

Package ‘GLMMRR’

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Type Package

Title Generalized Linear Mixed Model (GLMM) for Binary Randomized Response Data

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Imports lattice, stats, utils, grDevices

Description Generalized Linear Mixed Model (GLMM) for Binary Randomized Response Data. Includes Cauchit, Compl. Log-Log, Logistic, and Probit link functions for Bernoulli Distributed RR data. RR Designs: Warner, Forced Response, Unrelated Question, Kuk, Crosswise, and Triangular.

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getCellMeans

Get cell means for unique groups of covariates

Description

Get cell means for unique groups of covariates

Usage

```
getCellMeans(x, y, factor.groups)
```

Arguments

`x` a matrix-like object containing the covariates.
`y` a vector of values to compute the means from.
`factor.groups` a factor of unique groups of covariates.

Value

the cell means.

| | |
|--------------|---|
| getCellSizes | <i>Get number of units in each cell</i> |
|--------------|---|

Description

Get number of units in each cell

Usage

```
getCellSizes(x, n, factor.groups)
```

Arguments

x a matrix-like object containing the covariates.
n the total number of units.
factor.groups a factor of unique groups of covariates.

Value

the number of units in each cell.

| | |
|-----------------|--|
| getMLPrevalence | <i>Compute Estimated Population Prevalence</i> |
|-----------------|--|

Description

Reference: Fox, J-P, Klotzke, K. and Veen, D. (2016). *Generalized Linear Mixed Models for Randomized Responses*. Manuscript submitted for publication.

Usage

```
getMLPrevalence(mu, n, c, d)
```

Arguments

mu observed mean response.
n number of units.
c randomized response parameter c.
d randomized response parameter d.

Value

maximum likelihood estimate of the population prevalence and its variance.

| | |
|-----------------|---|
| getRRparameters | <i>Compute Randomized Response parameters</i> |
|-----------------|---|

Description

Represent Randomize Response models with two parameters, c and d. Reference: Fox, J-P, Klotzke, K. and Veen, D. (2016). *Generalized Linear Mixed Models for Randomized Responses*. Manuscript submitted for publication.

Usage

```
getRRparameters(vec.RRmodel, vec.p1, vec.p2)
```

Arguments

| | |
|-------------|---|
| vec.RRmodel | a character vector of Randomized Response models. |
| vec.p1 | a numeric vector of p1 values. |
| vec.p2 | a numeric vector of p2 values. |

Value

a list with c and d values.

| | |
|-----------------|--|
| getUniqueGroups | <i>Get unique groups of covariates</i> |
|-----------------|--|

Description

Get unique groups of covariates

Usage

```
getUniqueGroups(x)
```

Arguments

| | |
|---|---|
| x | a matrix-like object containing the covariates. |
|---|---|

Value

a factor of unique groups.

| | |
|-------|----------------------|
| hello | <i>Hello, World!</i> |
|-------|----------------------|

Description

Prints 'Hello, world!'.

Usage

```
hello()
```

Examples

```
hello()
```

| | |
|------------|--|
| Plagiarism | <i>An Experimental Survey Measuring Plagiarism Using the Crosswise Model</i> |
|------------|--|

Description

A dataset containing the responses to sensitive questions about plagiarism and other attributes of 812 students. The crosswise model (CM) and direct questioning (DQ) were utilized to gather the data. Each row holds the response to one question for one student. The variables are as follows:

Usage

```
data(Plagiarism)
```

Format

A data frame with 812 rows and 24 variables

Details

- `id`. identification code of the student
- `question`. which question was asked (1 and 3: Partial Plagiarism, 2 and 4: Severe Plagiarism)
- `gender`. gender of the student (0: male, 1: female)
- `age`. age in years
- `nationality`. nationality of the student (0: German or Swiss, 1: other)
- `no_papers`. number of papers
- `uni`. location of data collection (1: ETH Zurich, 2: LMU Munich, 3: University Leipzig)
- `course`. course in which the data was collected
- `Aspired_Degree`. aspired degree of the student

- Semester. semesters enrolled
- ur_none. used resources: none
- ur_books. used resources: books
- ur_art. used resources: articles
- ur_int. used resources: internet
- ur_fsp. used resources: fellow students' papers
- ur_other. used resources: other
- preading. proofreading
- gradesf. satisfaction with grades
- pp. Plagiarism indicator (0: Severe Plagiarism, 1: Partial Plagiarism)
- RR. Randomized Response indicator (0: DQ, 1: Crosswise)
- RRp1. Randomized Response parameter p1
- RRp2. Randomized Response parameter p2
- RRmodel. Randomized Response Model

