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Type Package

Title Extended Graphical Model Checks for the Rasch Family of Models

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Description The function plotLRT() draws pairwise graphical model checks for the Rasch Model (RM; Rasch, 1960), the Partial Credit Model (PCM; Masters, 1982), and the Rating Scale Model (RSM; Andrich, 1978) using the output object of eRm::LRtest(). The function cLRT() provides a conditional Likelihood Ratio Test (Andersen, 1973), using the routines of 'psychotools' (Zeileis et al., 2026). Users may choose to plot the threshold parameters, the cumulative thresholds, the average thresholds per item, or the person parameters. Extended coloring options allow for automated item-wise or threshold-wise coloring. For multi-group splits, all pairwise group comparisons are drawn automatically. The function plotMLT() draws a graphical model check for the Martin-Loef-Test (MLT). If type='persons', it draws scatterplots of the person parameter estimates of each pair of item sub-groups. If type='items', it draws a scatterplot of the item/threshold parameter estimates of each of the two sub-groups vertically against the estimates of the total sample horizontally.

Depends R (>= 3.0.0)

License GPL (>= 3)

Imports psychotools

Suggests eRm

NeedsCompilation no

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cLRT *Conditional Likelihood Ratio Test (cLRT) using psychotool's routines*

Description

Calculates the cLRT and delivers subgroup's estimates for further processing with `plotLRT()`.

Usage

```
cLRT(dat, splitcr = "median", model = "PCM", print = TRUE, ...)
```

Arguments

`dat`	The data set (matrix or data.frame) to be evaluated.
`splitcr`	The split criterion. One of the following: • the keyword `"median"` • the keyword `"all.r"` • a single numeric (s) indicating r <= s vs. r > s • a vector of length `n` with each row's group allocation.
`model`	The model to be applied. May either contain the model's name (i.e., `"RM"`,`"PCM"`, or `"RSM"`) or the respective function name (i.e., `"raschmodel()"`, `"pcmodel()"`,`"rsmodel()"`).
`print`	(logical) Print the cLRT result to the console (default TRUE).
`...`	Further arguments to be passed to the estimation routines.

Value

`cLRT` returns an object of class cLRT with the elements

- X The data set.
- X.list A list of data sub-sets split by the split criterion
- split The split criterion as provided.
- spl.gr The split vector

- nullmod Result object of the H0 model.
- grpmod Result object of the H1 model (one list entry per split group.)
- lrt Results of the cLRT (vector).
- LR The test statistic of the cLRT.
- df The degrees of freedom of the cLRT.
- pvalue The p-value of the cLRT.
- threshpar A data.frame of the estimated threshold parameters per group.
- betapar A data.frame of the estimated cumulative threshold parameters per group.
- meanpar A data.frame of the estimated threshold parameter means per item per group.
- perspar A data.frame of the estimated person parameters per group.
- se.beta A data.frame of the S.E. of the est. threshold parameters per group.
- se.thresh A data.frame of the S.E. of the estimated cumulative threshold parameters per group.
- se.mean A data.frame of the S.E. of the estimated threshold parameter means per item per group.
- se.pers A data.frame of the S.E. of the estimated person parameters per group.

Author(s)

Rainer W. Alexandrowicz

Examples

```
library(eRm)
data(pcmdat2)

mod = cLRT(pcmdat2)   # psychotools based (defaults: PCM, median split)
plotLRT(mod)
```

`gmx` *Extended Graphical Model Checks for multi-group splits of RM/PCM/RSM*

Description

Draws pairwise graphical model checks for RM/PCM/RSM using the output object of eRm::LRtest() or GMX::clrt(). Supports threshold parameters, cumulative threshold parameters, mean of threshold parameters, or person parameters of the split groups.

Usage

```
gmx(...)
```

Arguments

`...`	Any argument valid for `plotLRT`.

