2 second compositional variable

V3 third compositional variable

V4 fourth compositional variable

V5 fifth compositional variable

sbp *Sequential Binary Partition*

Description

A matrix of sequential binary partition.

Usage

```
sbp
```

Format

A matrix with 5 columns and 4 rows.

- **V1** first compositional variable
- **V2** second compositional variable
- **V3** third compositional variable
- **V4** fourth compositional variable
- **V5** fifth compositional variable

submargins *Average Marginal Substitution Model.*

Description

Using a fitted model object, estimates the the average marginal difference when compositional parts are substituted for specific unit(s). The `submargins` output encapsulates the substitution results for all compositional parts present in the `brmcoda` object.

Usage

```
submargins(object, delta, basesub, level = "total", type = "marginal", ...)
```

Arguments

`object`	A fitted `brmcoda` object. Required.
`delta`	A integer, numeric value or vector indicating the amount of substituted change between compositional parts.
`basesub`	A `data.frame` or `data.table` of the base possible substitution of compositional parts. This data set can be computed using function `basesub`. If `NULL`, all possible pairwise substitution of compositional parts are used.
`level`	A character string or vector. Should the estimate be at the `between`-person and/or `within`-person level? Required.
`type`	A character string or vector. Should the estimate be `conditional` mean or average `marginal` mean? Required.
`...`	Additional arguments to be passed to `describe_posterior`.

Value

A list containing the result of multilevel compositional substitution model. Each element of the list is the estimation for a compositional part and include at least six elements.

- `Mean` Posterior means.
- `CI_low` and
- `CI_high` 95% credible intervals.
- `Delta` Amount substituted across compositional parts.
- `From` Compositional part that is substituted from.
- `To` Compositional parts that is substituted to.
- `Level`Level where changes in composition takes place.
- `EffectType`Either estimated `conditional` or average `marginal` changes.

Examples

```
data(mcompd)
data(sbp)
data(psub)
cilr <- compilr(data = mcompd, sbp = sbp,
                parts = c("TST", "WAKE", "MVPA", "LPA", "SB"), idvar = "ID")

# model with compositional predictor
m <- brmcoda(compilr = cilr,
             formula = STRESS ~ ilr1 + ilr2 + ilr3 + ilr4 + (1 | ID),
             chain = 1, iter = 500)
subm <- submargins(object = m, basesub = psub, delta = 5)
```

`substitution` *Substitution Model.*

Description

Estimate the difference in an outcome when compositional parts are substituted for specific unit(s). The `substitution` output encapsulates the substitution results for all compositional parts present in the `brmcoda` object.

Usage

```
substitution(
  object,
  delta,
  basesub = NULL,
  regrid = NULL,
  summary = TRUE,
```

```
  level = c("between", "within"),
  type = c("conditional", "marginal"),
  ...
)
```

Arguments

object	A fitted brmcoda object. Required.
delta	A integer, numeric value or vector indicating the amount of substituted change between compositional parts.
basesub	A data.frame or data.table of the base possible substitution of compositional parts. This data set can be computed using function basesub. If NULL, all possible pairwise substitution of compositional parts are used.
regrid	If non-NULL, a data.table of reference grid consisting of combinations of covariates over which predictions are made. If NULL, the reference grid is constructed via ref_grid.
summary	A logical value. Should the estimate at each level of the reference grid (FALSE) or their average (TRUE) be returned? Default to TRUE.
level	A character string or vector. Should the estimate be at the between-person and/or within-person level? Required.
type	A character string or vector. Should the estimate be conditional mean or average marginal mean? Required.
...	Additional arguments to be passed to describe_posterior.

Value

A list containing the result of multilevel compositional substitution model. Each element of the list is the estimation for a compositional part and include at least six elements.

- Mean Posterior means.
- CI_low and
- CI_high 95% credible intervals.
- Delta Amount substituted across compositional parts.
- From Compositional part that is substituted from.
- To Compositional parts that is substituted to.
- LevelLevel where changes in composition takes place. Either
- EffectTypeEither estimated conditional or average marginal changes.

Examples

```
data(mcompd)
data(sbp)
data(psub)
cilr <- compilr(data = mcompd, sbp = sbp,
                parts = c("TST", "WAKE", "MVPA", "LPA", "SB"), idvar = "ID")
```

```
# model with compositional predictor at between and between-person levels
m <- brmcoda(compilr = cilr,
             formula = STRESS ~ bilr1 + bilr2 + bilr3 + bilr4 +
                                wilr1 + wilr2 + wilr3 + wilr4 + (1 | ID),
             chain = 1, iter = 500)

subm <- substitution(object = m, delta = c(1, 10),
                     type = "conditional", level = c("between", "within"))
```

---

wsub *Within-person Basic Substitution Model*

Description

Using a fitted model object, estimate the difference in outcomes when compositional parts are substituted for specific unit(s) at `within-person` level. The `wsub` output encapsulates the substitution results for all compositional parts present in the `brmcoda` object.