Author(s)

Ben Jann and Laurcence Brandenberger

References

<http://dx.doi.org/10.7892/boris.51190>

plot.RRglm

Plot diagnostics for a RRglm object

Description

Six plots (selectable by which) are currently available: (1) a plot of estimated population prevalence per RR model, (2) a plot of estimated population prevalence per protection level, (3) a plot of ungrouped residuals against predicted honest response, (4) a plot of grouped (on covariates) residuals against predicted honest response, (5) a plot of grouped Hosmer-Lemeshow residuals against predicted response, and (6) a Normal Q-Q plot of grouped (on covariates) residuals. By default, plots 1, 3, 4 and 6 are provided. Reference: Fox, J-P, Klotzke, K. and Veen, D. (2016). *Generalized Linear Mixed Models for Randomized Responses*. Manuscript submitted for publication.

Usage

```
## S3 method for class 'RRglm'
plot(x, which = c(1, 3, 4, 6), type = c("deviance",
    "pearson"), ngroups = 10, ...)
```

Arguments

| | |
|---------|---|
| x | an object of class RRglm. |
| which | if a subset of the plots is required, specify a subset of the numbers 1:6 (default: 1, 3, 4, 6). |
| type | the type of residuals which should be used to be used for plots 3, 4 and 6. The alternatives are: "deviance" (default) and "pearson". |
| ngroups | the number of groups to compute the Hosmer-Lemeshow residuals for (default: 10). |
| ... | further arguments passed to or from other methods. |

Examples

```
out <- RRglm(response ~ Gender + RR + pp + age, link="RRlink.logit", RRmodel=RRmodel,
             p1=RRp1, p2=RRp2, data=Plagiarism, etastart=rep(0.01, nrow(Plagiarism)))
plot(out, which = 1:6, type = "deviance", ngroups = 50)
```

| | |
|-----------------|---|
| plot.RRglmerMod | <i>Plot diagnostics for a RRglmerMod object</i> |
|-----------------|---|

Description

Five plots (selectable by which) are currently available: (1) a plot of estimated population prevalence per RR model, (2) a plot of estimated population prevalence per protection level, (3) a plot of random effects and their conditional variance (95 (4) a plot of conditional pearson residuals against predicted honest response, and (5) a plot of unconditional pearson residuals against predicted honest response. By default, plots 1, 3, 4 and 5 are provided. Reference: Fox, J-P, Klotzke, K. and Veen, D. (2016). *Generalized Linear Mixed Models for Randomized Responses*. Manuscript submitted for publication.

Usage

```
## S3 method for class 'RRglmerMod'
plot(x, which = c(1, 3, 4, 5), ...)
```

Arguments

| | |
|-------|--|
| x | an object of class RRglmerMod. |
| which | if a subset of the plots is required, specify a subset of the numbers 1:5 (default: 1, 3, 4, 5). |
| ... | further arguments passed to or from other methods. |

Examples

```
out <- RRglmer(response ~ Gender + RR + pp + (1+pp|age), link="RRlink.logit", RRmodel=RRmodel,
              p1=RRp1, p2=RRp2, data=Plagiarism, na.action = "na.omit",
              etastart = rep(0.01, nrow(Plagiarism)),
              control = glmerControl(optimizer = "Nelder_Mead", tolPwrss = 1e-03), nAGQ = 1)
plot(out, which = 1:5)
```

```
print.RRglmGOF      Print RRglmGOF values
```

Description

Print RRglmGOF values

Usage

```
## S3 method for class 'RRglmGOF'
print(x, digits = 3, ...)
```

Arguments

x an object of class RRglmGOF.
 digits minimal number of *significant digits* (default: 3).
 ... further arguments passed to or from other methods.

```
print.summary.RRglm  Print RRglm summary
```

Description

Print RRglm summary

Usage

```
## S3 method for class 'summary.RRglm'
print(x, printPrevalence = TRUE,
      printPrevalencePerLevel = FALSE, printResiduals = FALSE, digits = 5,
      ...)
```

Arguments

x an object of class summary.RRglm.
 printPrevalence print estimated population prevalence per item and RR model (default: true).
 printPrevalencePerLevel print estimated population prevalence per item, RRmodel and protection level (default: false).
 printResiduals print deviance residuals (default: false).
 digits minimal number of *significant digits* (default: 5).
 ... further arguments passed to or from other methods.

```
print.summary.RRglmerMod
      Print RRglmer summary
```

Description

Print RRglmer summary

Usage

```
## S3 method for class 'summary.RRglmerMod'
print(x, printPrevalence = TRUE,
      printPrevalencePerLevel = FALSE, printResiduals = FALSE, digits = 5,
      ...)
```

Arguments

`x` an object of class `summary.RRglmerMod`.

