Package 'ggExametrika'

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Type Package

Title Visualization of 'exametrika' Output Using 'ggplot2'

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Description Provides 'ggplot2'-based visualization functions for output objects from the 'exametrika' package, which implements test data engineering methods described in Shojima (2022, ISBN:978-981-16-9547-1). Supports a wide range of psychometric models including Item Response Theory, Latent Class Analysis, Latent Rank Analysis, Biclustering (binary, ordinal, and nominal), Bayesian Network Models, and related network models. All plot functions return 'ggplot2' objects that can be further customized by the user.

URL https://kosugitti.github.io/ggExametrika/, https://github.com/kosugitti/ggExametrika

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Author Koji Kosugi [aut, cre] (ORCID: <https://orcid.org/0000-0001-5816-0099>), Daichi Kamimura [aut]

Maintainer Koji Kosugi <kosugitti@gmail.com>

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`combinePlots_gg` *Display Multiple Plots Simultaneously from ggExametrika Output*

Description

This function arranges multiple ggplot objects from ggExametrika functions into a single display using a grid layout. Useful for comparing plots across items or students.

Usage

```
combinePlots_gg(plots, selectPlots = c(1:6))
```

Arguments

plots	A list of ggplot objects, typically output from functions like plotICC_gg, plotIRP_gg, etc.
selectPlots	A numeric vector specifying which plots to display. Default is 1:6 (first 6 plots). Indices exceeding the list length are automatically excluded.

Details

This function uses gridExtra::grid.arrange to combine multiple plots. The number of rows and columns is automatically determined. For more control over layout, consider using gridExtra::grid.arrange directly with the nrow and ncol arguments.

Value

A gtable object containing the arranged plots, displayed as a side effect.

Examples

```
library(exametrika)
result <- IRT(J15S500, model = 3)
plots <- plotICC_gg(result)
combinePlots_gg(plots, selectPlots = 1:6) # Show first 6 items
combinePlots_gg(plots, selectPlots = c(1, 5, 10)) # Show specific items
```

ItemInformationFunc *Item Information Function for 4PLM*

Description

Computes the Item Information Function (IIF) for the four-parameter logistic model in Item Response Theory. The information function indicates how precisely an item measures ability at different theta levels.

Usage

```
ItemInformationFunc(x, a = 1, b, c = 0, d = 1)
```

Arguments

x	Numeric. The ability parameter (theta).
a	Numeric. The slope (discrimination) parameter. Default is 1.
b	Numeric. The location (difficulty) parameter.
c	Numeric. The lower asymptote (guessing) parameter. Default is 0.
d	Numeric. The upper asymptote (carelessness) parameter. Default is 1.

Details

Higher discrimination (a) parameters result in higher information. Items provide maximum information near their difficulty (b) parameter. The guessing (c) and upper asymptote (d) parameters reduce the maximum information an item can provide.

Value

A numeric value representing the item information at the given ability level.

See Also

LogisticModel

Examples

```
# Information at ability = 0 for an item with b = 0
ItemInformationFunc(x = 0, a = 1.5, b = 0, c = 0, d = 1)

# Compare information at different ability levels
sapply(seq(-3, 3, 0.5), function(x) ItemInformationFunc(x, a = 1, b = 0))
```

ItemInformationFunc_GRM

GRM Item Information Function

Description

Computes the Item Information Function (IIF) for the Graded Response Model. The information function indicates how precisely an item measures ability at different theta levels.

Usage

```
ItemInformationFunc_GRM(theta, a, b)
```

Arguments

theta	Numeric. The ability parameter (theta).
a	Numeric. The slope (discrimination) parameter.
b	Numeric vector. The threshold (boundary) parameters.

Details

The information is Samejima's (1969) item information for the GRM, computed identically to `exametrika::grm_iif` (>= 1.15.0.9000) so that ggExametrika plots match the base plots of the parent package:

$$I(\theta) = \sum_{k=1}^{K} \frac{[P_k'(\theta)]^2}{P_k(\theta)}$$

where $P_k(\theta) = P_{k-1}^*(\theta) - P_k^*(\theta)$ is the category response probability, $P_k^*(\theta)$ is the cumulative (boundary) probability with $P_0^* = 1$ and $P_K^* = 0$, and $P_k^{*\prime}(\theta) = aP_k^*(\theta)[1 - P_k^*(\theta)]$. The logistic metric of the parent package's estimation is used as is (no 1.702 scaling constant).

Value

A numeric value representing the item information at the given ability level.

See Also

`plotICRF_gg`

Examples

```
# Information at ability = 0 for a 5-category item
ItemInformationFunc_GRM(theta = 0, a = 1.5, b = c(-1, -0.5, 0.5, 1))
```

`LogisticModel` *Four-Parameter Logistic Model*

Description

Computes the probability of a correct response using the four-parameter logistic model (4PLM) in Item Response Theory.

Usage

```
LogisticModel(x, a = 1, b, c = 0, d = 1)
```

Arguments

`x`	Numeric. The ability parameter (theta).
`a`	Numeric. The slope (discrimination) parameter. Default is 1.
`b`	Numeric. The location (difficulty) parameter.
`c`	Numeric. The lower asymptote (guessing) parameter. Default is 0.
`d`	Numeric. The upper asymptote (carelessness) parameter. Default is 1.

Details

The four-parameter logistic model extends the 3PLM by adding an upper asymptote parameter d, which accounts for careless errors by high-ability examinees.

The model formula is:

$$P(\theta) = c + \frac{d - c}{1 + \exp(-a(\theta - b))}$$

Special cases:

- 1PLM: a = 1, c = 0, d = 1
- 2PLM: c = 0, d = 1
- 3PLM: d = 1

Value

A numeric value representing the probability of a correct response.

See Also

ItemInformationFunc

Examples

```
# Compute probability for ability = 0, difficulty = 0
LogisticModel(x = 0, a = 1, b = 0, c = 0, d = 1) # Returns 0.5

# 3PLM with guessing parameter
LogisticModel(x = -3, a = 1.5, b = 0, c = 0.2, d = 1)
```

---

plotArray_gg *Plot Array from exametrika*

Description

This function takes exametrika output as input and generates array plots using ggplot2. Array plots visualize the response patterns of students (rows) across items (columns), showing both the original data and the clustered/reordered data.

Supports both binary (0/1) and multi-valued (ordinal/nominal) data.

Usage

```
plotArray_gg(
  data,
  Original = TRUE,
  Clustered = TRUE,
  Clustered_lines = TRUE,
  Clustered_lines_color = NULL,
  title = TRUE,
  colors = NULL,
  show_legend = NULL,
  legend_position = "right",
  border = FALSE,
  border_linewidth = 0.5
)
```

Arguments

data	An object of class `c("exametrika", "Biclustering")`, `c("exametrika", "nominalBiclustering")`, `c("exametrika", "ordinalBiclustering")`, `c("exametrika", "ratedBiclustering")`, `c("exametrika", "IRM")`, `c("exametrika", "LDB")`, or `c("exametrika", "BINET")`.
Original	Logical. If `TRUE` (default), plot the original (unsorted) response data.
Clustered	Logical. If `TRUE` (default), plot the clustered (sorted by class and field) response data.
Clustered_lines	Logical. If `TRUE` (default), draw lines on the clustered plot to indicate class and field boundaries.
Clustered_lines_color	Character. Color of the boundary lines. If `NULL` (default), uses `"red"` for binary data or `"white"` for multi-valued data.
title	Logical or character. If `TRUE` (default), display auto-generated titles. If `FALSE`, no titles. If a character string, use it as a custom title prefix.
colors	Character vector of colors for each category. If `NULL` (default), uses white/black for binary data or a colorblind-friendly palette for multi-valued data.
show_legend	Logical. If `TRUE`, display the legend. Default is `FALSE` for binary data, `TRUE` for multi-valued.
legend_position	Character. Position of the legend. One of `"right"` (default), `"top"`, `"bottom"`, `"left"`, `"none"`.
border	Logical or character. If `TRUE`, draw a rectangular border around each panel so that the original and clustered panels are visually separated. If `FALSE` (default), no border is drawn (the v1.1.0 behavior). A character string is used as the border color (default color is `"black"`).
border_linewidth	Numeric. Line width of the panel border. Default is `0.5`.