Notes: The reference composition for substitution model is the compositional mean of the data set provided. For average marginal effect, use `wsubmargins`.

Usage

```
wsub(
  object,
  delta,
  basesub,
  regrid = NULL,
  summary = TRUE,
  level = "within",
  type = "conditional",
  ...
)
```

Arguments

`object`	A fitted `brmcoda` object. Required.
`delta`	A integer, numeric value or vector indicating the amount of substituted change between compositional parts.
`basesub`	A `data.frame` or `data.table` of the base possible substitution of compositional parts. This data set can be computed using function `basesub`. If `NULL`, all possible pairwise substitution of compositional parts are used.
`regrid`	If non-`NULL`, a `data.table` of reference grid consisting of combinations of covariates over which predictions are made. If `NULL`, the reference grid is constructed via `ref_grid`.

summary	A logical value. Should the estimate at each level of the reference grid (FALSE) or their average (TRUE) be returned? Default to TRUE.
level	A character string or vector. Should the estimate be at the between-person and/or within-person level? Required.
type	A character string or vector. Should the estimate be conditional mean or average marginal mean? Required.
...	Additional arguments to be passed to describe_posterior.

Value

A list containing the result of multilevel compositional substitution model. Each element of the list is the estimation for a compositional part and include at least six elements.

- Mean Posterior means.
- CI_low and
- CI_high 95% credible intervals.
- Delta Amount substituted across compositional parts.
- From Compositional part that is substituted from.
- To Compositional parts that is substituted to.
- LevelLevel where changes in composition takes place.
- EffectTypeEither estimated conditional or average marginal changes.

Examples

```
data(mcompd)
data(sbp)
data(psub)
cilr <- compilr(data = mcompd, sbp = sbp,
                parts = c("TST", "WAKE", "MVPA", "LPA", "SB"), idvar = "ID")

# model with compositional predictor at between and within-person levels
m <- brmcoda(compilr = cilr,
             formula = STRESS ~ bilr1 + bilr2 + bilr3 + bilr4 +
                                wilr1 + wilr2 + wilr3 + wilr4 + (1 | ID),
             chain = 1, iter = 500)

subm <- wsub(object = m, basesub = psub, delta = 5)
```

wsubmargins *Between-person Average Marginal Substitution Model.*

Description

Using a fitted model object, estimates the the average marginal difference when compositional parts are substituted for specific unit(s) at `within-person` level. The `wsubmargins` output encapsulates the substitution results for all compositional parts present in the `brmcoda` object.

Usage

```
wsubmargins(object, delta, basesub, level = "within", type = "marginal", ...)
```

Arguments

`object`	A fitted `brmcoda` object. Required.
`delta`	A integer, numeric value or vector indicating the amount of substituted change between compositional parts.
`basesub`	A `data.frame` or `data.table` of the base possible substitution of compositional parts. This data set can be computed using function `basesub`. If `NULL`, all possible pairwise substitution of compositional parts are used.
`level`	A character string or vector. Should the estimate be at the `between`-person and/or `within`-person level? Required.
`type`	A character string or vector. Should the estimate be `conditional` mean or average `marginal` mean? Required.
`...`	Additional arguments to be passed to `describe_posterior`.

Value

A list containing the result of multilevel compositional substitution model. Each element of the list is the estimation for a compositional part and include at least six elements.

- `Mean` Posterior means.
- `CI_low` and
- `CI_high` 95% credible intervals.
- `Delta` Amount substituted across compositional parts.
- `From` Compositional part that is substituted from.
- `To` Compositional parts that is substituted to.
- `Level`Level where changes in composition takes place.
- `EffectType`Either estimated `conditional` or average `marginal` changes.

Examples

```
data(mcompd)
data(sbp)
data(psub)
cilr <- compilr(data = mcompd, sbp = sbp,
                parts = c("TST", "WAKE", "MVPA", "LPA", "SB"), idvar = "ID")

library(doFuture)
registerDoFuture()
plan(multisession, workers = 5)

# model with compositional predictor at between and within-person levels
m <- brmcoda(compilr = cilr,
             formula = STRESS ~ bilr1 + bilr2 + bilr3 + bilr4 +
                                wilr1 + wilr2 + wilr3 + wilr4 + (1 | ID),
             chain = 1, iter = 500)
subm <- wsubmargins(object = m, basesub = psub, delta = 5)
```

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