`printPrevalence` print estimated population prevalence per item and RR model (default: true).

`printPrevalencePerLevel` print estimated population prevalence per item, RRmodel and protection level (default: false).

`printResiduals` print conditional deviance residuals (default: false).

`digits` minimal number of *significant digits* (default: 5).

`...` further arguments passed to or from other methods.

```
residuals.RRglm      Accessing GLMMRR Fits for fixed-effect models
```

Description

Compute residuals for RRglm objects. Extends [residuals.glm](#) with residuals for grouped binary Randomized Response data. Reference: Fox, J-P, Klotzke, K. and Veen, D. (2016). *Generalized Linear Mixed Models for Randomized Responses*. Manuscript submitted for publication.

Usage

```
## S3 method for class 'RRglm'
residuals(object, type = c("deviance", "pearson", "working",
  "response", "partial", "deviance.grouped", "pearson.grouped",
  "hosmer-lemeshow"), ngroups = 10, ...)
```

Arguments

| | |
|---------|---|
| object | an object of class RRglm. |
| type | the type of residuals which should be returned. The alternatives are: "deviance" (default), "pearson", "working", "response", "partial", "deviance.grouped", "pearson.grouped" and "hosmer-lemeshow". |
| ngroups | the number of groups if Hosmer-Lemeshow residuals are computed (default: 10). |
| ... | further arguments passed to or from other methods. |

Value

A vector of residuals.

See Also

[residuals.glm](#)

residuals.RRglmerMod *Accessing GLMMRR Fits for mixed-effect models*

Description

Compute residuals for RRglmer objects. Extends [residuals.glmResp](#) to access conditional and unconditional residuals for grouped binary Randomized Response data. Reference: Fox, J-P, Klotzke, K. and Veen, D. (2016). *Generalized Linear Mixed Models for Randomized Responses*. Manuscript submitted for publication.

Usage

```
## S3 method for class 'RRglmerMod'
residuals(object, type = c("deviance", "pearson",
  "working", "response", "partial", "unconditional.response",
  "unconditional.pearson"), ...)
```

Arguments

| | |
|--------|--|
| object | an object of class RRglmer. |
| type | the type of residuals which should be returned. The alternatives are: "deviance" (default), "pearson", "working", "response", "partial", "unconditional.response" and "unconditional.pearson". |
| ... | further arguments passed to or from other methods. |

Value

A vector of residuals.

See Also[residuals.glmResp](#)

RRbinomial

*Binomial family adjusted for Randomized Response parameters.***Description**

The upper and lower limits for μ 's depend on the Randomized Response parameters.

Usage

```
RRbinomial(link, c, d, ...)
```

Arguments

| | |
|------|---|
| link | a specification for the model link function. Must be an object of class "link-glm". |
| c | a numeric vector containing the parameter c. |
| d | a numeric vector containing the parameter d. |
| ... | other potential arguments to be passed to binomial . |

Value

A binomial family object.

See Also[family](#)

RRglm

*Fitting Generalized Linear Models with binary Randomized Response data***Description**

Fit a generalized linear model (GLM) with binary Randomized Response data. Implemented as a wrapper for [glm](#). Reference: Fox, J-P, Klotzke, K. and Veen, D. (2016). *Generalized Linear Mixed Models for Randomized Responses*. Manuscript submitted for publication.

Usage

```
RRglm(formula, link, item, RRmodel, p1, p2, data, na.action = "na.omit", ...)
```

Arguments

| | |
|------------------------|--|
| <code>formula</code> | a two-sided linear formula object describing the model to be fitted, with the response on the left of a <code>~</code> operator and the terms, separated by <code>+</code> operators, on the right. |
| <code>link</code> | a <code>glm</code> link function for binary outcomes. Must be a function name. Available options: "RRlink.logit", "RRlink.probit", "RRlink.cloglog" and "RRlink.cauchit" |
| <code>item</code> | optional item identifier for long-format data. |
| <code>RRmodel</code> | the Randomized Response model, defined per case. Available options: "DQ", "Warner", "Forced", "UQM", "Crosswise", "Triangular" and "Kuk" |
| <code>p1</code> | the Randomized Response parameter <code>p1</code> , defined per case. Must be $0 \leq p1 \leq 1$. |
| <code>p2</code> | the Randomized Response parameter <code>p2</code> , defined per case. Must be $0 \leq p2 \leq 1$. |
| <code>data</code> | a data frame containing the variables named in <code>formula</code> as well as the Randomized Response model and parameters. If the required information cannot be found in the data frame, or if no data frame is given, then the variables are taken from the environment from which <code>RRglm</code> is called. |
| <code>na.action</code> | a function that indicates what should happen when the data contain NAs. The default action (<code>na.omit</code> , as given by <code>getOption("na.action")</code>) strips any observations with any missing values in any variables. |
| <code>...</code> | other potential arguments to be passed to <code>glm</code> . |

Value

An object of class `RRglm`. Extends the class `glm` with Randomize Response data.