Details

The function gmx() is superseded by plotLRT() as of version 0.9-2 of GMX, which is the first version made available on CRAN (for previous versions see https://osf.io/2ryd8/. It is included for backward compatibility. The options of both functions are identical, in fact, any call to gmx() is forwarded to plotLRT().

Value

gmx() returns a data.frame with the parameters used for plotting (i.e., the selected thresholds, cumulative thresholds, mean item parameters, or thetas).

Author(s)

Rainer W. Alexandrowicz

Examples

```
library(eRm)
data(pcmdat2)

mod = PCM(pcmdat2)                              # eRm based
grp = rep(1:3, each=100)
tst = LRtest(mod, splitcr=grp)

gmx(tst)
```

---

plotLRT *Extended Graphical Model Checks for multi-group splits of RM/PCM/RSM*

Description

Draws pairwise graphical model checks for RM/PCM/RSM using the output object of eRm::LRtest() or GMX::clrt(). Supports threshold parameters, cumulative threshold parameters, mean of threshold parameters, or person parameters of the split groups.

Usage

```
plotLRT(
  lrtobj,
  type = c("thresholds", "cumulative", "means", "perspar", "betas"),
  isel = NULL,
  psel = NULL,
  gsel = NULL,
  nc = 3,
  ds = 4,
  dotcol = "dodgerblue",
  regcol = "dodgerblue3",
```

```
  regline = TRUE,
  pch = 16,
  xlim = NULL,
  ylim = NULL,
  EQlims = TRUE,
  glabs = "auto",
  tlabs = "names",
  title = "none",
  annot = c("r", "LRT"),
  confell = TRUE,
  conferr = 0.05,
  confcol = grey(0.8),
  extwin = TRUE,
  parskip = FALSE,
  ...
)
```

Arguments

lrtobj	Output object of a previous call to eRm::LRtest or GMX::clrt().
type	Plot "betas", "thresholds" (PCM & RSM only), or person parameters ("perspar"). May be abbreviated. See details.
isel	Item selection: Vector of item numbers to plot (includes all parameters of the selected items). Takes precedence over psel and is ignored if type=perspar.
psel	Parameter selection: Vector of parameter numbers to plot. Ignored if type=perspar.
gsel	Group selection: which subgroups to plot (numeric vector).
nc	Number of columns of the combined plot. The number of rows is determined automatically from the number of split groups.
ds	Diagram size of each single diagram. Defaults to 7x7 inch for a two-group split and 4 x 4 inch for a multi-group split.
dotcol	Dot color. May be a vector of length(number of parameters) for distinguishing parameter groups (e.g., if items belong to different domains). It also accepts the keywords "items" for using the same color for all parameters per item and "thresholds" for using the same colors for all first/second/... parameters per item.
regcol	Color of regression line (vertical group ~ horizontal group)
regline	(logical) Shall the regression line be drawn?
pch	Point character. May be a vector (see col).
xlim	Manually set limits of the horizontal axes (if EQlims=FALSE).
ylim	Manually set limits of the vertical axes (if EQlims=FALSE).
EQlims	Force horizontal and vertical axes to share the same range. (i.e., xlim=ylim). Uses +/-1.2 times the maximum value of all split groups. Takes precedence over xlim and ylim.

glabs	Vector of group labels to use for axis labeling. Keyword 4 "auto" will use the labels provided by LRtest. (Note: Use a factor for the split criterion in LRtest(), although the documentation of LRtest also permits character vectors.)
tlabs	Either a keyword defining point labelling: "none" = no labels, "numbers" = consecutive numbers of parameters, "names" = paramter names as provided by LRtest (default), "identify" = Interactive labelling (see ?eRm::plotGOF), or a vector with user-provided labels.
title	Either keyword "none" (default) to omit a title, keyword "auto" to print the test statistic/df/p-value of the LRT, or a custom title string.
annot	A string vector containing the strings "r" and/or "LRT": "r" prints the correlation of the plotted parameters and"LRT" the test statistic, the df, and the p-value of the LRT (the latter only in the top left diagram for multiple group splits).
confell	(logical). Draw confidence ellipses.
conferr	Probability of an error of the first kind used for the confidence ellipses.
confcol	Color of the confidence ellipses. The keyword "auto" will use the point colors (default: grey(.8)).
extwin	(logical) Draw diagram(s) into an external window (for better compatibility with RStudio; default: TRUE)
parskip	Skip internal settings for graphical options (par=) to take full control; default: FALSE.
...	Further arguments to be passed to plot().