Details

The array plot provides a visual representation of the biclustering result. For binary data, black cells indicate correct responses (1) and white cells indicate incorrect responses (0). For multi-valued data, different colors represent different response categories.

In a well-fitted model, the clustered plot should show a clear block diagonal pattern where high-ability students (bottom rows) answer difficult items (right columns) correctly.

Value

When both `Original` and `Clustered` are `TRUE`, a gtable (grid arrangement of the two panels side by side, drawn as a side effect). Otherwise, a list containing the single requested ggplot object.

See Also

`plotFRP_gg`, `plotTRP_gg`

Examples

```
library(exametrika)
result <- Biclustering(J35S515, nfld = 5, ncls = 6)

# Basic usage
plotArray_gg(result)

# Custom boundary line color
plotArray_gg(result, Clustered_lines_color = "blue")

# Multi-valued data with custom colors
synthetic_data <- matrix(sample(0:3, 50 * 20, replace = TRUE), nrow = 50, ncol = 20)
result_multi <- Biclustering(synthetic_data, nfld = 4, ncls = 5)
plotArray_gg(result_multi, show_legend = TRUE, Clustered_lines_color = "darkgreen")
```

---

plotCMP_gg *Plot Class Membership Profile (CMP) from exametrika*

Description

This function takes exametrika output as input and generates Class Membership Profile (CMP) plots using ggplot2. CMP shows each student's membership probability across all latent classes.

Usage

```
plotCMP_gg(
  data,
  title = TRUE,
  colors = NULL,
  linetype = "dashed",
```

```
  show_legend = FALSE,
  legend_position = "right"
)
```

Arguments

data	An object of class `c("exametrika", "LCA")` or `c("exametrika", "BINET")`. If LRA, Biclustering, LDLRA, or LDB output is provided, RMP will be plotted instead with a warning.
title	Logical or character. If `TRUE` (default), display an auto-generated title. If `FALSE`, no title. If a character string, use it as a custom title (only for single-student plots).
colors	Character vector. Color(s) for points and lines. If `NULL` (default), a colorblind-friendly palette is used.
linetype	Character or numeric specifying the line type. Default is `"dashed"`.
show_legend	Logical. If `TRUE`, display the legend. Default is `FALSE`.
legend_position	Character. Position of the legend. One of `"right"` (default), `"top"`, `"bottom"`, `"left"`, `"none"`.

Details

The Class Membership Profile visualizes how strongly each student belongs to each latent class. Students with high membership probability in a single class are well-classified, while students with similar probabilities across classes may be ambiguous cases.

Value

A list of ggplot objects, one for each student. Each plot shows the membership probability across all latent classes.

See Also

plotRMP_gg, plotLCD_gg

Examples

```
library(exametrika)

result <- LCA(J15S500, ncls = 5)
plots <- plotCMP_gg(result)
plots[[1]] # Show CMP for the first student
```

plotCRV_gg *Plot Class Reference Vector (CRV) from exametrika*

Description

This function takes exametrika Biclustering output as input and generates a Class Reference Vector (CRV) plot using ggplot2. CRV shows how each latent class performs across fields, with one line per class.

Supports both binary (2-valued) and polytomous (multi-valued) biclustering models. For polytomous data, the `stat` parameter controls how expected scores are calculated from category probabilities.

Usage

```
plotCRV_gg(
  data,
  title = TRUE,
  colors = NULL,
  linetype = "solid",
  show_legend = TRUE,
  legend_position = "right",
  stat = "mean",
  show_labels = FALSE
)
```

Arguments

`data`	An object of class `c("exametrika", "Biclustering")` from `exametrika::Biclustering()`.
`title`	Logical or character. If `TRUE` (default), display an auto-generated title. If `FALSE`, no title. If a character string, use it as a custom title.
`colors`	Character vector of colors for each class. If `NULL` (default), a colorblind-friendly palette is used.
`linetype`	Character or numeric scalar specifying the line type applied to all lines. Default is `"solid"`.
`show_legend`	Logical. If `TRUE` (default), display the legend.
`legend_position`	Character. Position of the legend. One of `"right"` (default), `"top"`, `"bottom"`, `"left"`, `"none"`.
`stat`	Character. Statistic for polytomous data: `"mean"` (default), `"median"`, or `"mode"`. For binary data, this parameter is ignored. • `"mean"`: Expected score (sum of category x probability) • `"median"`: Median category (cumulative probability >= 0.5) • `"mode"`: Most probable category
`show_labels`	Logical. If `TRUE`, displays class labels on each point using `ggrepel` to avoid overlaps. Defaults to `FALSE` since the legend already provides class information.

Details

The Class Reference Vector is the transpose of the Field Reference Profile (FRP). While FRP shows one plot per field, CRV displays all classes in a single plot with fields on the x-axis. Each line represents a latent class, showing its correct response rate pattern across fields.

Binary Data (2 categories):

- Y-axis shows "Correct Response Rate" (0.0 to 1.0)
- Values represent the probability of correct response

Polytomous Data (3+ categories):

- Y-axis shows "Expected Score" (1 to max category)
- Values are calculated using the `stat` parameter
- Higher scores indicate better performance

CRV is used when latent classes are nominal (unordered). For ordered latent ranks, use `plotRRV_gg` instead.

Value

A single ggplot object showing the Class Reference Vector.

See Also

`plotRRV_gg`, `plotFRP_gg`, `plotScoreField_gg`

Examples

```
# Binary biclustering
library(exametrika)
result <- Biclustering(J35S515, nfld = 5, ncls = 6)
plotCRV_gg(result)


# Ordinal biclustering (polytomous)
data(J35S500)
result_ord <- Biclustering(J35S500, ncls = 5, nfld = 5, method = "R")
plotCRV_gg(result_ord) # Default: mean
plotCRV_gg(result_ord, stat = "median")
plotCRV_gg(result_ord, stat = "mode")
```

plotDistractor_gg *Plot Distractor Analysis for Rated Models*

Description

Creates stacked bar charts showing the proportion of each response category by rank/class for each item. The correct answer category is highlighted in a distinct color to visualize how well each item discriminates across ability levels.

Usage

```
plotDistractor_gg(
  data,
  items = NULL,
  ranks = NULL,
  title = TRUE,
  colors = NULL,
  show_legend = TRUE,
  legend_position = "right"
)
```

Arguments

data	An object of class c("DistractorAnalysis", "exametrika") from exametrika::DistractorAnalys
items	Integer vector of item indices to plot. If NULL (default), plots all items.
ranks	Integer vector of rank/class indices to display. If NULL (default), displays all ranks/classes.
title	Logical or character. If TRUE (default), displays an auto-generated title. If FALSE, no title. If a character string, uses it as a custom title (appended with item label).
colors	Character vector of colors for response categories. If NULL (default), uses steel-blue for the correct answer and gray70 for distractor categories. When specified, colors are assigned to categories in order (Cat1, Cat2, ...).
show_legend	Logical. If TRUE (default), displays the legend.
legend_position	Character. Position of the legend. One of "right" (default), "top", "bottom", "left", "none".

Details

Distractor Analysis examines how examinees in different ability ranks or latent classes respond to multiple-choice items. For each item, a stacked bar chart shows the proportion of respondents choosing each category.

A well-functioning item should show the correct answer category (highlighted in blue by default) increasing in proportion as rank/class increases, while distractor categories decrease.

This function works with DistractorAnalysis objects produced from LRA (rated data) and Biclustering / Biclustering_IRM (rated data) results.

Value

A named list of ggplot objects, one per item. Names correspond to item labels.

See Also

plotIRP_gg, plotFCRP_gg, combinePlots_gg

Examples

```
library(exametrika)
# LRA.rated example
result_lra <- LRA(J21S300, nrank = 5, mic = TRUE)
da <- DistractorAnalysis(result_lra)

# Plot a single item
plots <- plotDistractor_gg(da, items = 1)
plots[[1]]

# Plot multiple items
plots <- plotDistractor_gg(da, items = 1:6)
combinePlots_gg(plots, selectPlots = 1:6)

# Select specific ranks
plots <- plotDistractor_gg(da, items = 1, ranks = c(1, 3, 5))

# Custom colors
plots <- plotDistractor_gg(da,
  items = 1,
  colors = c("tomato", "steelblue", "gold", "gray70")
)
```

---

plotFCBR_gg *Plot Field Cumulative Boundary Reference from exametrika*

Description

This function takes exametrika ordinalBiclustering output as input and generates a Field Cumulative Boundary Reference (FCBR) plot using ggplot2. The plot shows cumulative probability curves for each category boundary across latent classes or ranks. For each field, multiple lines represent the probability of scoring at or above each category boundary.

Usage

```
plotFCBR_gg(
  data,
  fields = NULL,
```

```
  title = TRUE,
  colors = NULL,
  linetype = NULL,
  show_legend = TRUE,
  legend_position = "right"
)
```

Arguments

data	An object of class c("exametrika", "ordinalBiclustering") from exametrika::Biclustering() with dataType = "ordinal".
fields	Integer vector specifying which fields to plot. Default is all fields.
title	Logical or character. If TRUE (default), display field labels as subplot titles. If FALSE, no titles. If a character string, use it as the main plot title.
colors	Character vector. Colors for category boundary lines. If NULL (default), uses the package default palette.
linetype	Character or numeric vector. Line types for category boundaries. If NULL (default), uses automatic line type assignment.
show_legend	Logical. If TRUE, display the legend showing boundary labels. Default is TRUE.
legend_position	Character. Position of the legend. One of "right" (default), "top", "bottom", "left", "none".

Details

The Field Cumulative Boundary Reference (FCBR) visualizes how the probability of reaching each category boundary changes across latent classes or ranks in ordinal biclustering. This is particularly useful for understanding the difficulty of each response category threshold across different ability levels.

For a field with K categories (1, 2, ..., K), the FCBR shows:

- Line 1: P(response >= 1 | class/rank) = 1.0 (always)
- Line 2: P(response >= 2 | class/rank)
- Line 3: P(response >= 3 | class/rank)
- ...
- Line K: P(response >= K | class/rank)

The boundary probabilities are calculated by summing the probabilities of all categories at or above the boundary threshold. P(Q>=1) is always 1.0 and appears as a horizontal line at the top. Higher classes/ranks (higher ability) typically show higher probabilities for higher boundaries.

Value

A single ggplot object with faceted subplots for each field.

See Also

plotFCRP_gg, plotScoreField_gg, plotArray_gg

Examples

```
library(exametrika)
# Ordinal biclustering example with polytomous data
result <- Biclustering(J35S500, ncls = 4, nfld = 5)

# Plot first 4 fields
plot <- plotFCBR_gg(result, fields = 1:4)
plot

# Custom colors and title (5 colors needed for 5-category ordinal data)
plot <- plotFCBR_gg(result,
  fields = 1:5,
  title = "Field Cumulative Boundary Reference",
  colors = c("red", "blue", "green", "purple", "orange")
)
plot
```

---

plotFCRP_gg *Plot Field Category Response Profile (FCRP) for Polytomous Biclustering*

Description

Creates a Field Category Response Profile (FCRP) plot for polytomous (ordinal or nominal) Biclustering results. FCRP displays the probability of each response category for each latent class/rank within each field.

Usage

```
plotFCRP_gg(
  data,
  style = c("line", "bar"),
  title = TRUE,
  colors = NULL,
  linetype = NULL,
  show_legend = TRUE,
  legend_position = "right"
)
```

Arguments

data	An object of class `c("exametrika", "ordinalBiclustering")`, `c("exametrika", "nominalBiclustering")`, or `c("exametrika", "ratedBiclustering")` from `exametrika::Biclustering()`.
style	Character string specifying the plot style. One of:

	`"line"` Line plot with points (default) `"bar"` Stacked bar chart
`title`	Logical or character. If `TRUE` (default), displays an auto-generated title. If `FALSE`, no title. If a character string, uses it as a custom title.
`colors`	Character vector of colors for categories. If `NULL` (default), uses a colorblind-friendly palette.
`linetype`	Character or numeric vector specifying line types for `style = "line"`. If `NULL` (default), uses solid lines. Only applies to line plots.
`show_legend`	Logical. If `TRUE` (default), displays the legend.
`legend_position`	Character. Position of the legend. One of `"right"` (default), `"top"`, `"bottom"`, `"left"`, `"none"`.

Details

FCRP (Field Category Response Profile) visualizes how response category probabilities change across latent classes or ranks within each field. For each field, the plot shows $P(response = k|class/rank)$ for all categories k. Probabilities sum to 1.0 for each class/rank.

This plot is only available for polytomous Biclustering models (`ordinalBiclustering`, `nominalBiclustering`, or `ratedBiclustering`) that have 3 or more response categories.

The `style` parameter allows two visualizations:

- `"line"`: Shows category probability curves as lines with points
- `"bar"`: Shows stacked bar chart with category proportions

Value

A ggplot object showing category response probabilities for each field and latent class/rank.

See Also

`plotFCBR_gg`, `plotScoreField_gg`

Examples

```
library(exametrika)
# Ordinal Biclustering with 5 categories
result <- Biclustering(J35S500, ncls = 5, nfld = 5, method = "R")

# Line plot (default)
plotFCRP_gg(result, style = "line")

# Stacked bar chart
plotFCRP_gg(result, style = "bar")

# Custom styling
plotFCRP_gg(result,
```

```
  style = "line",
  title = "Category Response Patterns",
  colors = c("#E69F00", "#56B4E9", "#009E73", "#F0E442", "#CC79A7")
)
```

`plotFieldPIRP_gg` *Plot Field PIRP (Parent Item Reference Profile) from exametrika*

Description

This function takes exametrika LDB output as input and generates Field PIRP (Parent Item Reference Profile) plots using ggplot2. Field PIRP shows the correct response rate for each field as a function of the number-right score in parent fields.

Usage

```
plotFieldPIRP_gg(
  data,
  title = TRUE,
  colors = NULL,
  linetype = "solid",
  show_legend = FALSE,
  legend_position = "right"
)
```

Arguments

`data`	An object of class `c("exametrika", "LDB")`.
`title`	Logical or character. If `TRUE` (default), display an auto-generated title. If `FALSE`, no title. If a character string, use it as a custom title prefix (rank number will be appended).
`colors`	Character vector. Colors for each field line. If `NULL` (default), uses black for all lines (with text labels for field identification).
`linetype`	Character or numeric specifying the line type. Default is `"solid"`.
`show_legend`	Logical. If `TRUE`, display the legend. Default is `FALSE` (uses text labels instead).
`legend_position`	Character. Position of the legend. One of `"right"` (default), `"top"`, `"bottom"`, `"left"`, `"none"`.

Details

In Local Dependence Biclustering (LDB), items in a field may depend on performance in parent fields. The Field PIRP visualizes this dependency by showing how the correct response rate in each field changes based on the number of correct responses in parent fields.

Note: Warning messages about NA values may appear during plotting but the behavior is normal.

Value

A list of ggplot objects, one for each rank. Each plot shows the correct response rate curves for all fields at that rank level.

See Also

plotFRP_gg, plotArray_gg

Examples

```
library(exametrika)
# LDB requires field configuration and edge structure
conf <- c(
  1, 6, 6, 8, 9, 9, 4, 7, 7, 7, 5, 8, 9, 10, 10, 9, 9,
  10, 10, 10, 2, 2, 3, 3, 5, 5, 6, 9, 9, 10, 1, 1, 7, 9, 10
)
edges_data <- data.frame(
  "From Field (Parent) >>>" = c(6, 4, 5, 1, 1, 4, 3, 4, 6, 2, 4, 4, 3, 6, 4, 1, 7, 9, 6, 7),
  ">>> To Field (Child)" = c(8, 7, 8, 7, 2, 5, 5, 8, 8, 4, 6, 7, 5, 8, 5, 8, 10, 10, 8, 9),
  "At Class/Rank (Locus)" = c(2, 2, 2, 2, 2, 2, 3, 3, 3, 3, 3, 3, 4, 4, 4, 4, 5, 5, 5, 5)
)
tmp_file <- tempfile(fileext = ".csv")
write.csv(edges_data, file = tmp_file, row.names = FALSE)
result <- LDB(J35S515, ncls = 5, conf = conf, adj_file = tmp_file)
unlink(tmp_file)
plots <- plotFieldPIRP_gg(result)
plots[[1]] # Show Field PIRP for rank 1
```

---

plotFRP_gg *Plot Field Reference Profile (FRP) from exametrika*

Description

This function takes exametrika output as input and generates a Field Reference Profile (FRP) plot using ggplot2. For binary data, it displays correct response rates. For polytomous data, it shows expected scores calculated using the specified statistic.

Usage

```
plotFRP_gg(
  data,
  stat = "mean",
  fields = NULL,
  title = TRUE,
  colors = NULL,
```

```
  linetype = "solid",
  show_legend = TRUE,
  legend_position = "right"
)
```

Arguments

`data`	An object from exametrika: Biclustering, nominalBiclustering, ordinalBiclustering, ratedBiclustering, IRM, LDB, or BINET output.
`stat`	Character. Statistic to use for polytomous data: `"mean"` (default), `"median"`, or `"mode"`. Ignored for binary data.
`fields`	Integer vector specifying which fields to plot. Default is all fields.
`title`	Logical or character. If `TRUE` (default), display automatic title. If `FALSE`, no title. If a character string, use it as the title.
`colors`	Character vector. Colors for each field line. If `NULL` (default), uses the package default palette.
`linetype`	Character or numeric. Line type for all lines. Default is `"solid"`.
`show_legend`	Logical. If `TRUE` (default), display the legend.
`legend_position`	Character. Position of the legend: `"right"` (default), `"top"`, `"bottom"`, `"left"`, `"none"`.

Details

The Field Reference Profile shows how response patterns vary across latent classes/ranks for each field (cluster of items).

For **binary data** (Biclustering, IRM, LDB, BINET):

- Y-axis: Correct Response Rate (0-1)
- Each line represents one field

For **polytomous data** (nominalBiclustering, ordinalBiclustering, ratedBiclustering):

- Y-axis: Expected Score (calculated using `stat` parameter)
- `stat = "mean"`: Weighted average across categories (default)
- `stat = "median"`: Median category value
- `stat = "mode"`: Most probable category

Value

A single ggplot object with all selected fields.

See Also

`plotIRP_gg`, `plotTRP_gg`, `plotCRV_gg`, `plotRRV_gg`

Examples

```
library(exametrika)

# Binary biclustering
result_bin <- Biclustering(J35S515, ncls = 4, nfld = 3)
plot <- plotFRP_gg(result_bin)


# Ordinal biclustering with mean (default)
result_ord <- Biclustering(J35S500, ncls = 4, nfld = 3)
plot_mean <- plotFRP_gg(result_ord, stat = "mean")

# Using mode for polytomous data
plot_mode <- plotFRP_gg(result_ord,
  stat = "mode",
  title = "Field Reference Profile (Mode)",
  colors = c("red", "blue", "green")
)
```

---

plotGraph_gg *Plot DAG (Directed Acyclic Graph) from exametrika*

Description

Creates a ggplot2-based visualization of DAG structures from exametrika Bayesian network models. Supports BNM, LDLRA, LDB, and BINET models. Design based on TDE figures with items as rounded rectangles and fields as diamonds.

Usage

```
plotGraph_gg(
  data,
  layout = "sugiyama",
  direction = "BT",
  node_size = 12,
  label_size = 4,
  arrow_size = 3,
  title = TRUE,
  colors = NULL,
  show_legend = FALSE,
  legend_position = "right"
)
```

Arguments

`data`	An object of class "exametrika" with model type BNM, LDLRA, LDB, or BINET.
`layout`	Character string specifying the layout algorithm. Options include "sugiyama" (default, hierarchical), "fr" (Fruchterman-Reingold), "kk" (Kamada-Kawai), "tree", "stress".
`direction`	Character string for hierarchical layout direction. Controls the direction of arrows and node placement in hierarchical layouts. Only applies when `layout = "sugiyama"` (default). • **"BT"** (default): Bottom-to-Top. Source nodes at bottom, arrows point upward. Use when representing progression or growth (e.g., learning paths). • **"TB"**: Top-to-Bottom. Source nodes at top, arrows point downward. Traditional hierarchical view (e.g., organizational charts). • **"LR"**: Left-to-Right. Source nodes at left, arrows point right. Good for wide displays or process flows. • **"RL"**: Right-to-Left. Source nodes at right, arrows point left. Alternative horizontal layout. For other layouts (e.g., "fr", "kk"), this parameter is ignored.
`node_size`	Numeric value for node size. Default is 12.
`label_size`	Numeric value for label text size inside nodes. Default is 4.
`arrow_size`	Numeric value for arrow size. Default is 3.
`title`	Logical or character. If `TRUE` (default), display an auto-generated title. If `FALSE`, no title. If a character string, use it as a custom title. For LDLRA, a single string gets " - Rank N" appended; a character vector of length equal to the number of ranks assigns each element as the title for the corresponding rank.
`colors`	Character vector. Colors for node types. For BNM/LDLRA: single color for Item nodes. For LDB: single color for Field nodes. For BINET: two colors for Class and Field nodes (positional or named). If `NULL` (default), uses the default node type colors (Item=purple, Field=green, Class=blue).
`show_legend`	Logical. If `TRUE`, display the node type legend. Default is `FALSE`.
`legend_position`	Character. Position of the legend. One of `"right"` (default), `"top"`, `"bottom"`, `"left"`, `"none"`.

Details

Design follows TDE figure specifications:

- BNM: Items shown as purple circles with numbers inside
- LDLRA: Items as circles per rank/class, one plot per rank. Isolated nodes auto-removed
- LDB: Fields shown as green diamonds, one plot per rank. Isolated nodes auto-removed
- BINET: Integrated graph with Class nodes (blue squares) and Field nodes (green diamonds) as intermediates. Field nodes are smaller and placed between the Class nodes they connect

Direction Guidelines:

Choose the direction that best represents your data structure:

- Use **BT (default)** for learning progression, skill development, or upward growth
- Use **TB** for traditional hierarchies or causal flows
- Use **LR/RL** for temporal sequences or wide-format displays

Auto-Scaling:

The function automatically scales node and arrow sizes based on graph complexity:

- 1-5 nodes: 100\
- 6-10 nodes: 80\
- 11-20 nodes: 60\
- 21+ nodes: 50\

Arrows maintain a minimum size of 2mm to ensure visibility.

Value

A list of ggplot objects. For BNM, a single-element list. For LDLRA/LDB, one plot per rank/class. For BINET, the integrated graph.

Note

The `linetype` common option is not applicable to DAG visualization, as edges are drawn as directed arrows rather than standard lines.

Examples

```
library(exametrika)
library(ggExametrika)

# BNM example
DAG <- matrix(c(
  "Item01", "Item02", "Item02", "Item03",
  "Item02", "Item04", "Item03", "Item05",
  "Item04", "Item05"
), ncol = 2, byrow = TRUE)
g <- igraph::graph_from_data_frame(DAG)
result <- BNM(J5S10, g = g)

# Default: Bottom-to-Top (arrows point upward)
plots <- plotGraph_gg(result)
plots[[1]]

# Alternative directions
plotGraph_gg(result, direction = "TB")[[1]] # Top-to-Bottom
plotGraph_gg(result, direction = "LR")[[1]] # Left-to-Right
plotGraph_gg(result, direction = "RL")[[1]] # Right-to-Left
```

```
# Force-directed layout (no direction parameter)
plotGraph_gg(result, layout = "fr")[[1]]

# Custom title
plotGraph_gg(result, title = "My Network Model")[[1]]
```

---

plotICBR_gg *Plot Item Category Boundary Response from exametrika*

Description

This function takes exametrika LRAordinal output as input and generates an Item Category Boundary Response (ICBR) plot using ggplot2. The plot shows cumulative probability curves for each category boundary across latent ranks. For each item, multiple lines represent the probability of scoring at or above each category boundary.

Usage

```
plotICBR_gg(
  data,
  items = NULL,
  title = TRUE,
  colors = NULL,
  linetype = NULL,
  show_legend = TRUE,
  legend_position = "right"
)
```

Arguments

data	An object of class c("exametrika", "LRAordinal") from exametrika::LRA() with dataType = "ordinal".
items	Integer vector specifying which items to plot. Default is all items.
title	Logical or character. If TRUE (default), display item labels as subplot titles. If FALSE, no titles. If a character string, use it as the main plot title.
colors	Character vector. Colors for category boundary lines. If NULL (default), uses the package default palette.
linetype	Character or numeric vector. Line types for category boundaries. If NULL (default), uses automatic line type assignment.
show_legend	Logical. If TRUE, display the legend showing category labels. Default is TRUE.
legend_position	Character. Position of the legend. One of "right" (default), "top", "bottom", "left", "none".

Details

The Item Category Boundary Response (ICBR) visualizes how the probability of reaching each category boundary changes across latent ranks. This is particularly useful for understanding the difficulty of each response category in ordinal items.

For an item with K categories (0, 1, ..., K-1), the ICBR shows:

- Line 1: P(response >= 1 | rank)
- Line 2: P(response >= 2 | rank)
- ...
- Line K-1: P(response >= K-1 | rank)

Ranks are shown in natural order (rank 1, rank 2, ...), matching the base plots of the parent exametrika package.

Value

A single ggplot object with faceted subplots for each item, or a combined plot using gridExtra if faceting is not suitable.

See Also

plotScoreFreq_gg, plotLRD_gg, plotRMP_gg

Examples

```
library(exametrika)

result <- LRA(J5S1000, nrank = 4, dataType = "ordinal")

# Plot first 4 items
plot <- plotICBR_gg(result, items = 1:4)
plot

# Custom colors and title
plot <- plotICBR_gg(result,
  items = 1:6,
  title = "Item Category Boundary Response",
  colors = c("red", "blue", "green", "purple")
)
plot
```

plotICC_gg *Plot Item Characteristic Curves (ICC) from exametrika*

Description

This function takes exametrika IRT output as input and generates Item Characteristic Curves (ICC) using ggplot2. ICC shows the probability of a correct response as a function of ability (theta).

Usage

```
plotICC_gg(
  data,
  items = NULL,
  xvariable = c(-4, 4),
  title = TRUE,
  colors = NULL,
  linetype = "solid",
  show_legend = FALSE,
  legend_position = "right"
)
```

Arguments

data	An object of class `c("exametrika", "IRT")` from `exametrika::IRT()`.
items	Numeric vector specifying which items to plot. If `NULL` (default), all items are plotted.
xvariable	A numeric vector of length 2 specifying the range of the x-axis (ability). Default is `c(-4, 4)`.
title	Logical or character. If `TRUE` (default), display an auto-generated title. If `FALSE`, no title. If a character string, use it as a custom title (only for single-item plots).
colors	Character vector. Color(s) for the curve. If `NULL` (default), a colorblind-friendly palette is used.
linetype	Character or numeric specifying the line type. Default is `"solid"`.
show_legend	Logical. If `TRUE`, display the legend. Default is `FALSE`.
legend_position	Character. Position of the legend. One of `"right"` (default), `"top"`, `"bottom"`, `"left"`, `"none"`.

Details

The function supports 2PL, 3PL, and 4PL IRT models:

- 2PL: slope (a) and location (b) parameters
- 3PL: adds lower asymptote (c) parameter
- 4PL: adds upper asymptote (d) parameter

The ICC is computed using the four-parameter logistic model:

$$P(\theta) = c + \frac{d - c}{1 + \exp(-a(\theta - b))}$$

Value

A list of ggplot objects, one for each item. Each plot shows the Item Characteristic Curve for that item.

See Also

plotIIC_gg, plotTIC_gg

Examples

```
library(exametrika)
result <- IRT(J15S500, model = 3)
plots <- plotICC_gg(result)
plots[[1]] # Show ICC for the first item
combinePlots_gg(plots, selectPlots = 1:6) # Show first 6 items
```

---

plotICC_overlay_gg *Plot All Item Characteristic Curves Overlaid from exametrika*

Description

This function takes exametrika IRT output as input and generates an overlay plot of all Item Characteristic Curves (ICC) using ggplot2. All item curves are displayed on a single graph for easy comparison.

Usage

```
plotICC_overlay_gg(
  data,
  items = NULL,
  xvariable = c(-4, 4),
  title = TRUE,
  colors = NULL,
  linetype = "solid",
  show_legend = TRUE,
  legend_position = "right"
)
```

Arguments

data	An object of class c("exametrika", "IRT") from exametrika::IRT().
items	Numeric vector specifying which items to plot. If NULL (default), all items are plotted.
xvariable	A numeric vector of length 2 specifying the range of the x-axis (ability). Default is c(-4, 4).
title	Logical or character. If TRUE (default), display an auto-generated title. If FALSE, no title. If a character string, use it as a custom title.
colors	Character vector of colors for each item. If NULL (default), a colorblind-friendly palette is used.
linetype	Character or numeric specifying the line type. Can be a single value for all items or a vector for each item. Default is "solid".
show_legend	Logical. If TRUE (default), display the legend.
legend_position	Character. Position of the legend. One of "right" (default), "top", "bottom", "left", "none".

Details

This function is similar to calling plot(IRT_result, type = "IRF", overlay = TRUE) in the exametrika package, but returns a ggplot2 object that can be further customized.

The ICC is computed using the four-parameter logistic model:

$$P(\theta) = c + \frac{d - c}{1 + \exp(-a(\theta - b))}$$

Value

A single ggplot object showing all Item Characteristic Curves overlaid on one graph.

See Also

plotICC_gg, plotIIC_gg

Examples

```
library(exametrika)
result <- IRT(J15S500, model = 3)
plotICC_overlay_gg(result) # All items
plotICC_overlay_gg(result, items = 1:5) # First 5 items only
plotICC_overlay_gg(result, title = "My Custom Title", show_legend = TRUE)
```

plotICRF_gg *Plot Item Category Response Function (ICRF) for GRM from exametrika*

Description

This function takes exametrika GRM output as input and generates Item Category Response Function (ICRF) plots using ggplot2. Each plot shows the probability of selecting each response category as a function of ability (theta).

Usage

```
plotICRF_gg(
  data,
  items = NULL,
  xvariable = c(-4, 4),
  title = TRUE,
  colors = NULL,
  linetype = "solid",
  show_legend = TRUE,
  legend_position = "right"
)
```

Arguments

data	An object of class c("exametrika", "GRM") from exametrika::GRM().
items	Numeric vector specifying which items to plot. If NULL (default), all items are plotted.
xvariable	A numeric vector of length 2 specifying the range of the x-axis (ability). Default is c(-4, 4).
title	Logical or character. If TRUE (default), display an auto-generated title. If FALSE, no title. If a character string, use it as a custom title applied to every item's plot.
colors	Character vector of colors for each category. If NULL (default), a colorblind-friendly palette is used.
linetype	Character or numeric specifying the line type. Default is "solid".
show_legend	Logical. If TRUE (default), display the legend.
legend_position	Character. Position of the legend. One of "right" (default), "top", "bottom", "left", "none".

Details

The Graded Response Model (GRM) estimates the probability of selecting each ordered response category. For an item with K categories, the ICRF shows K curves, one for each category. At any given ability level, the probabilities across all categories sum to 1.

The category probabilities are derived from cumulative probabilities:

$$P_k^*(\theta) = \frac{1}{1 + \exp(-a(\theta - b_k))}$$

$$P_k(\theta) = P_k^*(\theta) - P_{k+1}^*(\theta)$$

Value

A list of ggplot objects, one for each item. Each plot shows the Item Category Response Function for that item.

See Also

plotICC_gg

Examples

```
library(exametrika)

result <- GRM(J5S1000)
plots <- plotICRF_gg(result)
plots[[1]] # Show ICRF for the first item
combinePlots_gg(plots, selectPlots = 1:5)
```

---

plotICRP_gg *Plot Item Category Reference Profile from exametrika*

Description

This function takes exametrika LRAordinal or LRArated output as input and generates an Item Category Reference Profile (ICRP) plot using ggplot2. The plot shows response probability curves for each category across latent ranks. For each item, multiple lines represent the probability of selecting each response category.

Usage

```
plotICRP_gg(
  data,
  items = NULL,
  title = TRUE,
  colors = NULL,
  linetype = NULL,
  show_legend = TRUE,
  legend_position = "right"
)
```

Arguments

data	An object of class c("exametrika", "LRAordinal") or c("exametrika", "LRArated") from exametrika::LRA().
items	Integer vector specifying which items to plot. Default is all items.
title	Logical or character. If TRUE (default), display item labels as subplot titles. If FALSE, no titles. If a character string, use it as the main plot title.
colors	Character vector. Colors for category lines. If NULL (default), uses the package default palette.
linetype	Character or numeric vector. Line types for categories. If NULL (default), uses automatic line type assignment.
show_legend	Logical. If TRUE, display the legend showing category labels. Default is TRUE.
legend_position	Character. Position of the legend. One of "right" (default), "top", "bottom", "left", "none".

Details

The Item Category Reference Profile (ICRP) visualizes how the response probability for each category changes across latent ranks. Unlike ICBR which shows cumulative probabilities, ICRP shows the raw probability of selecting each specific category.

For an item with K categories (0, 1, ..., K-1), the ICRP shows:

- Line for Cat0: P(response = 0 | rank)
- Line for Cat1: P(response = 1 | rank)
- ...
- Line for CatK: P(response = K | rank)

The sum of all probabilities at each rank equals 1.0, as they represent mutually exclusive response options.

Ranks are shown in natural order (rank 1, rank 2, ...), matching the base plots of the parent exametrika package.

Value

A single ggplot object with faceted subplots for each item.

See Also

plotICBR_gg, plotScoreFreq_gg, plotLRD_gg

Examples

```
library(exametrika)

result <- LRA(J5S1000, nrank = 4, dataType = "ordinal")

# Plot first 4 items
```

```
plot <- plotICRP_gg(result, items = 1:4)
plot

# Custom colors and title
plot <- plotICRP_gg(result,
  items = 1:6,
  title = "Item Category Reference Profile",
  colors = c("red", "blue", "green", "purple")
)
plot
```

---

plotIIC_gg *Plot Item Information Curves (IIC) from exametrika*

Description

This function takes exametrika IRT or GRM output as input and generates Item Information Curves (IIC) using ggplot2. IIC shows how much information each item provides at different ability levels.

Usage

```
plotIIC_gg(
  data,
  items = NULL,
  xvariable = c(-4, 4),
  title = TRUE,
  colors = NULL,
  linetype = "solid",
  show_legend = FALSE,
  legend_position = "right"
)
```

Arguments

data	An object of class `c("exametrika", "IRT")` from `exametrika::IRT()` or `c("exametrika", "GRM")` from `exametrika::GRM()`.
items	Numeric vector specifying which items to plot. If `NULL` (default), all items are plotted.
xvariable	A numeric vector of length 2 specifying the range of the x-axis (ability). Default is `c(-4, 4)`.
title	Logical or character. If `TRUE` (default), display an auto-generated title. If `FALSE`, no title. If a character string, use it as a custom title (only for single-item plots).
colors	Character vector of colors. For IRT, single color for the curve. If `NULL` (default), a colorblind-friendly palette is used.
linetype	Character or numeric specifying the line type. Default is `"solid"`.

show_legend Logical. If TRUE, display the legend (mainly for GRM). Default is FALSE.

legend_position Character. Position of the legend. One of "right" (default), "top", "bottom", "left", "none".

Details

The Item Information Function indicates how precisely an item measures ability at each point on the theta scale. Items with higher discrimination parameters provide more information. The peak of the information curve occurs near the item's difficulty parameter.

For IRT models (2PL, 3PL, 4PL), the function uses the standard IRT information function. For GRM, the information is computed as:

$$I(\theta) = a^2 \sum_{k=1}^{K-1} P_k^*(\theta)[1 - P_k^*(\theta)]$$

Value

A list of ggplot objects, one for each item. Each plot shows the Item Information Curve for that item.

See Also

plotICC_gg, plotTIC_gg, plotICRF_gg

Examples

```
library(exametrika)

# IRT example
result_irt <- IRT(J15S500, model = 3)
plots_irt <- plotIIC_gg(result_irt)
plots_irt[[1]] # Show IIC for the first item

# GRM example
result_grm <- GRM(J5S1000)
plots_grm <- plotIIC_gg(result_grm)
plots_grm[[1]] # Show IIC for the first item
```

---

plotIIC_overlay_gg *Plot All Item Information Curves Overlaid from exametrika*

Description

This function takes exametrika IRT or GRM output as input and generates an overlay plot of all Item Information Curves (IIC) using ggplot2. All item curves are displayed on a single graph for easy comparison.

Usage

```
plotIIC_overlay_gg(
  data,
  items = NULL,
  xvariable = c(-4, 4),
  title = TRUE,
  colors = NULL,
  linetype = "solid",
  show_legend = TRUE,
  legend_position = "right"
)
```

Arguments

data	An object of class c("exametrika", "IRT") from exametrika::IRT() or c("exametrika", "GRM") from exametrika::GRM().
items	Numeric vector specifying which items to plot. If NULL (default), all items are plotted.
xvariable	A numeric vector of length 2 specifying the range of the x-axis (ability). Default is c(-4, 4).
title	Logical or character. If TRUE (default), display an auto-generated title. If FALSE, no title. If a character string, use it as a custom title.
colors	Character vector of colors for each item. If NULL (default), a colorblind-friendly palette is used.
linetype	Character or numeric specifying the line type. Can be a single value for all items or a vector for each item. Default is "solid".
show_legend	Logical. If TRUE (default), display the legend.
legend_position	Character. Position of the legend. One of "right" (default), "top", "bottom", "left", "none".

Details

This function is similar to calling plot(IRT_result, type = "IIF", overlay = TRUE) or plot(GRM_result, type = "IIF", overlay = TRUE) in the exametrika package, but returns a ggplot2 object that can be further customized.

The Item Information Function indicates how precisely an item measures ability at each point on the theta scale. Items with higher discrimination parameters provide more information. The peak of the information curve occurs near the item's difficulty parameter.

Value

A single ggplot object showing all Item Information Curves overlaid on one graph.

See Also

plotIIC_gg, plotICC_gg

Examples

```
library(exametrika)

# IRT example
result_irt <- IRT(J15S500, model = 3)
plotIIC_overlay_gg(result_irt) # All items
plotIIC_overlay_gg(result_irt, items = 1:5) # First 5 items only

# GRM example
result_grm <- GRM(J5S1000)
plotIIC_overlay_gg(result_grm, show_legend = TRUE)
```

---

plotIRP_gg *Plot Item Reference Profile (IRP) from exametrika*

Description

This function takes exametrika output as input and generates Item Reference Profile (IRP) plots using ggplot2. IRP shows the probability of a correct response for each item at each latent class or rank level.

Usage

```
plotIRP_gg(
  data,
  title = TRUE,
  colors = NULL,
  linetype = "dashed",
  show_legend = FALSE,
  legend_position = "right"
)
```

Arguments

data	An object of class c("exametrika", "LCA"), c("exametrika", "LRA"), or c("exametrika", "LDLRA").
title	Logical or character. If TRUE (default), display an auto-generated title. If FALSE, no title. If a character string, use it as a custom title (only for single-item plots).
colors	Character vector. Color(s) for points and lines. If NULL (default), a colorblind-friendly palette is used.
linetype	Character or numeric specifying the line type. Default is "dashed".
show_legend	Logical. If TRUE, display the legend. Default is FALSE.
legend_position	Character. Position of the legend. One of "right" (default), "top", "bottom", "left", "none".

Details

The Item Reference Profile visualizes how item difficulty varies across latent classes (LCA) or ranks (LRA, LDLRA). Items with monotonically increasing profiles indicate good discrimination between classes/ranks.

Value

A list of ggplot objects, one for each item. Each plot shows the correct response rate across latent classes or ranks.

See Also

plotFRP_gg, plotTRP_gg

Examples

```
library(exametrika)
result <- LRA(J15S500, nrank = 5)
plots <- plotIRP_gg(result)
plots[[1]] # Show IRP for the first item
```

---

plotLCD_gg *Plot Latent Class Distribution (LCD) from exametrika*

Description

This function takes exametrika output as input and generates a Latent Class Distribution (LCD) plot using ggplot2. LCD shows the number of students in each latent class and the class membership distribution.

Usage

```
plotLCD_gg(
  data,
  Num_Students = TRUE,
  title = TRUE,
  colors = NULL,
  linetype = "dashed",
  show_legend = FALSE,
  legend_position = "right"
)
```

Arguments

data	An object of class c("exametrika", "LCA") or c("exametrika", "BINET"). If LRA or Biclustering output is provided, LRD will be plotted instead with a warning.
Num_Students	Logical. If TRUE (default), display the number of students on each bar.
title	Logical or character. If TRUE (default), display the auto-generated title. If FALSE, no title. If a character string, use it as a custom title.
colors	Character vector of length 2. First element is the bar fill color, second is the line/point color. If NULL (default), uses gray for bars and black for line/points.
linetype	Character or numeric specifying the line type for the frequency line. Default is "dashed".
show_legend	Logical. If TRUE, display the legend. Default is FALSE.
legend_position	Character. Position of the legend. One of "right" (default), "top", "bottom", "left", "none".

Details

The Latent Class Distribution shows how students are distributed across latent classes. The bar graph shows the number of students assigned to each class, and the line graph shows the cumulative class membership distribution.

Value

A single ggplot object with dual y-axes showing both the student count and membership frequency.

See Also

plotLRD_gg, plotTRP_gg

Examples

```
library(exametrika)
result <- LCA(J15S500, ncls = 5)
plot <- plotLCD_gg(result)
plot
```

---

plotLDPSR_gg *Plot LDPSR (Local Dependence Passing Student Rate) from exametrika*

Description

This function takes exametrika BINET output as input and generates LDPSR (Local Dependence Passing Student Rate) plots using ggplot2. LDPSR visualizes the correct response rate for items within a field, comparing the parent class and child class at each DAG edge.

Each plot corresponds to one edge in the BINET DAG structure, showing how item-level performance differs between the parent class (lower ability) and the child class (higher ability) connected through a specific field.

Usage

```
plotLDPSR_gg(
  data,
  title = TRUE,
  colors = NULL,
  linetype = "solid",
  show_legend = TRUE,
  legend_position = "right"
)
```

Arguments

data	An object of class c("exametrika", "BINET").
title	Logical or character. If TRUE (default), display an auto-generated title showing the field and class transition. If FALSE, no title. If a character string, use it as a custom title prefix.
colors	Character vector of length 2. Colors for the parent class line (colors[1]) and the child class line (colors[2]). If NULL (default), uses the package default palette.
linetype	Character or numeric specifying the line type. Default is "solid".
show_legend	Logical. If TRUE (default), display the legend identifying parent and child class lines.
legend_position	Character. Position of the legend. One of "right" (default), "top", "bottom", "left", "none".

Details

In BINET (Bicluster Network Model), latent classes are connected by a directed acyclic graph (DAG), where edges pass through specific fields. LDPSR shows the item-level passing rate for each such edge: the parent class line represents the correct response rate of students in the originating class, and the child class line shows the rate for students in the destination class.

The gap between the two lines indicates how much students improve on each item when transitioning from the parent class to the child class via the specified field.

Value

A list of ggplot objects, one for each DAG edge. Each plot shows the correct response rate profiles for the parent class and child class on items belonging to the connecting field.

See Also

plotFRP_gg, plotArray_gg, plotGraph_gg, combinePlots_gg

Examples

```
library(exametrika)
# BINET requires field configuration and edge structure
conf <- c(
  1, 5, 5, 5, 9, 9, 6, 6, 6, 6, 2, 7, 7, 11, 11, 7, 7,
  12, 12, 12, 2, 2, 3, 3, 4, 4, 4, 8, 8, 12, 1, 1, 6, 10, 10
)
edges_data <- data.frame(
  "From Class (Parent) >>>" = c(1, 2, 3, 4, 5, 7, 2, 4, 6, 8, 10, 6, 6, 11, 8, 9, 12),
  ">>> To Class (Child)" = c(2, 4, 5, 5, 6, 11, 3, 7, 9, 12, 12, 10, 8, 12, 12, 11, 13),
  "At Field (Locus)" = c(1, 2, 2, 3, 4, 4, 5, 5, 5, 5, 5, 7, 8, 8, 9, 9, 12)
)
tmp_file <- tempfile(fileext = ".csv")
write.csv(edges_data, file = tmp_file, row.names = FALSE)
result <- BINET(J35S515, ncls = 13, nfld = 12, conf = conf, adj_file = tmp_file)
unlink(tmp_file)
plots <- plotLDPSR_gg(result)
plots[[1]] # Show LDPSR for the first edge
```

---

plotLRD_gg *Plot Latent Rank Distribution (LRD) from exametrika*

Description

This function takes exametrika output as input and generates a Latent Rank Distribution (LRD) plot using ggplot2. LRD shows the number of students in each latent rank and the rank membership distribution.

Usage

```
plotLRD_gg(
  data,
  Num_Students = TRUE,
  title = TRUE,
  colors = NULL,
  linetype = "dashed",
  show_legend = FALSE,
  legend_position = "right"
)
```

Arguments

data	An object of class c("exametrika", "LRA"), c("exametrika", "Biclustering"), c("exametrika", "LDLRA"), or c("exametrika", "LDB"). If LCA or BINET output is provided, LCD will be plotted instead with a warning.
Num_Students	Logical. If TRUE (default), display the number of students on each bar.
title	Logical or character. If TRUE (default), display the auto-generated title. If FALSE, no title. If a character string, use it as a custom title.
colors	Character vector of length 2. First element is the bar fill color, second is the line/point color. If NULL (default), uses gray for bars and black for line/points.
linetype	Character or numeric specifying the line type for the frequency line. Default is "dashed".
show_legend	Logical. If TRUE, display the legend. Default is FALSE.
legend_position	Character. Position of the legend. One of "right" (default), "top", "bottom", "left", "none".

Details

The Latent Rank Distribution shows how students are distributed across latent ranks. Unlike latent classes, ranks have an ordinal interpretation where higher ranks indicate higher ability levels.

Value

A single ggplot object with dual y-axes showing both the student count and membership frequency.

See Also

plotLCD_gg, plotTRP_gg

Examples

```
library(exametrika)
result <- LRA(J15S500, nrank = 5)
plot <- plotLRD_gg(result)
plot
```

---

plotRMP_gg *Plot Rank Membership Profile (RMP) from exametrika*

Description

This function takes exametrika output as input and generates Rank Membership Profile (RMP) plots using ggplot2. RMP shows each student's membership probability across all latent ranks.

Usage

```
plotRMP_gg(
  data,
  title = TRUE,
  colors = NULL,
  linetype = "dashed",
  show_legend = FALSE,
  legend_position = "right"
)
```

Arguments

data	An object of class `c("exametrika", "LRA")`, `c("exametrika", "Biclustering")`, `c("exametrika", "LDLRA")`, or `c("exametrika", "LDB")`. If LCA or BINET output is provided, CMP will be plotted instead with a warning.
title	Logical or character. If `TRUE` (default), display an auto-generated title. If `FALSE`, no title. If a character string, use it as a custom title (only for single-student plots).
colors	Character vector. Color(s) for points and lines. If `NULL` (default), a colorblind-friendly palette is used.
linetype	Character or numeric specifying the line type. Default is `"dashed"`.
show_legend	Logical. If `TRUE`, display the legend. Default is `FALSE`.
legend_position	Character. Position of the legend. One of `"right"` (default), `"top"`, `"bottom"`, `"left"`, `"none"`.

Details

The Rank Membership Profile visualizes how strongly each student belongs to each latent rank. Unlike class membership, rank membership has an ordinal interpretation. Students with unimodal profiles centered on a single rank are well-classified.

Value

A list of ggplot objects, one for each student. Each plot shows the membership probability across all latent ranks.

See Also

plotCMP_gg, plotLRD_gg

Examples

```
library(exametrika)

result <- LRA(J15S500, nrank = 5)
plots <- plotRMP_gg(result)
plots[[1]] # Show RMP for the first student
```

plotRRV_gg *Plot Rank Reference Vector (RRV) from exametrika*

Description

This function takes exametrika Biclustering output as input and generates a Rank Reference Vector (RRV) plot using ggplot2. RRV shows how each latent rank performs across fields, with one line per rank.

Supports both binary (2-valued) and polytomous (multi-valued) biclustering models. For polytomous data, the `stat` parameter controls how expected scores are calculated from category probabilities.

Usage

```
plotRRV_gg(
  data,
  title = TRUE,
  colors = NULL,
  linetype = "solid",
  show_legend = TRUE,
  legend_position = "right",
  stat = "mean",
  show_labels = FALSE
)
```

Arguments

`data`	An object of class `c("exametrika", "Biclustering")` from `exametrika::Biclustering()`.
`title`	Logical or character. If `TRUE` (default), display an auto-generated title. If `FALSE`, no title. If a character string, use it as a custom title.
`colors`	Character vector of colors for each rank. If `NULL` (default), a colorblind-friendly palette is used.
`linetype`	Character or numeric scalar specifying the line type applied to all lines. Default is `"solid"`.
`show_legend`	Logical. If `TRUE` (default), display the legend.
`legend_position`	Character. Position of the legend. One of `"right"` (default), `"top"`, `"bottom"`, `"left"`, `"none"`.
`stat`	Character. Statistic for polytomous data: `"mean"` (default), `"median"`, or `"mode"`. For binary data, this parameter is ignored. • `"mean"`: Expected score (sum of category x probability) • `"median"`: Median category (cumulative probability >= 0.5)

- "mode": