

Package ‘pcIRT’

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Author Christine Hohensinn

Maintainer Christine Hohensinn <christine.hohensinn@univie.ac.at>

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Description pcIRT estimates the multidimensional polytomous Rasch model (Rasch, 1961) and the Continuous Rating Scale model (Mueller, 1987)

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pcIRT-package

IRT models for polytomous and continuous item responses

Description

This package estimates the multidimensional polytomous Rasch model (Rasch, 1961) and provides functions to set linear restrictions on the item category parameters of this models. With this functions it is possible to test whether item categories can be collapsed or set as linear dependent. Thus it is also possible to test whether the multidimensional model can be reduced to a unidimensional model that is whether item categories represent a unidimensional continuum. For this case the scoring parameter of the categories is estimated.

This package estimates the Continuous Rating Scale model by Mueller (1987). It is an extension of the Rating Scale Model by Andrich (1978) on continuous responses (e.g. taken by a visual analog scale).

Details

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License: GPL-3

Author(s)

Christine Hohensinn Maintainer: Christine Hohensinn <christine.hohensinn@univie.ac.at>

References

Andersen, E. B. (1995). Polytomous Rasch models and their estimation. In G. H. Fischer and I. Molenaar (Eds.). *Rasch Models - Foundations, Recent Developements, and Applications*. Springer.

Fischer, G. H. (1974). *Einfuehrung in die Theorie psychologischer Tests [Introduction to test theory]*. Bern: Huber.

Mueller, H. (1987). A Rasch model for continuous ratings. *Psychometrika*, 52, 165-181.

Rasch, G. (1961). On general laws and the meaning of measurement in psychology, *Proceedings Fourth Berekely Symposium on Mathematical Statistiscs and Probability* 5, 321-333.

See Also

[MPRM CRSM](#)

Examples

```
#simulate data set according to the multidimensional polytomous Rasch model (MPRM)
simdat <- simMPRM(rbind(matrix(c(-1.5,0.5,0.5,1,0.8,-0.3, 0.2,-1.2), ncol=4),0), 500)

#estimate MPRM item parameters
res_mprm <- MPRM(simdat$datmat)

summary(res_mprm)
```

 CRSM

Estimation of Continuous Rating Scale Model (Mueller, 1987)

Description

Estimation of the Rating Scale Model for continuous data by Mueller (1987).

$$P_{vi}(a \leq X \leq b) = \frac{\int_a^b \exp[x\mu + x(2c - x)\theta] dx}{\int_{c-\frac{d}{2}}^{c+\frac{d}{2}} \exp[t\mu + t(2c - t)\theta] dt}$$

Parameters are estimated by a pairwise algorithm.

Usage

```
CRSM(data, start, min, max)

## S3 method for class 'CRSM'
summary(object, ...)
## S3 method for class 'CRSM'
print(x, ...)
```

Arguments

data	Data matrix or data frame; rows represent observations (persons), columns represent the items.
start	Starting values for parameter estimation. If missing, a vector of 0 is used as starting values.
min	The minimum value of the response scale (on which the data are based).
max	The maximum value of the response scale (on which the data are based).
object	object of class CRSM
x	object of class CRSM
...	...

Details

The parameters of the Continuous Rating Scale Model are estimated by a pairwise algorithm (the algorithm is described in detail in Mueller, 1999) using Newton-Raphson iterations for optimizing. For the pairwise algorithm no assumption on the person parameter distribution is necessary.

Value

<code>data</code>	data matrix according to the input
<code>data_p</code>	data matrix with data transformed to a response interval between 0 and 1
<code>itempar</code>	estimated item parameters
<code>itempar_se_low</code>	estimated lower boundary for standard errors of estimated item parameters
<code>itempar_se_up</code>	estimated upper boundary for standard errors of estimated item parameters
<code>itempar_se</code>	estimated mean standard errors of estimated item parameters
<code>distrpar</code>	estimated distribution parameter
<code>distrpar_se_low</code>	estimated lower boundary for standard errors of estimated distribution parameter
<code>distrpar_se_up</code>	estimated upper boundary for standard errors of estimated distribution parameter
<code>itempar_se</code>	estimated mean standard errors of estimated distribution parameter
<code>iterations</code>	Number of Newton-Raphson iterations for each item pair
<code>call</code>	call of the CRSM function

Author(s)

Christine Hohensinn

References

- Mueller, H. (1987). A Rasch model for continuous ratings. *Psychometrika*, 52, 165-181.
- Mueller, H. (1999). *Probabilistische Testmodelle fuer diskrete und kontinuierliche Ratingskalen*. [Probabilistic models for discrete and continuous rating scales]. Bern: Huber.

Examples

```
#estimate CRSM item parameters
data(example1)
res_crsm <- CRSM(example1, min=0, max=1)

summary(res_crsm)
```

`dLRT`*Dimensionality test for the multidimensional polytomous Rasch model*

Description

This function tests whether the multidimensional polytomous Rasch model can be reduced to a unidimensional polytomous model.

Usage

```
dLRT(MPRMobj)

## S3 method for class 'dLR'
summary(object, ...)
## S3 method for class 'dLR'
print(x, ...)
```

Arguments

<code>MPRMobj</code>	Object of class MPRM
<code>object</code>	object of class dLR
<code>x</code>	object of class dLR
<code>...</code>	...

Details

For this test, a unidimensional model assuming the categories as linearly dependent is computed. Subsequently a Likelihood Ratio test is conducted.

Value

<code>emp_chi2</code>	χ^2 distributed value of the Likelihood Ratio test
<code>df</code>	degrees of freedom of the test statistic
<code>pval</code>	p value of the test statistic

Author(s)

Christine Hohensinn

References

Fischer, G. H. (1974). Einführung in die Theorie psychologischer Tests [Introduction to test theory]. Bern: Huber.

See Also[MPRM LRT](#)**Examples**

```
#simulate data set
simdat <- simMPRM(rbind(matrix(c(-1.5,0.5,0.5,1,0.8,-0.3, 0.2,-1.2), ncol=4),0), 500)

#estimate MPRM item parameters
res_mprm <- MPRM(simdat$datmat)

res_dlrt <- dLRT(res_mprm)
summary(res_dlrt)
```

`example1`*Simulated estimation results*

Description

This object contains simulated data according to a continuous Rating Scale Model. The data set contains 6 items and 400 observations.

Usage

```
data(example1)
```

Format

```
workspace
```

Source

```
Simulation
```

`example2`*Simulated data set*

Description

This object contains simulated data according to a constrained multidimensional polytomous Rasch model. The data set contains 8 items and 500 observations.

Usage

```
data(example2)
```

Format

workspace

Source

Simulation

gmc*Graphical model check*

Description

A graphical model check is performed for the multidimensional polytomous Rasch model or the continuous Rating Scale Model.

Usage

```
gmc(object, ...)

## S3 method for class 'aLR'
gmc(object, ...)
## S3 method for class 'CRSM'
gmc(object, ..., splitcrit = "score")
```

Arguments

object	Object of class aLR for graphical model check of the MPRM or object of class CRSM for graphical model check of the CRSM
splitcrit	Vector or the character vector "score" to define the split criterion. The default split criterion "score" splits the sample according to the median of the raw score. Vector can be numeric, factor or character. (see details)
...	...

Details

The graphical model check plots the item parameter estimates of two subsamples to check the homogeneity. This is according to the subsample split in Andersen's Likelihood Ratio test. For conducting the graphical model check of the MPRM, at first, a [LRT](#) has to be computed and the resulting object is the input for the gmc function.

For plotting a graphical model check for the CRSM, the model has to be estimated with [CRSM](#) and subsequently the resulting object is the input for the gmc function. For the CRSM a split criterion has to be input as vector.

Author(s)

Christine Hohensinn

References

Wright, B.D., and Stone, M.H. (1999). Measurement Essentials. Wilmington: Wide Range Inc.

See Also

[LRT CRSM](#)

Examples

```
#estimate CRSM for the first three items
data(example1)
res_cr <- CRSM(example1[,1:3], min=0, max=1)

#graphical model check for CRSM for the first three items with default split criterion score
gmc(res_cr)
```

LRT	<i>Computes Andersen's Likelihood Ratio Test for the multidimensional polytomous Rasch model</i>
-----	--

Description

Andersen's Likelihood Ratio Test is a model test for Rasch models (based on CML estimation) and splits the data set into subsamples to test the person homogeneity

Usage

```
LRT(MPRMobj, splitcrit = "score")

## S3 method for class 'aLR'
summary(object, ...)
## S3 method for class 'aLR'
print(x, ...)
```

Arguments

MPRMobj	Object of class MPRM
splitcrit	Vector or the character vector "score" to define the split criterion. The default split criterion "score" splits the sample according to the median of the raw score. Vector can be numeric, factor or character. (see details)
object	object of class aLR
x	object of class aLR
...	...

Details

The default split criterion "score" computes the raw score of every person according to the category values in the data set. The sample is split by the median of this raw score.

Value

emp_Chi2	χ^2 distributed value of the Likelihood Ratio test
df	degrees of freedom of the test statistic
pval	p value of the test statistic
itempar	estimated item parameters for each subsample
item_se	estimated standard errors for the item parameters for each subsample

Author(s)

Christine Hohensinn

References

- Andersen, E. B. (1973). A goodness of fit test for the Rasch model. *Psychometrika*, 38, 123- 140.
- Fischer, G. H. (1974). *Einfuehrung in die Theorie psychologischer Tests [Introduction to test theory]*. Bern: Huber.

See Also

[MPRM dLRT](#)

Examples

```
#simulate data set
simdat <- simMPRM(rbind(matrix(c(-1.5,0.5,0.5,1,0.8,-0.3, 0.2,-1.2), ncol=4),0), 500)

#estimate MPRM item parameters
res_mprm <- MPRM(simdat$datmat)

#compute Andersen's Likelihood Ratio test
res_lrt <- LRT(res_mprm)
summary(res_lrt)
```

MPRM

Estimation of Multidimensional Polytomous Rasch model (Rasch, 1961)

Description

This function estimates the multidimensional polytomous Rasch model by Rasch (1961). The model estimates item category parameters β for each item and each category and takes each category of data as another dimension.

$$P_{vih} = \frac{\exp(\theta_{vh} + \beta_{ih})}{\sum_{j=0}^m \exp(\theta_{vj} + \beta_{ij})}$$

Parameters are estimated by CML method.

Usage

```
MPRM(data, desmat, start)

## S3 method for class 'MPRM'
summary(object, ...)
## S3 method for class 'MPRM'
print(x, ...)
```

Arguments

data	Data matrix or data frame; rows represent observations (persons), columns represent the items
desmat	Design matrix; if missing, the design matrix will be created automatically.
start	Starting values for parameter estimation. If missing, a vector of 0 is used as starting values.
object	object of class MPRM
x	object of class MPRM
...	...

Details

The parameters of the multidimensional polytomous Rasch model (Rasch, 1961) are estimated by CML estimation. For the CML estimation no assumption on the person parameter distribution is necessary.

Value

data	data matrix according to the input
design	design matrix either according to the input or according to the automatically generated matrix
logLikelihood	conditional log-likelihood
estpar	estimated basic item category parameters
estpar_se	estimated standard errors for basic item category parameters
itempar	estimated item category parameters
itempar_se	estimated standard errors for item category parameters
hessian	Hessian matrix
convergence	convergence of solution (see help files in optim)
fun_calls	number of function calls (see help files in optim)

Author(s)

Christine Hohensinn

References

- Andersen, E. B. (1995). Polytomous Rasch models and their estimation. In G. H. Fischer and I. Molenaar (Eds.). *Rasch Models - Foundations, Recent Developments, and Applications*. Springer.
- Fischer, G. H. (1974). *Einfuehrung in die Theorie psychologischer Tests [Introduction to test theory]*. Bern: Huber.
- Rasch, G. (1961). On general laws and the meaning of measurement in psychology, *Proceedings Fourth Berkeley Symposium on Mathematical Statistics and Probability* 5, 321-333.

Examples

```
#simulate data set
simdat <- simMPRM(rbind(matrix(c(-1.5,0.5,0.5,1,0.8,-0.3, 0.2,-1.2), ncol=4),0), 500)

#estimate MPRM item parameters
res_mprm <- MPRM(simdat$datmat)

summary(res_mprm)
```

MPRMI	<i>Estimation of Multidimensional Polytomous Rasch model with linear restrictions</i>
-------	---

Description

Estimation of the multidimensional polytomous Rasch model with setting linear restrictions on the item category parameters β .

Parameter estimations is done by CML method.

Usage

```
MPRMI(data, desmat, ldes, lp, start)
```

Arguments

data	Data matrix or data frame; rows represent observations (persons), columns represent the items
desmat	Design matrix
ldes	a numeric vector of the same length as the number of item category parameters indicating which parameters are set linear dependent of which other parameters (see details)
lp	a numeric vector with length equal to the number of item parameters set linear dependent. The vector indicates the number of scoring parameters (see details)
start	Starting values for parameter estimation. If missing, a vector of 0 is used as starting values.

Details

With this function linear restrictions can be set on the general multidimensional polytomous Rasch model. Item category parameters can be set as being linear dependent to other item category parameters and the scoring parameter (as the multiple of the linear dependent parameters) is estimated. The restrictions are set by defining the arguments `ldes` and `lp`. `ldes` is a numerical vector of the same length as item category parameters in the general MPRM. A 0 in this vector indicates that no restriction is set. Putting in another number sets the item category parameter according to the vector position as linear dependent to that item category parameter with the position of the number included. For example, if item category parameter of item 1 and category 2 (that is position 2 in the vector `ldes`) should be linear dependent to the item category parameter of item 1 and category 1 (that is position 1 in the vector `ldes`), then the number 1 has to be on the second element of vector `ldes`. With the vector `lp` it is set, how many different scoring parameters have to be estimated and (if there are more than two) which of them should be equal. For example if 5 item category parameters are set linear dependent (by `ldes`) and according to the `ldes` vector the first, third and fourth have the same scoring parameters and the second and fifth have another scoring parameter, then `lp` must be a vector `lp = c(1, 2, 1, 1, 2)`.

It is necessary that the design matrix is specified in accordance with the restrictions in `ldes` and `lp`.

Value

data	data matrix according to the input
design	design matrix according to the input
logLikelihood	conditional log-likelihood
estpar	estimated basic item category parameters
estpar_se	estimated standard errors for basic item category parameters
itempar	estimated item category parameters
itempar_se	estimated standard errors for item category parameters
linpar	estimated scoring parameters
linpar_se	estimated standard errors for scoring parameters
hessian	Hessian matrix
convergence	convergence of solution (see help files in optim)
fun_calls	number of function calls (see help files in optim)

Author(s)

Christine Hohensinn

References

- Andersen, E. B. (1974). Das mehrkategoriale logistische Testmodell [The polytomous logistic test model] In. W. F. Kempf (Ed.), Probabilistische Modelle in der Sozialpsychologie [Probabilistic model in social psychology]. Bern: Huber.
- Fischer, G. H. (1974). Einfuehrung in die Theorie psychologischer Tests [Introduction to test theory]. Bern: Huber.
- Rasch, G. (1961). On general laws and the meaning of measurement in psychology, Proceedings Fourth Berkeley Symposium on Mathematical Statistics and Probability 5, 321-333.

See Also

[MPRM](#)

Examples

```
#simulate data set according to the general MPRM
simdat <- simMPRM(rbind(matrix(c(-1.5,0.5,0.5,1,0.8,-0.3, 0.2,-1.2), ncol=4),0), 500)

#estimate the general MPRM
res_mprm <- MPRM(simdat$datmat)

#estimate a MPRM with linear restrictions;
#for item 1 and 2 the second category is set linear dependent to the first category
ldes1 <- rep(0,length(res_mprm$itempar))
ldes1[c(2,5)] <- c(1,4)
lp1 <- rep(1,2)
#take the design matrix from the general MPRM and modify it according to the linear restriction
```

```

design1 <- res_mprm$design
design1[2,1] <- 1
design1[5,3] <- 1
design1[11,c(1,3)] <- -1
design1 <- design1[,-c(2,4)]

res_mprm1 <- MPRM(simdat$datmat, desmat=design1, ldes=ldes1, lp=lp1)

summary(res_mprm1)

```

person_par

Estimation of person parameters

Description

This function performs the estimation of person parameters for the multidimensional polytomous Rasch model or the continuous Rating Scale model.

Usage

```

person_par(object, ...)

## S3 method for class 'MPRM'
person_par(object, ..., set0=FALSE)
## S3 method for class 'CRSM'
person_par(object, ...)

```

Arguments

object	Object of class MPRM or CRSM
set0	if set0=TRUE for those raw scores patterns with 0 observations (except in the reference category) the person parameter value is set minimal. With this procedure it is possible to estimate at least the remaining person parameters of these raw score pattern. Note: only relevant for person parameter estimation of MPRM.
...	...

Details

The estimation is performed by Maximum Likelihood Estimation. Thus, parameters for extreme scores are not calculated!

Value

ptable	table showing for each (observed) raw score the corresponding estimated person parameter and standard error
pparList	for each person raw score, estimated person parameter and the standard error is displayed

fun_calls	number of function calls
call	function call

Author(s)

Christine Hohensinn

References

Fischer, G. H. (1974). Einfuehrung in die Theorie psychologischer Tests [Introduction to test theory]. Bern: Huber.

Mueller, H. (1999). Probabilistische Testmodelle fuer diskrete und kontinuierliche Ratingskalen. [Probabilistic models for discrete and continuous rating scales]. Bern: Huber.

See Also[CRSM](#)**Examples**

```
#estimate CRSM for the first four items
data(example1)
ex_cr <- CRSM(example1[,1:4], min=0, max=1)

#estimate person parameters for CRSM
pp <- person_par(ex_cr)
```

 simCRSM

simulate data according to CRSM

Description

With this function data sets according to the Continuous Rating Scale Model are simulated

Usage

```
simCRSM(itempar, distr, perspar, mid = 0.5, len = 1, seed=NULL)
```

Arguments

itempar	a numerical vector with item parameters
distr	a number setting the distribution parameter for the item set
perspar	a numerical vector with the person parameters
mid	the midpoint of the response scale (on which the data set is generated)
len	the length of the response scale (on which the data set is generated)
seed	a seed for the random number generated can optionally be set

Details

The midpoint and the length of the response scale define the interval of the data set generated. The default of the function generates data according to a response scale between 0 and 1 - that is midpoint 0.5 and length 1.

Value

datmat	simulated data set
true_itepar	the fixed item parameters according to the input
true_distrpar	the fixed distribution parameter according to the input
true_perspar	the fixed person parameters according to the input

Author(s)

Christine Hohensinn

References

Mueller, H. (1987). A Rasch model for continuous ratings. *Psychometrika*, 52, 165-181.

See Also

[simMPRM](#)

Examples

```
#set item parameters
item_p <- c(-1.5, -0.5, 0.5, 1)

#set distribution parameter for items
dis_p <- 5

#generate person parameters by a standard normal distribution
pp <- rnorm(50, 0, 1)

#simulate data set
#this is only an illustrating example for simulating data!
#In practice, a sample size of n=50 will be too small for most application demands
simdatC <- simCRSM(item_p, dis_p, pp)
```

simMPRM	<i>simulate data according to MPRM</i>
---------	--

Description

With this function data sets according to the multidimensional polytomous Rasch model (MPRM) are simulated

Usage

```
simMPRM(itempar, persons = 500, seed = NULL)
```

Arguments

itempar	a matrix with item category parameters; each row represents a category and each column an item (see details)
persons	an integer representing the number of persons (observations) of the data set (see details)
seed	a seed for the random number generated can optionally be set

Details

Data are generated with category values starting with 0. Thus the first row of the matrix containing the item parameters is matched to the category value 0 and so on. The last category is the reference category. Please note, that the item category parameters of the last category have to be 0 (due to parameter normalization)!

Person parameters are generated by a standard normal distribution.

Value

datmat	simulated data set
true_itempar	the fixed item parameters according to the input
true_perspar	the fixed person parameters

Author(s)

Christine Hohensinn

References

Fischer, G. H. (1974). Einfuehrung in die Theorie psychologischer Tests [Introduction to test theory]. Bern: Huber.

Rasch, G. (1961). On general laws and the meaning of measurement in psychology, Proceedings Fourth Berkeley Symposium on Mathematical Statistics and Probability 5, 321-333.

See Also[simCRSM](#)**Examples**

```
#set item parameters
item_p <- rbind(matrix(c(-1.5,0.5,0.5,1,0.8,-0.3, 0.2,-1.2), ncol=4),0)

#number of persons
pn <- 500

#simulate data set
simdatM <- simMPRM(item_p, pn)
```

weight_test	<i>Test for the scoring weights in the unidimensional polytomous Rasch model</i>
-------------	--

Description

This functions tests the fit of fixed scoring parameters in a unidimensional polytomous Rasch model.

Usage

```
weight_test(MPRMobj, score_param)

## S3 method for class 'wt'
summary(object, ...)
## S3 method for class 'wt'
print(x, ...)
```

Arguments

MPRMobj	Object of class MPRM
score_param	Numerical vector with the scoring parameters that are tested
object	object of class wt
x	object of class wt
...	...

Details

If the unidimensional polytomous Rasch model fits the data, the weight test can be performed to test whether assumed scoring parameters are appropriate. An unconstrained unidimensional polytomous Rasch model is calculated including estimation of scoring parameters. Furthermore a constrained unidimensional polytomous Rasch model is estimated with fixed scoring parameters (according to the input). Subsequently a Likelihood Ratio test tests the fit of the fixed scoring parameters.

Value

emp_Chi2	χ^2 distributed value of the Likelihood Ratio test
df	degrees of freedom of the test statistic
pval	p value of the test statistic
unconstrLoglikelihood	log-likelihood of the unconstrained model
constrLoglikelihood	log-likelihood of the constrained model
unconstrNrPar	number of estimated parameters in the unconstrained model
constrNrPar	number of estimated parameters in the constrained model
unconstrItempar	estimated item parameters of the unconstrained model
constrItempar	estimated item parameters of the constrained model
unconstrScoreParameter	estimated scoring parameters of the unconstrained model

Author(s)

Christine Hohensinn

References

Fischer, G. H. (1974). Einfuehrung in die Theorie psychologischer Tests [Introduction to test theory]. Bern: Huber.

See Also

[MPRM dLRT](#)

Examples

```
#simulate data set
simdat <- simMPRM(rbind(matrix(c(-1.5,0.5,0.5,1,0.8,-0.3, 0.2,-1.2), ncol=4),0), 500)

#estimate MPRM item parameters
res_mprm <- MPRM(simdat$datmat)

#tests the scoring parameter 0.5 for the unidimensional polytomous model
res_weight <- weight_test(res_mprm, score_param=c(0.5))
summary(res_weight)
```

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