Details

- In the dichotomous case, both type="cumulative" and type="mean" plot the item difficulty parameters.
- It is recommended to use factors for splitcr= when calling eRm::LRtest().

Changes in version 0.9 of GMX:

- The default type is "thresholds" (unlike "betas" of previous versions).
- The former "type=betas" is now called "type=cumulative", but "type=betas" is still supported for backward compatibility).
- The "type=means" delivers the threshold means per item.
- The col= argument has been renamed to dotcol=.

Value

plotLRT() returns a data.frame with the parameters used for plotting (i.e., the selected thresholds, cumulative thresholds, mean item parameters, or thetas).

Author(s)

Rainer W. Alexandrowicz

Examples

```
library(eRm)
data(pcmdat2)

mod = PCM(pcmdat2)                                  # eRm based
grp = rep(1:3, each=100)
tst = LRtest(mod, splitcr=grp)

plotLRT(tst)                                        # thresholds (default)
plotLRT(tst,type="p")                               # person parameters

col = rep(c("deepskyblue","firebrick2","green3","steelblue"),each=2)
plotLRT(tst,type="t",dotcol=col,cex=2)              # distinguish items
plotLRT(tst,type="t",dotcol=col,cex=2,confcol=col,tlab="nam")

col = rep(c("steelblue1","orangered2"),4)           # distinguish thresholds
plotLRT(tst,type="t",dotcol=col,cex=2, confcol=col, tlab="nam")

palette(c("deepskyblue","firebrick2","green3","steelblue"))
plotLRT(tst,type="t",dotcol="items",cex=2,tlab="nam")   # auto-distinguish items

palette(c("steelblue1","orangered2"))               # auto-distinguish thresholds
plotLRT(tst,type="t",dotcol="thresholds",cex=2,tlab="nam")

pp = plotLRT(tst,type="p",dotcol=rainbow(7))
t(apply(pp,1,diff))                                 # group differences of thetas

plotLRT(tst,type="t",tlab="nam",isel=1)             # plot only first item
plotLRT(tst,type="t",tlab="nam",isel=c(2,3))        # plot items 2 and 3

plotLRT(tst,type="t",tlab="nam",psel=c(1,3,5,7)) # plot threshold 1 of all items


mod = cLRT(pcmdat2)                                 # psychotools based
plotLRT(mod)
plotLRT(mod,type="p")
```

`plotMLT` *Graphical Model Checks for the Martin-Loef-Test*

Description

Supports the Martin-Loef-Test by drawing scatterplots of person and item parameter estimates of the Rasch Model (RM), the Partial Credit Model (PCM), and the Rating Scale Model (RSM) using the return object of `eRm::MLoef()`.

Usage

```
plotMLT(
```

```
  mod,
  type = c("persons", "items"),
  pcol = NULL,
  ilim = NULL,
  plim = NULL,
  nc = 3,
  jit = TRUE,
  leg = TRUE,
  reg = TRUE,
  legcex = 1.1,
  extwin = TRUE,
  w = 6,
  h = 6,
  parskip = FALSE,
  confell = TRUE,
  conferr = 0.05,
  confcol = grey(0.8),
  ...
)
```

Arguments

mod	Return object of a previous call to eRm::MLtest().
type	Plot "items" or "persons" (may be abbreviated).
pcol	Colors for item/threshold parameter of the two subgroups.
ilim	Maximum axis value to be used for the item parameter plot.
plim	Maximum axis value to be used for the person parameter plot.
nc	Number of columns of the combined plot. The number of rows is determined automatically from the number of split groups.
jit	Jitter person parameter estimates.
leg	Draw a legend? (default:TRUE).
reg	Draw regression lines? (default:TRUE).
legcex	Size of legend text (default: 1.1).
extwin	(logical) Draw diagram(s) into an external window (for better compatibility with RStudio; default: TRUE)
w	Width of graphics device (default: 6 inch).
h	Height of graphics device (default: 6 inch).
parskip	Skip internal settings for graphical options (par=) to take full control; default: FALSE.
confell	(logical). Draw confidence ellipses (type="item" only).
conferr	Probability of an error of the first kind used for the confidence ellipses.
confcol	Color of the confidence ellipses. The keyword "auto" will use the point colors (default: grey(.8)).
...	Further arguments to be passed to plot().

Details

This function supports the interpretation of the results of the Martin-Loef-Test (hence the name). See Gustafsson (1980) for a comprehensive summary, and Christensen et al. (2002) for the extension to polytomous items.

The Martin-Loef-Test (MLT) is sensitive to violations of the unidimensionality assumption. It is a Likelihood-Ratio-Test based on a 'vertical' split of the data, i.e., comparing item subsets. A unidimensional model (i.e., all items measuring the same latent construct) will yield highly correlated person parameter estimates across the analyzed item sub-sets. In contrast, if the item-split reflects different latent dimensions, the correlations between the person parameters of the item sub-sets will vanish. Therefore, the default is `type="person"`. The item parameter estimates of the sub-groups may also differ from the total estimates.

The option `type="persons"` (default) plots the estimated person parameters of all pairs of item groups against each other. As there are usually only few distinct values, they are by default jittered (`jit=TRUE`).

The option `type="items"` plots the item difficulty (RM) or item threshold (PCM/RSM) parameters of the total sample (horizontal) against the estimates per sub-sample (cf. Rasch, 1960, p.97, Fig. 14) using the colors in `col=`. For polytomous items (i.e., PCM/RSM), the function plots both the threshold parameter estimates (unlike `eRm::plotGOF()`, which uses the cumulative 'betas') along with the threshold average per item ('location'), the former indicated by circles and the latter by bullets.

The function processes the return object of `eRm::MLtest()`. It will open a new graphics device if `extwin=TRUE`.

Value

A list of class `MLTplot` with the following elements:

- `items` is a `data.frame` with the estimated item parameters of both the total sample and all item subsamples, each along with the respective standard errors (if `se=TRUE` was specified in the model estimation (`RM`, `PCM`, or `RSM`)
- `pers` is a `data.frame` with the estimated person parameters of both the total sample and all item subsamples, each along with the respective standard errors (if `se=TRUE` was specified in the model estimation (`RM`, `PCM`, or `RSM`)
- `pers_cor` is the matrix of Pearson correlation coefficients of the sub-group person parameter estimates.

Author(s)

Rainer W. Alexandrowicz

References

Christensen, K. B., Bjorner, J. B., Kreiner, S. & Petersen, J. H. (2002). *Testing Unidimensionality in Polytomous Models* Psychometrika, 67 (4), 563-574. <DOI:10.1007/BF02295131>

Gustafsson, J.-E. (1980). *A solution of the conditional estimation problem for long tests in the Rasch model for dichotomous items* Educational and Psychological Measurement, 40 , 377-385. <DOI:10.1177/001316448004000214>

Rasch, G. (1960). *Probabilistic Models for Some Intelligence and Attainment Tests.* Danmarks Paedagogiske Institut <ISBN:9780598554512>

Examples

```
library(eRm)
mod = PCM(pcmdat2)
tst = MLoef(mod)
plotMLT(tst)
plotMLT(tst,type="p")
```

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