Package ‘difNLR’

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difNLR-package

DIF and DDF Detection by Non-Linear Regression Models.

Description

The difNLR package contains methods for detection of differential item functioning (DIF) based on non-linear regression. Both uniform and non-uniform DIF effects can be detected when considering one focal group. The method also allows to test the difference in guessing or inattention parameters between reference and focal group. DIF detection method is based either on likelihood-ratio test, or on F-test of a submodel. Package also offers method for DIF detection among ordinal data using adjacent category logit or cumulative logit models. Moreover, the difNLR package contains method for detection of differential distractor functioning (DDF) based on multinomial log-linear regression model.
difNLR-package

Details

Package: difNLR
Type: Package
Version: 1.3.5
Date: 2020-08-24
Depends: R (>= 3.1)
Imports: CTT, ggplot2 (>= 2.2.1), grDevices, methods, msm, nnet, plyr, reshape2, stats, VGAM
Suggests: ShinyItemAnalysis
License: GPL-3
BugReports: https://github.com/adelahladka/difNLR/issues
Encoding: UTF-8

Functions

• ddfMLR
• difNLR
• difORD
• estimNLR
• formulaNLR
• MLR
• NLR
• ORD
• startNLR

Datasets

• GMAT
• GMAT2
• MSATB

Note

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checkInterval

References


See Also

Useful links:

- Report bugs at https://github.com/adelahladka/difNLR/issues

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**checkInterval**

**Checks interval bounds.**

**Description**

Checks whether x lies in interval defined by bounds in vec. If it does, it returns value of x. In case that value of x is lower than lower bound specified in vec, it returns its value. In case that value of x is greater than upper bound specified in vec, it returns its value.

**Usage**

```r
checkInterval(x, vec)
```

**Arguments**

- `x` numeric.
- `vec` numeric: increasingly sorted bounds of interval.
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Examples

```r
## Not run:
checkInterval(x = 0.5, vec = c(0, 1))
checkInterval(x = 1.5, vec = c(0, 1))
checkInterval(x = -0.5, vec = c(0, 1))
## End(Not run)
```

---

c coef.ddfMLR  Extract model coefficients from an object of “ddfMLR” class.

Description

S3 method for extracting estimated model coefficients from an object of "ddfMLR" class.

Usage

```r
## S3 method for class 'ddfMLR'
coef(object, SE = FALSE, simplify = FALSE, ...)
```

Arguments

- **object**: an object of "ddfMLR" class.
- **SE**: logical: should the standard errors of estimated parameters be also returned? (default is FALSE).
- **simplify**: logical: should the estimated parameters be simplified to a matrix? (default is FALSE).
- **...**: other generic parameters for `coef()` method.
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See Also

ddfMLR for DDF detection among nominal data.
coef for generic function extracting model coefficients.

Examples

## Not run:
# Loading data based on GMAT
data(GMATtest, GMATkey)

Data <- GMATtest[, 1:20]
group <- GMATtest[, "group"]
key <- GMATkey

# Testing both DDF effects
(x <- ddfMLR(Data, group, focal.name = 1, key))

# Estimated parameters
coef(x)
coef(x, SE = TRUE)
coef(x, simplify = TRUE)
coef(x, SE = TRUE, simplify = TRUE)

## End(Not run)

coef.difNLR

Extract model coefficients from an object of "difNLR" class.

Description

S3 method for extracting model coefficients from an object of "difNLR" class.

Usage

## S3 method for class 'difNLR'
coef(object, SE = FALSE, simplify = FALSE, ...)


---
Arguments

- **object**: an object of "difNLR" class.
- **SE**: logical: should the standard errors of estimated parameters be also returned? (default is FALSE).
- **simplify**: logical: should the estimated parameters be simplified to a matrix? (default is FALSE).
- **...**: other generic parameters for predict() function.

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References


See Also

difNLR for DIF detection among binary data using generalized logistic regression model.
coef for generic function extracting model coefficients.

Examples

```r
## Not run:
# Loading data based on GMAT
data(GMAT)

Data <- GMAT[, 1:20]  

group <- GMAT[, "group"]

# Testing both DIF effects using likelihood-ratio test and
# 3PL model with fixed guessing for groups
```
(x <- difNLR(Data, group, focal.name = 1, model = "3PLcg"))

# Coefficients
coef(x)
coef(x, SE = TRUE)
coef(x, SE = TRUE, simplify = TRUE)

## End(Not run)

---

coefficient

**Extract model coefficients from an object of "difORD" class.**

**Description**

S3 method for extracting estimated model coefficients from an object of "difORD" class.

**Usage**

```r
## S3 method for class 'difORD'
coef(object, SE = FALSE, simplify = FALSE, ...)
```

**Arguments**

- `object`: an object of "difORD" class.
- `SE`: logical: should the standard errors of estimated parameters be also returned? (default is FALSE).
- `simplify`: logical: should the estimated parameters be simplified to a matrix? (default is FALSE).
- `...`: other generic parameters for `coef()` method.

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**See Also**

difORD for DIF detection among ordinal data.
coef for generic function extracting model coefficients.
ddfMLR

**Examples**

```r
## Not run:
# Loading data
data(dataMedicalgraded, package = "ShinyItemAnalysis")
Data <- dataMedicalgraded[, 1:5]
group <- dataMedicalgraded[, 101]

# Testing both DIF effects with adjacent category logit model
(x <- difORD(Data, group, focal.name = 1, model = "adjacent"))

# Estimated parameters
coef(x)
coef(x, SE = TRUE)
coef(x, simplify = TRUE)
coef(x, SE = TRUE, simplify = TRUE)

## End(Not run)
```

**ddfMLR**

**DDF detection for nominal data.**

**Description**

Performs DDF detection procedure for nominal data based on multinomial log-linear regression model and likelihood ratio test of a submodel.

**Usage**

```r
ddfMLR(Data, group, focal.name, key, type = "both", match = "zscore", anchor = NULL, 
      purify = FALSE, nrIter = 10, p.adjust.method = "none", parametrization = "irt", 
      alpha = 0.05)
```

**Arguments**

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data</td>
<td>data.frame or matrix: dataset which rows represent unscored examinee answers (nominal) and columns correspond to the items. In addition, Data can hold the vector of group membership.</td>
</tr>
<tr>
<td>group</td>
<td>numeric or character: a dichotomous vector of the same length as nrow(Data) or a column identifier of Data.</td>
</tr>
<tr>
<td>focal.name</td>
<td>numeric or character: indicates the level of group which corresponds to focal group.</td>
</tr>
<tr>
<td>key</td>
<td>character: the answer key. Each element corresponds to the correct answer of one item.</td>
</tr>
<tr>
<td>type</td>
<td>character: type of DDF to be tested. Either &quot;both&quot; for uniform and non-uniform DDF (i.e., difference in parameters &quot;a&quot; and &quot;b&quot;) (default), or &quot;udif&quot; for uniform DDF only (i.e., difference in difficulty parameter &quot;b&quot;), or &quot;nudif&quot; for non-uniform DDF only (i.e., difference in discrimination parameter &quot;a&quot;). Can be specified as a single value (for all items) or as an item-specific vector.</td>
</tr>
</tbody>
</table>
match numeric or character: matching criterion to be used as an estimate of trait. Can be either "zscore" (default, standardized total score), "score" (total test score), or vector of the same length as number of observations in Data.

anchor numeric or character: specification of DDF free items. Either NULL (default), or a vector of item names (column names of Data), or item identifiers (integers specifying the column number) determining which items are currently considered as anchor (DDF free) items. Argument is ignored if match is not "zscore" or "score".

purify logical: should the item purification be applied? (default is FALSE).

nrIter numeric: the maximal number of iterations in the item purification (default is 10).


parametrization character: parametrization of regression coefficients. Possible options are "irt" for difficulty-discrimination parametrization (default) and "classic" for intercept-slope parametrization. See Details.

alpha numeric: significance level (default is 0.05).

Details

Performs DDF detection procedure for nominal data based on multinomial log-linear regression model and likelihood ratio test of submodel. Probability of selection the $k$-th category (distractor) is

$$P(y = k) = \frac{\exp((a_k + a_kDif*g) * (x - b_k - b_kDif*g))}{1 + \sum \exp((a_l + a_lDif*g) * (x - b_l - b_lDif*g))},$$

where $x$ is by default standardized total score (also called Z-score) and $g$ is a group membership. Parameters $a_k$ and $b_k$ are discrimination and difficulty for the $k$-th category. Terms $a_kDif$ and $b_kDif$ then represent differences between two groups (reference and focal) in relevant parameters. Probability of correct answer (specified in argument key) is

$$P(y = k) = 1/(1 + \sum \exp((a_l + a_lDif*g) * (x - b_l - b_lDif*g))).$$

Parameters are estimated via neural networks. For more details see multinom.

Argument parametrization is a character which specifies parametrization of regression parameters. Default option is "irt" which returns IRT parametrization (difficulty-discrimination, see above). Option "classic" returns intercept-slope parametrization with effect of group membership and interaction with matching criterion, i.e. $b_0k + b_1k * x + b_2k * g + b_3k * x * g$ instead of $(a_k + a_kDif*g) * (x - b_k - b_kDif*g)).$

Missing values are allowed but discarded for item estimation. They must be coded as NA for both, Data and group arguments.
Value

The `ddfMLR()` function returns an object of class "ddfMLR". The output including values of the test statistics, p-values, and items marked as DDF is displayed by the `print()` method.