See Also

[glm](#)

Examples

```
# Fit the model with fixed effects for gender, RR, pp and age using the logit link function.
# The Randomized Response parameters p1, p2 and model
# are specified for each observation in the dataset.
out <- RRglm(response ~ Gender + RR + pp + age, link="RRlink.logit", RRmodel=RRmodel,
             p1=RRp1, p2=RRp2, data=Plagiarism, etastart=rep(0.01, nrow(Plagiarism)))
summary(out)
```

RRglmer *Fitting Generalized Linear Mixed-Effects Models with binary Randomized Response data*

Description

Fit a generalized linear mixed-effects model (GLMM) with binary Randomized Response data. Both fixed effects and random effects are specified via the model formula. Randomize response parameters can be entered either as single values or as vectors. Implemented as a wrapper for [glmer](#). Reference: Fox, J-P, Klotzke, K. and Veen, D. (2016). *Generalized Linear Mixed Models for Randomized Responses*. Manuscript submitted for publication.

Usage

```
RRglmer(formula, item, link, RRmodel, p1, p2, data, control = glmerControl(),
na.action = "na.omit", ...)
```

Arguments

| | |
|-----------|--|
| formula | a two-sided linear formula object describing both the fixed-effects and fixed-effects part of the model, with the response on the left of a <code>~</code> operator and the terms, separated by <code>+</code> operators, on the right. Random-effects terms are distinguished by vertical bars (<code> </code>) separating expressions for design matrices from grouping factors. |
| item | optional item identifier for long-format data. |
| link | a glm link function for binary outcomes. Must be a function name. Available options: "RRlink.logit", "RRlink.probit", "RRlink.cloglog" and "RRlink.cauchit" |
| RRmodel | the Randomized Response model, defined per case. Available options: "DQ", "Warner", "Forced", "UQM", "Crosswise", "Triangular" and "Kuk" |
| p1 | the Randomized Response parameter p1, defined per case. Must be $0 \leq p1 \leq 1$. |
| p2 | the Randomized Response parameter p2, defined per case. Must be $0 \leq p2 \leq 1$. |
| data | a data frame containing the variables named in formula as well as the Randomized Response model and parameters. If the required information cannot be found in the data frame, or if no data frame is given, then the variables are taken from the environment from which <code>RRglmer</code> is called. |
| control | a list (of correct class, resulting from <code>lmerControl()</code> or <code>glmerControl()</code> respectively) containing control parameters, including the nonlinear optimizer to be used and parameters to be passed through to the nonlinear optimizer, see the <code>*lmerControl</code> documentation for details. |
| na.action | a function that indicates what should happen when the data contain NAs. The default action (<code>na.omit</code> , as given by <code>getOption("na.action")</code>) strips any observations with any missing values in any variables. |
| ... | other potential arguments to be passed to glmer . |

Value

An object of class `RRglmerMod`. Extends the class `glmerMod` with Randomize Response data, for which many methods are available (e.g. `methods(class="glmerMod")`).

See Also

[lme4](#)

Examples

```
# Fit the model with fixed effects for gender, RR and pp
# and a random effect for age using the logit link function.
# The Randomized Response parameters p1, p2 and model
# are specified for each observation in the dataset.
out <- RRglmer(response ~ Gender + RR + pp + (1|age), link="RRlink.logit", RRmodel=RRmodel,
  p1=RRp1, p2=RRp2, data=Plagiarism, na.action = "na.omit",
  etastart = rep(0.01, nrow(Plagiarism)),
  control = glmerControl(optimizer = "Nelder_Mead", tolPwrss = 1e-03), nAGQ = 1)
summary(out)
```

RRglmGOF

Goodness-of-fit statistics for binary Randomized Response data

Description

Compute goodness-of-fit statistics for binary Randomized Response data. Pearson, Deviance and Hosmer-Lemeshow statistics are available. Reference: Fox, J-P, Klotzke, K. and Veen, D. (2016). *Generalized Linear Mixed Models for Randomized Responses*. Manuscript submitted for publication.

Usage

```
RRglmGOF(RRglmOutput, doPearson = TRUE, doDeviance = TRUE,
  doHlemeshow = TRUE, hlemeshowGroups = 10, rm.na = TRUE, print = TRUE)
```

Arguments

| | |
|------------------------------|--|
| <code>RRglmOutput</code> | a model fitted with the RRglm function. |
| <code>doPearson</code> | compute Pearson statistic. |
| <code>doDeviance</code> | compute Deviance statistic. |
| <code>doHlemeshow</code> | compute Hosmer-Lemeshow statistic. |
| <code>hlemeshowGroups</code> | number of groups to split the data into for the Hosmer-Lemeshow statistic (default: 10). |
| <code>rm.na</code> | remove cases with missing data. |
| <code>print</code> | print summary of goodness-of-fit statistics. |

Value

an option of class RRglmGOF.

Examples

```
out <- RRglm(response ~ Gender + RR + pp + age, link="RRlink.logit", RRmodel=RRmodel,
             p1=RRp1, p2=RRp2, data=Plagiarism, etastart=rep(0.01, nrow(Plagiarism)))
RRglmGOF(RRglmOutput = out, doPearson = TRUE, doDeviance = TRUE, doHlmeshow = TRUE, print = TRUE)
```

| | |
|----------------|---|
| RRlink.cauchit | <i>Cauchit link function with Randomized Response parameters.</i> |
|----------------|---|

Description

Reference: Fox, J-P, Klotzke, K. and Veen, D. (2016). *Generalized Linear Mixed Models for Randomized Responses*. Manuscript submitted for publication.

Usage

```
RRlink.cauchit(c, d)
```

Arguments

c a numeric vector containing the parameter c.
d a numeric vector containing the parameter d.

Value

RR link function.

| | |
|----------------|---|
| RRlink.cloglog | <i>Log-Log link function with Randomized Response parameters.</i> |
|----------------|---|

Description

Reference: Fox, J-P, Klotzke, K. and Veen, D. (2016). *Generalized Linear Mixed Models for Randomized Responses*. Manuscript submitted for publication.

Usage

```
RRlink.cloglog(c, d)
```

Arguments

c a numeric vector containing the parameter c.
d a numeric vector containing the parameter d.

Value

RR link function.

| | |
|--------------|---|
| RRlink.logit | <i>Logit link function with Randomized Response parameters.</i> |
|--------------|---|

Description

Reference: Fox, J-P, Klotzke, K. and Veen, D. (2016). *Generalized Linear Mixed Models for Randomized Responses*. Manuscript submitted for publication.

Usage

```
RRlink.logit(c, d)
```

Arguments

| | |
|---|--|
| c | a numeric vector containing the parameter c. |
| d | a numeric vector containing the parameter d. |

Value

RR link function.

| | |
|---------------|--|
| RRlink.probit | <i>Probit link function with Randomized Response parameters.</i> |
|---------------|--|

Description

Reference: Fox, J-P, Klotzke, K. and Veen, D. (2016). *Generalized Linear Mixed Models for Randomized Responses*. Manuscript submitted for publication.

Usage

```
RRlink.probit(c, d)
```

Arguments

| | |
|---|--|
| c | a numeric vector containing the parameter c. |
| d | a numeric vector containing the parameter d. |

Value

RR link function.

| | |
|---------------|--|
| summary.RRglm | <i>Summarizing GLMMRR fits for fixed-effect models</i> |
|---------------|--|

Description

Summarizing GLMMRR fits for fixed-effect models

Usage

```
## S3 method for class 'RRglm'
summary(object, p1p2.digits = 2, ...)
```

Arguments

| | |
|-------------|--|
| object | an object of class RRglm. |
| p1p2.digits | number of digits for aggregating data based on the level of protection (default: 2). |
| ... | further arguments passed to or from other methods. |

Value

An object of class summary.RRglm. Extends the class summary.glm with Randomize Response data.

| | |
|--------------------|--|
| summary.RRglmerMod | <i>Summarizing GLMMRR fits for fixed-effect models</i> |
|--------------------|--|

Description

Summarizing GLMMRR fits for fixed-effect models

Usage

```
## S3 method for class 'RRglmerMod'
summary(object, p1p2.digits = 2, ...)
```

Arguments

| | |
|-------------|--|
| object | an object of class RRglm. |
| p1p2.digits | number of digits for aggregating data based on the level of protection (default: 2). |
| ... | further arguments passed to or from other methods. |

Value

An object of class summary.RRglmerMod. Extends the class summary.glmerMod with Randomize Response data.

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