A list of class "ddfMLR" with the following arguments:

- `Sval` the values of likelihood ratio test statistics.
- `mlrPAR` the estimates of final model.
- `mlrSE` standard errors of the estimates of final model.
- `parM0` the estimates of null model.
- `parM1` the estimates of alternative model.
- `llM0` log-likelihood of null model.
- `llM1` log-likelihood of alternative model.
- `AIC0` AIC of null model.
- `AIC1` AIC of alternative model.
- `BIC0` BIC of null model.
- `BIC1` BIC of alternative model.
- `DDFitems` either the column identifiers of the items which were detected as DDF, or "No DDF item detected" in case no item was detected as DDF.
- `type` character: type of DDF that was tested.
- `purification purify value.`
- `nrPur` number of iterations in item purification process. Returned only if `purify` is TRUE.
- `ddfPur` a binary matrix with one row per iteration of item purification and one column per item. "1" in i-th row and j-th column means that j-th item was identified as DDF in i-th iteration. Returned only if `purify` is TRUE.
- `conv.puri` logical indicating whether item purification process converged before the maximal number `nrIter` of iterations. Returned only if `purify` is TRUE.
- `p.adjust.method` character: method for multiple comparison correction which was applied.
- `pval` the p-values by likelihood ratio test.
- `adj.pval` the adjusted p-values by likelihood ratio test using `p.adjust.method`.
- `df` the degrees of freedom of likelihood ratio test.
- `alpha` numeric: significance level.
- `Data` the data matrix.
- `group` the vector of group membership.
- `group.names` levels of grouping variable.
- `key` key of correct answers.
- `match` matching criterion.

For an object of class "ddfMLR" several methods are available (e.g. `methods(class = "ddfMLR"))"
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See Also

plot.ddfMLR for graphical representation of item characteristic curves.
coef.ddfMLR for extraction of item parameters with their standard errors.
logLik.ddfMLR, AIC.ddfMLR, BIC.ddfMLR for extraction of loglikelihood and information criteria.

p.adjust for multiple comparison corrections.
multinom for estimation function using neural networks.

Examples

## Not run:
# Loading data based on GMAT
data(GMATtest, GMATkey)

Data <- GMATtest[, 1:20]
group <- GMATtest[, "group"]
key <- GMATkey

# Testing both DDF effects
(x <- ddfMLR(Data, group, focal.name = 1, key))

# Graphical devices
plot(x, item = "Item1", group.names = c("Group 1", "Group 2"))
plot(x, item = x$DDFitems)
plot(x, item = 1)

# AIC, BIC, log-likelihood
AIC(x)
BIC(x)
logLik(x)

# AIC, BIC, log-likelihood for the first item
AIC(x, item = 1)
BIC(x, item = 1)
logLik(x, item = 1)

# Estimates
coef(x)
difNLR

DIF detection using non-linear regression method.

Description

Performs DIF detection procedure for dichotomous data based on non-linear regression model (generalized logistic regression) and either likelihood-ratio or F test of a submodel.

Usage

difNLR(Data, group, focal.name, model, constraints, type = "all", method = "nls", match = "zscore", anchor = NULL, purify = FALSE, nrIter = 10, test = "LR", alpha = 0.05, p.adjust.method = "none", start, initboot = T, nrBo = 20)

Arguments

Data      data.frame or matrix: dataset which rows represent scored examinee answers ("1" correct, "0" incorrect) and columns correspond to the items. In addition, Data can hold the vector of group membership.

group     numeric or character: a dichotomous vector of the same length as nrow(Data) or a column identifier of Data.

focal.name numeric or character: indicates the level of group which corresponds to focal group.

model     character: generalized logistic regression model to be fitted. See Details.
constraints character: which parameters should be the same for both groups. Possible values are any combinations of parameters "a", "b", "c", and "d". See Details.

type character: type of DIF to be tested. Possible values are "all" for detecting difference in any parameter (default), "udif" for uniform DIF only (i.e., difference in difficulty parameter "b"), "nudif" for non-uniform DIF only (i.e., difference in discrimination parameter "a"), "both" for uniform and non-uniform DIF (i.e., difference in parameters "a" and "b"), or combination of parameters "a", "b", "c", and "d". Can be specified as a single value (for all items) or as an item-specific vector.

method character: method used to estimate parameters. Either "nls" for non-linear least squares (default), or "likelihood" for maximum likelihood method.

match numeric or character: matching criterion to be used as an estimate of trait. Can be either "zscore" (default, standardized total score), "score" (total test score), or vector of the same length as number of observations in Data.

anchor numeric or character: specification of DIF free items. Either NULL (default), or a vector of item names (column names of Data), or item identifiers (integers specifying the column number) determining which items are currently considered as anchor (DIF free) items. Argument is ignored if match is not "zscore" or "score".

purify logical: should the item purification be applied? (default is FALSE).

nrIter numeric: the maximal number of iterations in the item purification (default is 10).

test character: test to be performed for DIF detection. Can be either "LR" for likelihood ratio test of a submodel (default), or "F" for F-test of a submodel.

alpha numeric: significance level (default is 0.05).


start numeric: initial values for estimation of parameters. If not specified, starting values are calculated with startNLR function. Otherwise, list with as many elements as a number of items. Each element is a named numeric vector of length 8 representing initial values for parameter estimation. Specifically, parameters "a", "b", "c", and "d" are initial values for discrimination, difficulty, guessing, and inattention for reference group. Parameters "aDif", "bDif", "cDif", and "dDif" are then differences in these parameters between reference and focal group.

initboot logical: in case of convergence issues, should be starting values re-calculated based on bootstrapped samples? (default is TRUE; newly calculated initial values are applied only to items/models with convergence issues).

nrBo numeric: the maximal number of iterations for calculation of starting values using bootstrapped samples (default is 20).
Details

DIF detection procedure based on non-linear regression is the extension of logistic regression procedure (Swaminathan and Rogers, 1990; Drabinova and Martinkova, 2017).

The unconstrained form of 4PL generalized logistic regression model for probability of correct answer (i.e., \( y = 1 \)) is

\[
P(y = 1) = \frac{c + cDif \ast g + (d + dDif \ast g - c - cDif \ast g)}{1 + \exp(-(a + aDif \ast g) \ast (x - b - bDif \ast g))},
\]

where \( x \) is by default standardized total score (also called Z-score) and \( g \) is a group membership. Parameters \( a, b, c, \) and \( d \) are discrimination, difficulty, guessing, and inattention. Terms \( aDif, bDif, cDif, \) and \( dDif \) then represent differences between two groups (reference and focal) in relevant parameters.

This 4PL model can be further constrained by model and constraints arguments. The arguments model and constraints can be also combined. Both arguments can be specified as a single value (for all items) or as an item-specific vector (where each element correspond to one item).

The model argument offers several predefined models. The options are as follows: Rasch for 1PL model with discrimination parameter fixed on value 1 for both groups, 1PL for 1PL model with discrimination parameter fixed for both groups, 2PL for logistic regression model, 3PLcg for 3PL model with fixed guessing for both groups, 3PLdg for 3PL model with fixed inattention for both groups, 3PLc (alternatively also 3PL) for 3PL regression model with guessing parameter, 3PLd for 3PL model with inattention parameter, 4PLcgdg for 4PL model with fixed guessing and inattention parameter for both groups, 4PLcgd (alternatively also 4PLd) for 4PL model with fixed guessing for both groups, 4PLcdg (alternatively also 4PLc) for 4PL model with fixed inattention for both groups, or 4PL for 4PL model.

The model can be specified in more detail with constraints argument which specifies what parameters should be fixed for both groups. For example, choice "ad" means that discrimination (parameter "a") and inattention (parameter "d") are fixed for both groups and other parameters ("b" and "c") are not. The NA value for constraints means no constraints.

Missing values are allowed but discarded for item estimation. They must be coded as NA for both, data and group arguments.

In case that model considers difference in guessing or inattention parameter, the different parameterization is used and parameters with standard errors are re-calculated by delta method. However, covariance matrices stick with alternative parameterization.

Value

The \( \text{difNLR()} \) function returns an object of class "difNLR". The output including values of the test statistics, p-values, and items detected as function differently is displayed by the \( \text{print()} \) method.

Object of class "difNLR" is a list with the following components:

- \( \text{Sval} \): the values of the test statistics.
- \( \text{n1rPAR} \): the estimates of final model.
- \( \text{n1rSE} \): the standard errors of estimates of final model.
- \( \text{parM0} \): the estimates of null model.
- \( \text{seM0} \): the standard errors of estimates of null model.
covM0  the covariance matrices of estimates of null model.
llM0  log-likelihood of null model.
parM1  the estimates of alternative model.
seM1  the standard errors of estimates of alternative model.
covM1  the covariance matrices of estimates of alternative model.
llM1  log-likelihood of alternative model.
DIFitems  either the column identifiers of the items which were detected as DIF, or "No DIF item detected" in case no item was detected as function differently.
model  fitted model.
constraints  constraints for the model.
type  character: type of DIF that was tested. If parameters were specified, the value is "other".
types  character: the parameters (specified by user, type has value "other") which were tested for difference.
p.adjust.method  character: method for multiple comparison correction which was applied.
pval  the p-values of the test.
adj.pval  the adjusted p-values of the test using p.adjust.method.
df  the degrees of freedom of the test.
test  used test.
purification purify value.
nrPur  number of iterations in item purification process. Returned only if purify is TRUE.
difPur  a binary matrix with one row per iteration of item purification and one column per item. "1" in i-th row and j-th column means that j-th item was identified as DIF in i-th iteration. Returned only if purify is TRUE.
conv.puri logical: indicating whether item purification process converged before the maximal number nrIter of iterations. Returned only if purify is TRUE.
method  used estimation method.
conv.fail numeric: number of convergence issues.
conv.fail.which  the identifiers of the items which did not converge.
alpha  numeric: significance level.
Data  the data matrix.
group  the vector of group membership.
group.names  names of groups.
match  matching criterion.

For an object of class "difNLR" several methods are available (e.g. methods(class = "difNLR")).
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References


See Also

plot.difNLR for graphical representation of item characteristic curves and DIF statistics.
coef.difNLR for extraction of item parameters with their standard errors.
predict.difNLR for prediction.
fitted.difNLR and residuals.difNLR for extraction of fitted values and residuals.
logLik.difNLR, AIC.difNLR, BIC.difNLR for extraction of loglikelihood and information criteria.
p.adjust for multiple comparison corrections.
nls for nonlinear least squares estimation.
startNLR for calculation of initial values of fitting algorithms in difNLR().

Examples

# Loading data based on GMAT
data(GMAT)
Data <- GMAT[, 1:20]
group <- GMAT[, "group"]

# Testing both DIF effects using likelihood-ratio test and
# 3PL model with fixed guessing for groups
(x <- difNLR(Data, group, focal.name = 1, model = "3PLcg"))
## Not run:
# Graphical devices
plot(x, item = x$DIFitems)
plot(x, item = "Item1")
plot(x, item = 1, group.names = c("Group 1", "Group 2"))
plot(x, plot.type = "stat")

# Coefficients
coeff(x)
coeff(x, SE = TRUE)
coeff(x, SE = TRUE, simplify = TRUE)

# Fitted values
fitted(x)
fitted(x, item = 1)

# Residuals
residuals(x)
residuals(x, item = 1)

# Predicted values
predict(x)
predict(x, item = 1)

# Predicted values for new subjects
predict(x, item = 1, match = 0, group = 0)
predict(x, item = 1, match = 0, group = 1)

# AIC, BIC, log-likelihood
AIC(x)
BIC(x)
logLik(x)

# AIC, BIC, log-likelihood for the first item
AIC(x, item = 1)
BIC(x, item = 1)
logLik(x, item = 1)

# Testing both DIF effects using F test and
# 3PL model with fixed guessing for groups
difNLR(Data, group, focal.name = 1, model = "3PLcg", test = "F")

# Testing both DIF effects using LR test,
# 3PL model with fixed guessing for groups
# and Benjamini-Hochberg correction
difNLR(Data, group, focal.name = 1, model = "3PLcg", p.adjust.method = "BH")

# Testing both DIF effects using LR test,
# 3PL model with fixed guessing for groups
# and item purification
difNLR(Data, group, focal.name = 1, model = "3PLcg", purify = TRUE)

# Testing both DIF effects using 3PL model with fixed guessing for groups
# and total score as matching criterion
difNLR(Data, group, focal.name = 1, model = "3PLcg", match = "score")
difORD

DIF detection among ordinal data.

Description

Performs DIF detection procedure for ordinal data based either on adjacent category logit model or on cumulative logit model and likelihood ratio test of a submodel.

Usage

difORD(Data, group, focal.name, model = "adjacent", type = "both", match = "zscore", anchor = NULL, purify = FALSE, nrIter = 10, p.adjust.method = "none", parametrization = "irt", alpha = 0.05)

Arguments

Data  data.frame or matrix: dataset which rows represent ordinaly scored examinee answers and columns correspond to the items. In addition, Data can hold the vector of group membership.

group numeric or character: a dichotomous vector of the same length as nrow(Data) or a column identifier of Data.

focal.name numeric or character: indicates the level of group which corresponds to focal group.

model character: logistic regression model for ordinal data (either "adjacent" (default) or "cumulative"). See Details.
type
counting: type of DIF to be tested. Either "both" for uniform and non-uniform DIF (i.e., difference in parameters "a" and "b") (default), or "udif" for uniform DIF only (i.e., difference in difficulty parameter "b"), or "nudif" for non-uniform DIF only (i.e., difference in discrimination parameter "a"). Can be specified as a single value (for all items) or as an item-specific vector.
match
counting: matching criterion to be used as an estimate of trait. Can be either "zscore" (default, standardized total score), "score" (total test score), or vector of the same length as number of observations in Data.
anchor
counting or character: specification of DIF free items. Either NULL (default), or a vector of item names (column names of Data), or item identifiers (integers specifying the column number) determining which items are currently considered as anchor (DIF free) items. Argument is ignored if match is not "zscore" or "score".
purify
logical: should the item purification be applied? (default is FALSE).

nrIter
numeric: the maximal number of iterations in the item purification (default is 10).
p.adjust.method
character: method for multiple comparison correction. Possible values are "holm", "hochberg", "hommel", "bonferroni", "BH", "BY", "fdr", and "none" (default). For more details see p.adjust.

parametrization
character: parametrization of regression coefficients. Possible options are "irt" for difficulty-discrimination parametrization (default) and "classic" for intercept-slope parametrization. See Details.

alpha
numeric: significance level (default is 0.05).

Details
Performs DIF detection procedure for ordinal data based either on adjacent category logit model or on cumulative logit model.

Using adjacent category logit model, logarithm of ratio of probabilities of two adjacent categories is

\[
\log(P(y = k)/P(y = k - 1)) = (a + aDif * g) \ast (x - b_k - b_kDif \ast g),
\]

where \(x\) is by default standardized total score (also called Z-score) and \(g\) is a group membership. Parameter \(a\) is a discrimination of the item and parameter \(b_k\) is difficulty for the \(k\)-th category of the item. Terms \(aDif\) and \(b_kDif\) then represent differences between two groups (reference and focal) in relevant parameters.

Using cumulative logit model, probability of gaining at least \(k\) points is given by 2PL model, i.e.,

\[
P(y \geq k) = \frac{\exp((a+aDif \ast g) \ast (x-b_k-b_kDif \ast g))/(1+\exp((a+aDif \ast g) \ast (x-b_k-b_kDif \ast g)))}{1+\exp((a+aDif \ast g) \ast (x-b_k-b_kDif \ast g)))}.
\]

The category probability (i.e., probability of gaining exactly \(k\) points) is then \(P(Y = k) = P(Y \geq k) - P(Y \geq k + 1)\).

Both models are estimated by iteratively reweighted least squares. For more details see vglm.

Argument parametrization is a character which specifies parametrization of regression parameters. Default option is "irt" which returns IRT parametrization (difficulty-discrimination, see
Option "classic" returns intercept-slope parametrization with effect of group membership and interaction with matching criterion, i.e. $b_0k + b_1 \times x + b_2k \times g + b_3 \times x \times g$ instead of $(a + a_{Diff} \times g) \times (x - b_k - b_k Dif \times g)$.

Missing values are allowed but discarded for item estimation. They must be coded as NA for both, Data and group parameters.

Value

The difORD() function returns an object of class "difORD". The output including values of the test statistics, p-values, and items marked as DIF is displayed by the print() method.

A list of class "difORD" with the following arguments:

- Sval: the values of likelihood ratio test statistics.
- ordPAR: the estimates of the final model.
- ordSE: standard errors of the estimates of the final model.
- parM0: the estimates of null model.
- parM1: the estimates of alternative model.
- llM0: log-likelihood of null model.
- llM1: log-likelihood of alternative model.
- AICM0: AIC of null model.
- AICM1: AIC of alternative model.
- BICM0: BIC of null model.
- BICM1: BIC of alternative model.
- DIFitems: either the column identifiers of the items which were detected as DIF, or "No DIF item detected" in case no item was detected as DIF.
- model: model used for DIF detection.
- type: character: type of DIF that was tested.
- parametrization: Parameters’ parametrization.
- purification: purify value.
- nrPur: number of iterations in item purification process. Returned only if purify is TRUE.
- difPur: a binary matrix with one row per iteration of item purification and one column per item. "1" in i-th row and j-th column means that j-th item was identified as DIF in i-th iteration. Returned only if purify is TRUE.
- conv.puri: logical indicating whether item purification process converged before the maximal number nrIter of iterations. Returned only if purify is TRUE.
- p.adjust.method: character: method for multiple comparison correction which was applied.
- pval: the p-values by likelihood ratio test.
- adj.pval: the adjusted p-values by likelihood ratio test using p.adjust.method.
- df: the degrees of freedom of likelihood ratio test.
- alpha: numeric: significance level.
- Data: the data matrix.
group the vector of group membership.
group.names levels of grouping variable.
match matching criterion.

For an object of class "difORD" several methods are available (e.g. methods(class = "difORD")),

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References


See Also

plot.difORD for graphical representation of item characteristic curves.
coef.difORD for extraction of item parameters with their standard errors.
logLik.difORD, AIC.difORD, BIC.difORD for extraction of loglikelihood and information criteria.

p.adjust for multiple comparison corrections.
vglm for estimation function using iteratively reweighted least squares.

Examples

# Loading data
data(dataMedicalgraded, package = "ShinyItemAnalysis")
Data <- dataMedicalgraded[, 1:5]
group <- dataMedicalgraded[, 101]

# Testing both DIF effects with adjacent category logit model
(x <- difORD(Data, group, focal.name = 1, model = "adjacent"))
## Not run:
# Graphical devices
plot(x, item = 3)
plot(x, item = "X2003")
plot(x, item = "X2003", group.names = c("Group 1", "Group 2"))

# Estimated parameters
coef(x)
coef(x, SE = TRUE) # with SE
coef(x, SE = TRUE, simplify = TRUE) # with SE, simplified
# AIC, BIC, log-likelihood
AIC(x)
BIC(x)
logLik(x)

# AIC, BIC, log-likelihood for the first item
AIC(x, item = 1)
BIC(x, item = 1)
logLik(x, item = 1)

# Testing both DIF effects with Benjamini-Hochberg adjustment method
difORD(Data, group, focal.name = 1, model = "adjacent", p.adjust.method = "BH")

# Testing both DIF effects with item purification
difORD(Data, group, focal.name = 1, model = "adjacent", purify = TRUE)

# Testing uniform DIF effects
difORD(Data, group, focal.name = 1, model = "adjacent", type = "udif")
# Testing non-uniform DIF effects
difORD(Data, group, focal.name = 1, model = "adjacent", type = "nudif")

# Testing both DIF effects with total score as matching criterion
difORD(Data, group, focal.name = 1, model = "adjacent", match = "score")

# Testing both DIF effects with cumulative logit model
# using IRT parametrization
(x <- difORD(Data, group, focal.name = 1, model = "cumulative", parametrization = "irt"))

# Graphical devices
plot(x, item = 3, plot.type = "cumulative")
plot(x, item = 3, plot.type = "category")

# Estimated parameters in IRT parametrization
coef(x, simplify = TRUE)

## End(Not run)

---

**estimNLR**

*Non-Linear Regression DIF models estimation.*

**Description**

Estimates parameters of non-linear regression models for DIF detection using either non-linear least squares or maximum likelihood method.

**Usage**

```
estimNLR(y, match, group, formula, method, lower, upper, start)
```
Arguments

- **y** numeric: binary vector of responses.
- **match** numeric: vector of matching criterion.
- **group** numeric: binary vector of group membership. "0" for reference group, "1" for focal group.
- **formula** formula: specification of the model. Can be obtained by `formulaNLR()` function.
- **method** character: method used to estimate parameters. The options are "nls" for non-linear least squares (default) and "likelihood" for maximum likelihood method.
- **lower** numeric: lower bounds for parameters of model specified in `formula`.
- **upper** numeric: upper bounds for parameters of model specified in `formula`.
- **start** numeric: initial parameters. Can be obtained by `startNLR()` function.

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Examples

data(GMAT)

# item 1
y <- GMAT[, 1]
match <- scale(rowSums(GMAT[, 1:20]))
group <- GMAT[, "group"]

# formula for 3PL model with the same guessing
M <- formulaNLR(model = "3PLcg", type = "both")

# starting values for 3PL model with the same guessing for item 1
start <- startNLR(GMAT[, 1:20], group, model = "3PLcg", parameterization = "classic")
start <- start[[1]]$parameters

# Non-linear least squares
fitNLSM0 <- estimNLR(
    y = y, match = match, group = group,
    formula = M$formula, method = "nls",
    lower = M$lower, upper = M$upper, start = start
)
fitted.difNLR

fitNLSM0

coef(fitNLSM0)
logLik(fitNLSM0)
vcov(fitNLSM0)
fitted(fitNLSM0)
residuals(fitNLSM0)

# Maximum likelihood
fitLKLM0 <- estimNLR(
  y = y, match = match, group = group,
  formula = M$M0$formula, method = "likelihood",
  lower = M$M0$lower, upper = M$M0$upper, start = start
)
fitLKLM0

coef(fitLKLM0)
logLik(fitLKLM0)
vcov(fitLKLM0)
fitted(fitLKLM0)
residuals(fitLKLM0)

---

fitted.difNLR  

*Fitted values and residuals for an object of "difNLR" class.*

**Description**

S3 methods for extracting fitted values and residuals for an object of "difNLR" class.

**Usage**

```
## S3 method for class 'difNLR'
fitted(object, item = "all", ...)

## S3 method for class 'difNLR'
residuals(object, item = "all", ...)
```

**Arguments**

- `object` an object of "difNLR" class.
- `item` numeric or character: either character "all" to apply for all converged items (default), or a vector of item names (column names of Data), or item identifiers (integers specifying the column number).
- `...` other generic parameters for S3 methods.
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References


See Also

difNLR for DIF detection among binary data using generalized logistic regression model.
fitted for generic function extracting fitted values.
residuals for generic function extracting residuals.

Examples

```r
## Not run:
# Loading data based on GMAT
data(GMAT)
Data <- GMAT[, 1:20]
group <- GMAT[, "group"]

# Testing both DIF effects using likelihood-ratio test and
# 3PL model with fixed guessing for groups
(x <- difNLR(Data, group, focal.name = 1, model = "3PLcg"))

# Fitted values
fitted(x)
fitted(x, item = 1)

# Residuals
residuals(x)
residuals(x, item = 1)
```
## formulaNLR

Function returns the formula of the non-linear regression DIF model based on model specification and DIF type to be tested.

### Usage

```r
formulaNLR(model, constraints = NULL, type = "all", parameterization = "classic", outcome)
```

### Arguments

- `model` character: generalized logistic regression model for which starting values should be estimated. See Details.
- `constraints` character: which parameters should be the same for both groups. Possible values are any combinations of parameters "a", "b", "c", and "d". Default value is NULL. See Details.
- `type` character: type of DIF to be tested. Possible values are "all" for detecting difference in any parameter (default), "udif" for uniform DIF only (i.e., difference in difficulty parameter "b"), "nudif" for non-uniform DIF only (i.e., difference in discrimination parameter "a"), "both" for uniform and non-uniform DIF (i.e., difference in parameters "a" and "b"), or combination of parameters "a", "b", "c", and "d". Can be specified as a single value (for all items) or as an item-specific vector.
- `parameterization` character: parameterization of regression coefficients. Possible options are "classic" (IRT parameterization), "alternative" (default) and "logistic" (logistic regression). See Details.
- `outcome` character: name of outcome to be printed in formula. If not specified "y" is used.

### Details

The unconstrained form of 4PL generalized logistic regression model for probability of correct answer (i.e., $y = 1$) is

$$ P(y = 1) = \frac{(c + c_{Dif} g) + (d + d_{Dif} g - c_{Dif} g) / (1 + \exp(-(a + a_{Dif} g) * (x - b - b_{Dif} g)))}{1 + \exp(-(a + a_{Dif} g) * (x - b - b_{Dif} g))}, $$

where $x$ is by default standardized total score (also called Z-score) and $g$ is a group membership. Parameters $a$, $b$, $c$, and $d$ are discrimination, difficulty, guessing, and inattention. Terms $a_{Dif}$, $b_{Dif}$, $c_{Dif}$, and $d_{Dif}$ then represent differences between two groups (reference and focal) in relevant parameters.
The model argument offers several predefined models. The options are as follows: Rasch for 1PL model with discrimination parameter fixed on value 1 for both groups, 1PL for 1PL model with discrimination parameter fixed for both groups, 2PL for logistic regression model, 3PLcg for 3PL model with fixed guessing for both groups, 3PLdg for 3PL model with fixed inattention for both groups, 3PLc (alternatively also 3PL) for 3PL regression model with guessing parameter, 3PLd for 3PL model with inattention parameter, 4PLcgdg for 4PL model with fixed guessing and inattention parameter for both groups, 4PLcgd (alternatively also 4PLd) for 4PL model with fixed guessing for both groups, 4PLc (alternatively also 4PL) for 4PL model with fixed inattention for both groups, or 4PL for 4PL model.

Three possible parameterization can be specified in "parameterization" argument: "classic" returns IRT parameters of reference group and differences in these parameters between reference and focal group. "alternative" returns IRT parameters of reference group, the differences in parameters "a" and "b" between two groups and parameters "c" and "d" for focal group. "logistic" returns parameters in logistic regression parameterization.

Value

A list of two models. Both includes formula, parameters to be estimated and their lower and upper constraints.

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See Also

difNLR

Examples

# 3PL model with the same guessing for both groups
# to test both types of DIF
formulaNLR(model = "3PLcg", type = "both")

# 4PL model with the same guessing and inattention
# to test uniform DIF
formulaNLR(model = "4PLcgdg", type = "udif")

# 2PL model to test non-uniform DIF
formulaNLR(model = "2PL", type = "nudif")

# 4PL model to test all possible DIF
# with alternative parameterization
formulaNLR(model = "4PL", type = "all", parameterization = "alternative")

# 4PL model with fixed a and c parameter
# to test difference in b with alternative parameterization
formulaNLR(model = "4PL", constraints = "ac", type = "b", parameterization = "alternative")

---

**genNLR**

Generates data set based on generalized logistic regression DIF and DDF models.

---

**Description**

Generates dichotomous, nominal, and ordinal data based on generalized logistic regression models for DIF and DDF detection.

**Usage**

```r
genNLR(N = 1000, ratio = 1, itemtype = "dich", a, b, c, d, mu = 0, sigma = 1)
```

**Arguments**

- **N**
  - numeric: number of rows representing respondents. (default is 1000).
- **ratio**
  - numeric: ratio of respondents number in reference and focal group.
- **itemtype**
  - character: type of items to be generated. Options are "dich" (default) for dichotomous item based on non-linear regression model for DIF detection (see difNLR for details), "nominal" for nominal items based on multinomial model for DDF detection (see ddfMLR for detail), and "ordinal" for ordinal data based on adjacent category logit model (for details see difORD).
- **a**
  - numeric: matrix representing discriminations with m rows (where m is number of items). Need to be provided. See Details.
- **b**
  - numeric: matrix representing difficulties with m rows (where m is number of items). Need to be provided. See Details.
- **c**
  - numeric: matrix representing guessings (lower asymptotes) with m rows (where m is number of items). Default is NULL. See Details.
- **d**
  - numeric: matrix representing inattentions (upper asymptotes) with m rows (where m is number of items). Default is NULL. See Details.
- **mu**
  - numeric: a mean vector of the underlying distribution. The first value corresponds to reference group, the second to focal group. Default is 0 value for both groups.
- **sigma**
  - numeric: a standard deviation vector of the underlying distribution. The first value corresponds to reference group, the second to focal group. Default is 1 value for both groups.
Details

The a, b, c and d are numeric matrices with m rows (where m is number of items) representing parameters of regression models for DIF and DDF detection.

For option `itemtype = "dich"`, matrices should have two columns. The first column represents parameters of the reference group and the second of the focal group. In case that only one column is provided, parameters are set to be the same for both groups.

For options `itemtype = "nominal"` and `itemtype = "ordinal"`, matrices c and d are ignored. Matrices a and b contain parameters for distractors. For example, when item with 4 different choices is supposed to be generated, user provide matrices with 6 columns. First 3 columns correspond to distractors parameters for reference group and last three columns for focal group. The number of choices can differ for items. Matrices a and b need to consist of as many columns as is the maximum number of distractors. Items with less choices can contain NAs.

Value

A data frame containing N rows representing respondents and m + 1 columns representing m items. The last column is group membership variable with coding "0" for reference group and "1" for focal group.

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References


See Also

difNLR, difORD, ddfMLR

Examples

```r
# seed
set.seed(123)

# generating parameters for dichotomous data with DIF, 5 items
a <- matrix(runif(10, 0.8, 2), ncol = 2)
b <- matrix(runif(10, -2, 2), ncol = 2)
c <- matrix(runif(10, 0, 0.25), ncol = 2)
```
d <- matrix(runif(10, 0.8, 1), ncol = 2)
# generating dichotomous data set with 300 observations (150 each group)
genNLR(N = 300, a = a, b = b, c = c, d = d)
# generating dichotomous data set with 300 observations (150 each group)
# and different mean and standard deviation for underlying distribution
ngenNLR(N = 300, a = a, b = b, c = c, d = d, mu = c(1, 0), sigma = c(1, 2))
# generating dichotomous data set with 300 observations (250 reference group, 50 focal)
genNLR(N = 300, ratio = 5, a = a, b = b, c = c, d = d)

# generating parameters for nominal data with DDF, 5 items,
# each item 3 choices
a <- matrix(runif(20, 0.8, 2), ncol = 4)
b <- matrix(runif(20, -2, 2), ncol = 4)
# generating nominal data set with 300 observations (150 each group)
genNLR(N = 300, itemtype = "nominal", a = a, b = b)
# generating nominal data set with 300 observations (250 reference group, 50 focal)
genNLR(N = 300, itemtype = "nominal", ratio = 5, a = a, b = b)

# generating parameters for nominal data with DDF, 5 items,
# items 1 and 2 have 2 choices, items 3, 4 and 5 have 3 choices
a[1:2, c(2, 4)] <- NA
b[1:2, c(2, 4)] <- NA
# generating nominal data set with 300 observations (150 each group)
genNLR(N = 300, itemtype = "nominal", a = a, b = b)
# generating nominal data set with 300 observations (250 reference group, 50 focal)
genNLR(N = 300, itemtype = "nominal", ratio = 5, a = a, b = b)

---

**GMAT**

**Dichotomous dataset based on GMAT with the same total score distribution for groups.**

**Description**

The GMAT is a generated dataset based on parameters from Graduate Management Admission Test (GMAT, Kingston et al., 1985). First two items were considered to function differently in uniform and non-uniform way respectively. The dataset represents responses of 2,000 subjects to multiple-choice test of 20 items. A correct answer is coded as 1 and incorrect answer as 0. The column group represents group membership, where 0 indicates reference group and 1 indicates focal group. Groups are the same size (i.e. 1,000 per group). The distributions of total scores (sum of correct answers) are the same for both reference and focal group (Martinkova et al., 2017). The column criterion represents generated continuous variable which is intended to be predicted by test.

**Usage**

data(GMAT)
Format

A GMAT data frame consists of 2,000 observations on the following 22 variables:

- **Item1-Item20** dichotomously scored items of the test
- **group** group membership vector, "0" reference group, "1" focal group
- **criterion** continuous criterion intended to be predicted by test

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References


See Also

- GMATtest, GMATkey

Dichotomous dataset based on GMAT.

Description

The GMAT2 is a generated dataset based on parameters from Graduate Management Admission Test (GMAT, Kingston et al., 1985). First two items were considered to function differently in uniform and non-uniform way respectively. The dataset represents responses of 1,000 subjects to multiple-choice test of 20 items. A correct answer is coded as 1 and incorrect answer as 0. The column group represents group membership, where 0 indicates reference group and 1 indicates focal group. Groups are the same size (i.e. 500 per group).
Usage

```r
data(GMAT2)
```

Format

A GMAT2 data frame consists of 1,000 observations on the following 21 variables:

- **Item1-Item20**: dichotomously scored items of the test
- **group**: group membership vector, "0" reference group, "1" focal group

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References


See Also

- GMAT2test, GMAT2key

---

**GMAT2key**

*Key of correct answers for GMAT2test dataset.*

Description

The GMAT2key is a vector of factors representing correct answers of generated GMAT2test data set based on Graduate Management Admission Test (GMAT) data set (Kingston et al., 1985).

Usage

```r
data(GMAT2key)
```
Format

A nominal vector with 20 values representing correct answers to items of GMAT2 test dataset. For more details see GMAT2test.

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References


See Also

GMAT2, GMAT2test

Description

The GMAT2test is a generated dataset based on parameters from Graduate Management Admission Test (GMAT, Kingston et al., 1985). First two items were considered to function differently in uniform and non-uniform way respectively. The data set represents responses of 1,000 subjects to multiple-choice test of 20 items. Additionally, 4 possible answers on all items were generated, coded A, B, C, and D. The column group represents group membership, where 0 indicates reference group and 1 indicates focal group. Groups are the same size (i.e. 500 per group).

Usage

data(GMAT2test)
Format

A GMAT2test data frame consists of 1,000 observations on the following 21 variables:

- **Item1-Item20** nominal items of the test coded A, B, C, and D
- **group** group membership vector, "0" reference group, "1" focal group

Correct answers are presented in GMAT2key data set.

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References


See Also

GMAT2, GMAT2key

---

**GMATkey**

*Key of correct answers for GMATtest dataset.*

Description

The GMATkey is a vector of factors representing correct answers of generated GMATtest data set based on Graduate Management Admission Test (GMAT, Kingston et al., 1985).

Usage

data(GMATkey)
Format

A nominal vector with 20 values representing correct answers to items of GMATtest dataset. For more details see GMATtest.

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References


See Also

GMAT, GMATtest

GMATtest | Dataset based on GMAT with the same total score distribution for groups.

Description

The GMATtest is a generated dataset based on parameters from Graduate Management Admission Test (GMAT, Kingston et al., 1985). First two items were considered to function differently in uniform and non-uniform way respectively. The dataset represents responses of 2,000 subjects to multiple-choice test of 20 items. Additionally, 4 possible answers on all items were generated, coded A, B, C, and D. The column group represents group membership, where 0 indicates reference group and 1 indicates focal group. Groups are the same size (i.e. 1,000 per group). The distributions of total scores (sum of correct answers) are the same for both reference and focal group (Martinkova et al., 2017). The column criterion represents generated continuous variable which is intended to be predicted by test.
Usage

data(GMATtest)

Format

A GMATtest data frame consists of 2,000 observations on the following 22 variables:

- **Item1-Item20**  nominal items of the test coded A, B, C, and D
- **group**  group membership vector, "0" reference group, "1" focal group
- **criterion**  continuous criterion intended to be predicted by test

Correct answers are presented in GMATkey data set.

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References


See Also

- GMAT, GMATkey
logLik.ddfMLR

| logLik.ddfMLR | Loglikelihood and information criteria for an object of "ddfMLR" class. |

Description

S3 methods for extracting loglikelihood, Akaike’s information criterion (AIC) and Schwarz’s Bayesian criterion (BIC) for an object of "ddfMLR" class.

Usage

```r
## S3 method for class 'ddfMLR'
logLik(object, item = "all", ...)

## S3 method for class 'ddfMLR'
AIC(object, item = "all", ...)

## S3 method for class 'ddfMLR'
BIC(object, item = "all", ...)
```

Arguments

- `object`: an object of "ddfMLR" class.
- `item`: numeric or character: either character "all" to apply for all converged items (default), or a vector of item names (column names of data), or item identifiers (integers specifying the column number).
- `...`: other other generic parameters for S3 methods.

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See Also

- `ddfMLR` for DDF detection among nominal data.
- `logLik` for generic function extracting loglikelihood.
- `AIC` for generic function calculating AIC and BIC.
Examples

```r
## Not run:
# Loading data based on GMAT
data(GMATtest, GMATkey)

Data <- GMATtest[, 1:20]
group <- GMATtest[, "group"]
key <- GMATkey

# Testing both DDF effects
(x <- ddfMLR(Data, group, focal.name = 1, key))

# AIC, BIC, log-likelihood
AIC(x)
BIC(x)
logLik(x)

# AIC, BIC, log-likelihood for the first item
AIC(x, item = 1)
BIC(x, item = 1)
logLik(x, item = 1)

## End(Not run)
```

---

logLik.difNLR

Loglikelihood and information criteria for an object of "difNLR" class.

Description

S3 methods for extracting loglikelihood, Akaike’s information criterion (AIC) and Schwarz’s Bayesian criterion (BIC) for an object of "difNLR" class.

Usage

```r
## S3 method for class 'difNLR'
logLik(object, item = "all", ...)

## S3 method for class 'difNLR'
AIC(object, item = "all", ...)

## S3 method for class 'difNLR'
BIC(object, item = "all", ...)
```

Arguments

- `object` an object of "difNLR" class.
item numeric or character: either character "all" to apply for all converged items (default), or a vector of item names (column names of Data), or item identifiers (integers specifying the column number).

... other generic parameters for S3 methods.

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References


See Also
difNLR for DIF detection among binary data using generalized logistic regression model.
logLik for generic function extracting loglikelihood.
AIC for generic function calculating AIC and BIC.

Examples

```r
## Not run:
# Loading data based on GMAT
data(GMAT)
Data <- GMAT[, 1:20]
group <- GMAT[, "group"]

# Testing both DIF effects using likelihood-ratio test and
# 3PL model with fixed guessing for groups
(x <- difNLR(Data, group, focal.name = 1, model = "3PLcg"))

# AIC, BIC, log-likelihood
```
logLik.difORD

AIC(x)
BIC(x)
logLik(x)

# AIC, BIC, log-likelihood for the first item
AIC(x, item = 1)
BIC(x, item = 1)
logLik(x, item = 1)

## End(Not run)

logLik.difORD Loglikelihood and information criteria for an object of "difORD" class.

Description
S3 methods for extracting loglikelihood, Akaike’s information criterion (AIC) and Schwarz’s Bayesian criterion (BIC) for an object of "difORD" class.

Usage

## S3 method for class 'difORD'
logLik(object, item = "all", ...)

## S3 method for class 'difORD'
AIC(object, item = "all", ...)

## S3 method for class 'difORD'
BIC(object, item = "all", ...)

Arguments

object an object of "difORD" class.
item numeric or character: either character "all" to apply for all converged items (default), or a vector of item names (column names of Data), or item identifiers (integers specifying the column number).

... other generic parameters for S3 methods.

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See Also

difORD for DIF detection among ordinal data.
logLik for generic function extracting loglikelihood.
AIC for generic function calculating AIC and BIC.

Examples

## Not run:
# Loading data
data(dataMedicalgraded, package = "ShinyItemAnalysis")
Data <- dataMedicalgraded[, 1:5]
group <- dataMedicalgraded[, 101]

# Testing both DIF effects with adjacent category logit model
(x <- difORD(Data, group, focal.name = 1, model = "adjacent"))

# AIC, BIC, log-likelihood
AIC(x)
BIC(x)
logLik(x)

# AIC, BIC, log-likelihood for the first item
AIC(x, item = 1)
BIC(x, item = 1)
logLik(x, item = 1)

## End(Not run)

---

### MLR

**DDF likelihood ratio statistics based on multinomial log-linear regression model.**

**Description**

Calculates DDF likelihood ratio statistics for nominal data based on multinomial log-linear model.

**Usage**

MLR(Data, group, key, type = "both", match = "zscore", anchor = 1:ncol(Data),
p.adjust.method = "none", parametrization = "irt", alpha = 0.05)
Arguments

Data
data.frame or matrix: dataset which rows represent unscored examinee answers (nominal) and columns correspond to the items.

group
numeric: binary vector of group membership. "0" for reference group, "1" for focal group.

key
character: the answer key. Each element corresponds to the correct answer of one item.

type
character: type of DDF to be tested. Either "both" for uniform and non-uniform DDF (i.e., difference in parameters "a" and "b") (default), or "udif" for uniform DDF only (i.e., difference in difficulty parameter "b"), or "nudif" for non-uniform DDF only (i.e., difference in discrimination parameter "a"). Can be specified as a single value (for all items) or as an item-specific vector.

match
numeric or character: matching criterion to be used as an estimate of trait. Can be either "zscore" (default, standardized total score), "score" (total test score), or vector of the same length as number of observations in Data.

anchor
character or numeric: specification of DIF free items. A vector of item identifiers (integers specifying the column number) specifying which items are currently considered as anchor (DIF free) items. Argument is ignored if match is not "zscore" or "score".

p.adjust.method
character: method for multiple comparison correction. Possible values are "holm", "hochberg", "hommel", "bonferroni", "BH", "BY", "fdr", and "none" (default). For more details see p.adjust.

parametrization
character: parametrization of regression coefficients. Possible options are "irt" for difficulty-discrimination parametrization (default) and "classic" for intercept-slope parametrization. See Details.

alpha
numeric: significance level (default is 0.05).

Details

Calculates DDF likelihood ratio statistics based on multinomial log-linear model. Probability of selection the k-th category (distractor) is

\[
P(y = k) = \frac{\exp((a_k + a_k\text{Diff} \ast g) \ast (x - b_k - b_k\text{Diff} \ast g))}{1 + \sum \exp((a_l + a_l\text{Diff} \ast g) \ast (x - b_l - b_l\text{Diff} \ast g))}
\]

where \(x\) is by default standardized total score (also called Z-score) and \(g\) is a group membership. Parameters \(a_k\) and \(b_k\) are discrimination and difficulty for the k-th category. Terms \(a_k\text{Diff}\) and \(b_k\text{Diff}\) then represent differences between two groups (reference and focal) in relevant parameters.

Probability of correct answer (specified in argument key) is

\[
P(y = k) = 1/(1 + \sum \exp((a_l + a_l\text{Diff} \ast g) \ast (x - b_l - b_l\text{Diff} \ast g)))
\]

Parameters are estimated via neural networks. For more details see multinom.

Argument parametrization is a character which specifies parametrization of regression parameters. Default option is "irt" which returns IRT parametrization (difficulty-discrimination, see above). Option "classic" returns intercept-slope parametrization with effect of group membership and interaction with matching criterion, i.e. \(b_0k + b_1k \ast x + b_2k \ast g + b_3k \ast x \ast g\) instead of \((a_k + a_k\text{Diff} \ast g) \ast (x - b_k - b_k\text{Diff} \ast g))\).
Value

A list with the following arguments:

Sval the values of likelihood ratio test statistics.
pval the p-values by likelihood ratio test.
adj.pval the adjusted p-values by likelihood ratio test using p.adjust.method.
df the degrees of freedom of likelihood ratio test.
par.m0 the estimates of null model.
par.m1 the estimates of alternative model.
se.m0 standard errors of parameters in null model.
se.m1 standard errors of parameters in alternative model.
ll.m0 log-likelihood of m0 model.
ll.m1 log-likelihood of m1 model.
AIC.m0 AIC of m0 model.
AIC.m1 AIC of m1 model.
BIC.m0 BIC of m0 model.
BIC.m1 BIC of m1 model.

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See Also

p.adjust multinom

Examples

## Not run:
# loading data based on GMAT
data(GMATtest, GMATkey)

Data <- GMATtest[, 1:20]
group <- GMATtest[, "group"]
key <- GMATkey

# Testing both DDF effects
MSATB

### Description

The MSATB dataset consists of the responses of 1,407 subjects (484 males, 923 females) to admission test to medical school in the Czech republic. It contains 20 selected items from original test while first item was previously detected as differently functioning (Vlckova, 2014). A correct answer is coded as 1 and incorrect answer as 0. The column `gender` represents gender of students, where 0 indicates males (reference group) and 1 indicates females (focal group).

### Usage

```r
data(MSATB)
```

### Format

A `MSATB` data frame consists of 1,407 observations on the following 21 variables:

- **Item**: dichotomously scored items of the test
- **gender**: gender of respondents, "0" males, "1" females

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```r
MLR(Data, group, key, type = "both")
# Testing uniform DDF effects
MLR(Data, group, key, type = "udif")
# Testing non-uniform DDF effects
MLR(Data, group, key, type = "nudif")
## End(Not run)
```
References


See Also

MSATBtest, MSATBkey

MSATBkey

Key of correct answers for MSATBtest dataset.

Description

The MSATBkey is a vector of factors representing correct answers of MSATBtest dataset.

Usage

data(MSATBkey)

Format

A nominal vector with 20 values representing correct answers to items of MSATBtest dataset. For more details see MSATBtest.

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References


See Also

MSATB, MSATBtest
**Description**

The MSATBtest dataset consists of the responses of 1,407 subjects (484 males, 923 females) to multiple-choice admission test to medical school in the Czech republic. It contains 20 selected items from original test while first item was previously detected as differently functioning (Vlckova, 2014). Possible answers were A, B, C, and D, while any combination of these can be correct. The column gender represents gender of students, where 0 indicates males (reference group) and 1 indicates females (focal group).

**Usage**

data(MSATBtest)

**Format**

A MSATBtest data frame consists of 1,407 observations on the following 21 variables:

- **Item** nominal items of the test
- **gender** gender of respondents, "0" males, "1" females

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**References**


**See Also**

MSATB, MSATBkey
NLR  

DIF statistics based on non-linear regression model.

Description

Calculates either DIF likelihood ratio statistics or F statistics for dichotomous data based on non-linear regression model (generalized logistic regression model).

Usage

NLR(Data, group, model, constraints = NULL, type = "all", method = "nls",
match = "zscore", anchor = 1:ncol(Data), start, p.adjust.method = "none", test = "LR",
alpha = 0.05, initboot = TRUE, nrBo = 20)

Arguments

- **Data**: data.frame or matrix: dataset which rows represent scored examinee answers ("1" correct, "0" incorrect) and columns correspond to the items.
- **group**: numeric: binary vector of group membership. "0" for reference group, "1" for focal group.
- **model**: character: generalized logistic regression model to be fitted. See Details.
- **constraints**: character: which parameters should be the same for both groups. Possible values are any combinations of parameters "a", "b", "c", and "d". Default value is NULL. See Details.
- **type**: character: type of DIF to be tested. Possible values are "all" for detecting difference in any parameter (default), "udif" for uniform DIF only (i.e., difference in difficulty parameter "b"), "nudif" for non-uniform DIF only (i.e., difference in discrimination parameter "a"), "both" for uniform and non-uniform DIF (i.e., difference in parameters "a" and "b"), or combination of parameters "a", "b", "c", and "d". Can be specified as a single value (for all items) or as an item-specific vector.
- **method**: character: method used to estimate parameters. The options are "nls" for non-linear least squares (default) and "likelihood" for maximum likelihood method.
- **match**: character or numeric: matching criterion to be used as estimate of trait. Can be either "zscore" (default, standardized total score), "score" (total test score), or numeric vector of the same length as number of observations in Data.
- **anchor**: character or numeric: specification of DIF free items. A vector of item identifiers (integers specifying the column number) specifying which items are currently considered as anchor (DIF free) items. Argument is ignored if match is not "zscore" or "score".
- **start**: numeric: initial values for estimation of parameters. If not specified, starting values are calculated with startNLR function. Otherwise, list with as many elements as number of items. Each element is a named numeric vector of length
8 representing initial values for parameter estimation. Specifically, parameters "a", "b", "c", and "d" are initial values for discrimination, difficulty, guessing, and inattention for reference group. Parameters "aDif", "bDif", "cDif", and "dDif" are then differences in these parameters between reference and focal group.

**p.adjust.method**

caracter: method for multiple comparison correction. Possible values are "holm", "hochberg", "hommel", "bonferroni", "BH", "BY", "fdr", and "none" (default). For more details see `p.adjust`.

**test**

caracter: test to be performed for DIF detection. Can be either "LR" for likelihood ratio test of a submodel (default), or "F" for F-test of a submodel.

**alpha**

numeric: significance level (default is 0.05).

**initboot**

logical: in case of convergence issues, should be starting values re-calculated based on bootstraped samples? (default is TRUE; newly calculated initial values are applied only to items/models with convergence issues).

**nrBo**

numeric: the maximal number of iterations for calculation of starting values using bootstraped samples (default is 20).

**Details**

Calculation of the test statistics using DIF detection procedure based on non-linear regression (extension of logistic regression procedure; Swaminathan and Rogers, 1990; Drabinova and Martinova, 2017).

The unconstrained form of 4PL generalized logistic regression model for probability of correct answer (i.e., \( y = 1 \)) is

\[
P(y = 1) = \frac{(c+cDif\times g)+(d+dDif\times g-c-cDif\times g)}{(1+exp(-(a+aDif\times g)\times(x-b-bDif\times g)))},
\]

where \( x \) is by default standardized total score (also called Z-score) and \( g \) is a group membership. Parameters \( a, b, c, \) and \( d \) are discrimination, difficulty, guessing, and inattention. Terms \( aDif, bDif, cDif, \) and \( dDif \) then represent differences between two groups (reference and focal) in relevant parameters.

This 4PL model can be further constrained by `model` and `constraints` arguments. The arguments `model` and `constraints` can be also combined. Both arguments can be specified as a single value (for all items) or as an item-specific vector (where each element correspond to one item).

The `model` argument offers several predefined models. The options are as follows: Rasch for 1PL model with discrimination parameter fixed on value 1 for both groups, 1PL for 1PL model with discrimination parameter fixed for both groups, 2PL for logistic regression model, 3PLcg for 3PL model with fixed guessing for both groups, 3PLDg for 3PL model with fixed inattention for both groups, 3PLcg (alternatively also 3PL) for 3PL regression model with guessing parameter, 3PLcd for 3PL model with inattention parameter, 4PLcgdg for 4PL model with fixed guessing and inattention parameter for both groups, 4PLcDg (alternatively also 4PLd) for 4PL model with fixed guessing for both groups, 4PLcdg (alternatively also 4PLc) for 4PL model with fixed inattention for both groups, or 4PL for 4PL model.

The `model` can be specified in more detail with `constraints` argument which specifies what parameters should be fixed for both groups. For example, choice "ad" means that discrimination
(parameter "a") and inattention (parameter "d") are fixed for both groups and other parameters ("b" and "c") are not. The NA value for constraints means no constraints.

In case that model considers difference in guessing or inattention parameter, the different parameterization is used and parameters with standard errors are re-calculated by delta method.

Value

A list with the following arguments:

- **Sval** the values of test statistics.
- **pval** the p-values by test.
- **adjusted.pval** adjusted p-values by p.adjust.method.
- **df** the degrees of freedom of test.
- **test** used test.
- **par.m0** the matrix of estimated item parameters for m0 model.
- **se.m0** the matrix of standard errors of item parameters for m0 model.
- **cov.m0** list of covariance matrices of item parameters for m0 model.
- **par.m1** the matrix of estimated item parameters for m1 model.
- **se.m1** the matrix of standard errors of item parameters for m1 model.
- **cov.m1** list of covariance matrices of item parameters for m1 model.
- **conv.fail** numeric: number of convergence issues.
- **conv.fail.which** the indicators of the items which did not converge.
- **ll.m0** log-likelihood of m0 model.
- **ll.m1** log-likelihood of m1 model.
- **startBo0** the binary matrix. Columns represents iterations of initial values re-calculations, rows represents items. The value of 0 means no convergence issue in m0 model, 1 means convergence issue in m0 model.
- **startBo1** the binary matrix. Columns represents iterations of initial values re-calculations, rows represents items. The value of 0 means no convergence issue in m1 model, 1 means convergence issue in m1 model.

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References


See Also

p.adjust

Examples

```r
## Not run:
# loading data based on GMAT
data(GMAT)

Data <- GMAT[, 1:20]
group <- GMAT[, "group"]

# Testing both DIF effects using LR test (default)
# and model with fixed guessing for both groups
NLR(Data, group, model = "3PLcg")

# Using F test
NLR(Data, group, model = "3PLcg", test = "F")

# Testing both DIF effects with Benjamini-Hochberg correction
# to test uniform DIF
NLR(Data, group, model = "3PLcg", p.adjust.method = "BH")

# 4PL model with the same guessing and inattention
# to test non-uniform DIF
NLR(Data, group, model = "4PLcgdg", type = "udif")

# 2PL model to test non-uniform DIF
NLR(Data, group, model = "2PL", type = "nudif")

# 4PL model with fixed a and c parameter
# to test difference in b
NLR(Data, group, model = "4PL", constraints = "ac", type = "b")

# using maximum likelihood estimation method
NLR(Data, group, model = "3PLcg", method = "likelihood")

## End(Not run)
```
DIF likelihood ratio statistics for ordinal data.

Description

Calculates DIF likelihood ratio statistics for ordinal data based either on adjacent category logit regression model or on cumulative logit regression model.

Usage

ORD(Data, group, model = "adjacent", type = "both", match = "zscore", anchor = 1:ncol(Data), p.adjust.method = "none", parametrization = "irt", alpha = 0.05)

Arguments

Data data.frame or matrix: dataset which rows represent ordinaly scored examinee answers and columns correspond to the items.
group numeric: binary vector of group membership. "0" for reference group, "1" for focal group.
model character: logistic regression model for ordinal data (either "adjacent" (default) or "cumulative"). See Details.
type character: type of DIF to be tested. Either "both" for uniform and non-uniform DIF (i.e., difference in parameters "a" and "b") (default), or "udif" for uniform DIF only (i.e., difference in difficulty parameter "b"), or "nudif" for non-uniform DIF only (i.e., difference in discrimination parameter "a"). Can be specified as a single value (for all items) or as an item-specific vector.
match numeric or character: matching criterion to be used as an estimate of trait. Can be either "zscore" (default, standardized total score), "score" (total test score), or vector of the same length as number of observations in Data.
anchor character or numeric: specification of DIF free items. A vector of item identifiers (integers specifying the column number) specifying which items are currently considered as anchor (DIF free) items. Argument is ignored if match is not "zscore" or "score".
parametrization character: parametrization of regression coefficients. Possible options are "irt" for difficulty-discrimination parametrization (default) and "classic" for intercept-slope parametrization. See Details.
alpha numeric: significance level (default is 0.05).
Details

Calculates DIF likelihood ratio statistics based either on adjacent category logit model or on cumulative logit model for ordinal data.

Using adjacent category logit model, logarithm of ratio of probabilities of two adjacent categories is

$$\log(P(y = k) / P(y = k - 1)) = (a + aDif * g) * (x - b_k - b_kDif * g),$$

where $x$ is by default standardized total score (also called Z-score) and $g$ is a group membership. Parameter $a$ is a discrimination of the item and parameter $b_k$ is difficulty for the $k$-th category of the item. Terms $aDif$ and $b_kDif$ then represent differences between two groups (reference and focal) in relevant parameters.

Using cumulative logit model, probability of gaining at least $k$ points is given by 2PL model, i.e.,

$$P(y >= k) = \exp((a+aDif*g)*(x-b_k-b_kDif*g))/(1+\exp((a+aDif*g)*(x-b_k-b_kDif*g))).$$

The category probability (i.e., probability of gaining exactly $k$ points) is then $P(Y = k) = P(Y >= k) - P(Y >= k + 1)$.

Both models are estimated by iteratively reweighted least squares. For more details see \texttt{vglm}.

Argument parametrization is a character which specifies parametrization of regression parameters. Default option is "irt" which returns IRT parametrization (difficulty-discrimination, see above). Option "classic" returns intercept-slope parametrization with effect of group membership and interaction with matching criterion, i.e. $b_0k + b_1 * x + b_2k * g + b_3 * x * g$ instead of $(a + aDif * g) * (x - b_k - b_kDif * g))$.

Value

A list with the following arguments:

- Sval the values of likelihood ratio test statistics.
- pval the p-values by likelihood ratio test.
- adj.pval the adjusted p-values by likelihood ratio test using \texttt{p.adjust.method}.
- df the degrees of freedom of likelihood ratio test.
- par.m0 the estimates of null model.
- par.m1 the estimates of alternative model.
- se.m0 standard errors of parameters in null model.
- se.m1 standard errors of parameters in alternative model.
- ll.m0 log-likelihood of null model.
- ll.m1 log-likelihood of alternative model.
- AIC.m0 AIC of null model.
- AIC.m1 AIC of alternative model.
- BIC.m0 BIC of null model.
- BIC.m1 BIC of alternative model.
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See Also

p.adjust vglm

Examples

```r
## Not run:
# loading data
data(dataMedicalgraded, package = "ShinyItemAnalysis")
df <- dataMedicalgraded[, c(1:5, 101)]
df <- df[complete.cases(df), ]

Data <- df[, 1:5]
group <- df[, 6]

# Testing both DIF effects
ORD(Data, group, type = "both")

# Testing uniform DIF effects
ORD(Data, group, type = "udif")

# Testing non-uniform DIF effects
ORD(Data, group, type = "nudif")

# Testing DIF using cumulative logit model
ORD(Data, group, model = "cumulative")

## End(Not run)
```

plot.ddfMLR

ICC plots for an object of "ddfMLR" class.

Description

Plot method for an object of "ddfMLR" class using `ggplot2`.

The characteristic curves for an item specified in `item` argument are plotted. Plotted curves represent the best model.
### plot.ddfMLR

#### Usage

```r
## S3 method for class 'ddfMLR'
plot(x, item = "all", group.names, ...)
```

#### Arguments

- `x`: an object of "ddfMLR" class.
- `item`: numeric or character: either character "all" to apply for all items (default), or a vector of item names (column names of `Data`), or item identifiers (integers specifying the column number).
- `group.names`: character: names of reference and focal group.
- `...`: other generic parameters for `plot()` function.

#### Value

Returns list of objects of class "ggplot".

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#### See Also

- `ddfMLR` for DDF detection.
- `ggplot` for general function to plot a "ggplot" object.

#### Examples

```r
## Not run:
# Loading data based on GMAT
data(GMATtest, GMATkey)

Data <- GMATtest[, 1:20]
group <- GMATtest[,"group"]
key <- GMATkey

# Testing both DDF effects
(x <- ddfMLR(Data, group, focal.name = 1, key))

# Graphical devices
plot(x, item = "Item1", group.names = c("Group 1", "Group 2"))
```
plot(x, item = x$DDFitems)
plot(x, item = 1)

## End(Not run)

plot.difNLR

 ICC and test statistics plots for an object of "difNLR" class.

Description

Plot method for an object of "difNLR" class using ggplot2.

Two types of plots are available. The first one is obtained by setting plot.type = "cc" (default). The characteristic curves for an item specified in item argument are plotted. Plotted curves represent the best model.

The second plot is obtained by setting plot.type = "stat". The test statistics (either LR-test, or F-test, depends on argument test) are displayed on the Y axis, for each converged item. The detection threshold is displayed by a horizontal line and items detected as DIF are printed with the red color. Only parameters size and title are used.

Usage

## S3 method for class 'difNLR'
plot(
  x,
  plot.type = "cc",
  item = "all",
  group.names,
  draw.empirical = TRUE,
  draw.CI = FALSE,
  ...
)

Arguments

x an object of "difNLR" class.

plot.type character: type of plot to be plotted (either "cc" for characteristic curve (default), or "stat" for test statistics).

item numeric or character: either character "all" to apply for all converged items (default), or a vector of item names (column names of Data), or item identifiers (integers specifying the column number).

group.names character: names of reference and focal group.

draw.empirical logical: should empirical probabilities be plotted as points? Default value is TRUE.

draw.CI logical: should confidence intervals for predicted values be plotted? Default value is FALSE.

... other generic parameters for plot() function.
**Value**

For an option `plot.type = "stat"`, returns object of class "ggplot". In case of `plot.type = "cc"`, returns list of objects of class "ggplot".

Outputs can be edited and modified as standard "ggplot" object including colours, titles, shapes or linetypes.

Note that option `draw.CI = TRUE` returns confidence intervals for predicted values as calculated by `predict.difNLR`. Confidence intervals may overlap even in case that item functions differently.

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**References**


**See Also**

difNLR for DIF detection among binary data using generalized logistic regression model.
predict.difNLR for prediction. ggplot for general function to plot a "ggplot" object.

**Examples**

```r
# Not run:
# Loading data based on GMAT
data(GMAT)

Data <- GMAT[, 1:20]
group <- GMAT[, "group"]

# Testing both DIF effects using likelihood-ratio test and
# 3PL model with fixed guessing for groups
```
(x <- difNLR(Data, group, focal.name = 1, model = "3PLcg"))

# Characteristic curves
plot(x)
plot(x, item = x$DIFitems)
plot(x, item = 1)
plot(x, item = "Item1")

# Characteristic curves without empirical probabilities
plot(x, item = 1, draw.empirical = FALSE)

# Characteristic curves without empirical probabilities but with CI
plot(x, item = 1, draw.empirical = FALSE, draw.CI = TRUE)

# Graphical devices - test statistics
plot(x, plot.type = "stat")

## End(Not run)

---

**plot.difORD**

*ICC plots for an object of "difORD" class.*

### Description

Plot method for an object of "difORD" class using *ggplot2*.

The characteristic curves (category probabilities) for an item specified in `item` argument are plotted. Plotted curves represent the best model. For cumulative logit model, also cumulative probabilities may be plotted.

### Usage

```r
## S3 method for class 'difORD'
plot(x, item = "all", plot.type, group.names, ...)
```

### Arguments

- **x**: an object of "difORD" class.
- **item**: numeric or character: either character "all" to apply for all converged items (default), or a vector of item names (column names of `Data`), or item identifiers (integers specifying the column number).
- **plot.type**: character: which plot should be displayed for cumulative logit regression model. Either "category" (default) for category probabilities or "cumulative" for cumulative probabilities.
- **group.names**: character: names of reference and focal group.
- **...**: other generic parameters for `plot()` function.
predict.difNLR

Value

Returns list of objects of class "ggplot".

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See Also

difORD for DIF detection among ordinal data.
ggplot for general function to plot a "ggplot" object.

Examples

## Not run:
# Loading data
data(dataMedicalgraded, package = "ShinyItemAnalysis")
Data <- dataMedicalgraded[, 1:5]
group <- dataMedicalgraded[, 101]

# Testing both DIF effects with adjacent category logit model
(x <- difORD(Data, group, focal.name = 1, model = "adjacent"))

# Graphical devices
plot(x, item = 3)
plot(x, item = "X2003", group.names = c("Group 1", "Group 2"))

# Testing both DIF effects with cumulative logit model
(x <- difORD(Data, group, focal.name = 1, model = "cumulative"))
plot(x, item = 3, plot.type = "cumulative")
plot(x, item = 3, plot.type = "category")

## End(Not run)
Usage

```r
## S3 method for class 'difNLR'
predict(
  object,
  item = "all",
  match,
  group,
  interval = "none",
  level = 0.95,
  ...
)
```

Arguments

- `object`: an object of "difNLR" class.
- `item`: numeric or character: either character "all" to apply for all converged items (default), or a vector of item names (column names of `Data`), or item identifiers (integers specifying the column number).
- `match`: numeric: matching criterion for new observations.
- `group`: numeric: group membership for new observations.
- `interval`: character: type of interval calculation, either "none" (default) or "confidence" for confidence interval.
- `level`: numeric: confidence level.
- `...`: other generic parameters for `predict()` function.

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References


See Also
difNLR for DIF detection among binary data using generalized logistic regression model. predict for generic function for prediction.

Examples

```r
## Not run:
# Loading data based on GMAT
data(GMAT)

Data <- GMAT[, 1:20]
group <- GMAT[, "group"]

# Testing both DIF effects using likelihood-ratio test and
# 3PL model with fixed guessing for groups
(x <- difNLR(Data, group, focal.name = 1, model = "3PLcg"))

# Predicted values
summary(predict(x))
predict(x, item = 1)
predict(x, item = "Item1")

# Predicted values for new observations - average score
predict(x, item = 1, match = 0, group = 0) # reference group
predict(x, item = 1, match = 0, group = 1) # focal group

# Predicted values for new observations - various z-scores and groups
new.match <- rep(c(-1, 0, 1), 2)
new.group <- rep(c(0, 1), each = 3)
predict(x, item = 1, match = new.match, group = new.group)

# Predicted values for new observations with confidence intervals
predict(x, item = 1, match = new.match, group = new.group, interval = "confidence")
predict(x, item = c(2, 4), match = new.match, group = new.group, interval = "confidence")

## End(Not run)
```

startNLR

Calculates starting values for non-linear regression DIF models.

Description

Calculates starting values for difNLR() function based on linear approximation.
Usage

\texttt{startNLR(Data, group, model, match = \texttt{"zscore"}, parameterization = \texttt{"alternative"}, simplify = \texttt{FALSE})}

Arguments

Data \texttt{Data} data.frame or matrix: dataset which rows represent scored examinee answers ("1" correct, "0" incorrect) and columns correspond to the items.

group \texttt{group} numeric: binary vector of group membership. "0" for reference group, "1" for focal group.

model \texttt{model} character: generalized logistic regression model for which starting values should be estimated. See Details.

match \texttt{match} character or numeric: matching criterion to be used as estimate of trait. Can be either "zscore" (default, standardized total score), "score" (total test score), or numeric vector of the same length as number of observations in Data.

parameterization \texttt{parameterization} character: parameterization of regression coefficients. Possible options are "classic" (IRT parameterization), "alternative" (default) and "logistic" (logistic regression). See Details.

simplify \texttt{simplify} logical: should initial values be simplified into the matrix? This is only applicable when parameterization is the same for all items.

Details

The unconstrained form of 4PL generalized logistic regression model for probability of correct answer (i.e., \(y = 1\)) is

\[
P(y = 1) = \frac{(c + cDif*g) + (d + dDif*g - c - cDif*g)}{(1 + \exp(-(a + aDif*g) \times (x - b - bDif*g)))},
\]

where \(x\) is by default standardized total score (also called Z-score) and \(g\) is a group membership. Parameters \(a\), \(b\), \(c\), and \(d\) are discrimination, difficulty, guessing, and inattention. Terms \(aDif\), \(bDif\), \(cDif\), and \(dDif\) then represent differences between two groups (reference and focal) in relevant parameters.

The \texttt{model} argument offers several predefined models. The options are as follows: Rasch for 1PL model with discrimination parameter fixed on value 1 for both groups, 1PL for 1PL model with discrimination parameter fixed for both groups, 2PL for logistic regression model, 3PLcg for 3PL model with fixed guessing for both groups, 3PLdg for 3PL model with fixed inattention for both groups, 3PLc (alternatively also 3PL) for 3PL regression model with guessing parameter, 3PLd for 3PL model with inattention parameter, 4PLcgdg for 4PL model with fixed guessing and inattention parameter for both groups, 4PLcdg (alternatively also 4PLd) for 4PL model with fixed guessing for both groups, 4PLcdg (alternatively also 4PLc) for 4PL model with fixed inattention for both groups, or 4PL for 4PL model.

Three possible parameterization can be specified in "parameterization" argument: "classic" returns IRT parameters of reference group and differences in these parameters between reference and focal group. "alternative" returns IRT parameters of reference group, the differences in parameters "a" and "b" between two groups and parameters "c" and "d" for focal group. "logistic" returns parameters in logistic regression parameterization.
Value

A list containing elements representing items. Each element is a named numeric vector of length 8 with initial values for generalized logistic regression model.

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References


See Also
difNLR

Examples

```r
# loading data based on GMAT
data(GMAT)

Data <- GMAT[, 1:20]
group <- GMAT[, "group"

# starting values for 3PL model
startNLR(Data, group, model = "3PL")

# starting values for 3PL model
# simplified into single table
startNLR(Data, group, model = "3PL", simplify = TRUE)

# starting values for 3PL model
# with score as matching criterion
startNLR(Data, group, model = "3PL", match = "score")

# starting values for model specified for each item
startNLR(Data, group,
    model = c(
        rep("1PL", 5), rep("2PL", 5),
        rep("3PL", 5), rep("4PL", 5))
```
startNLR

) )

)
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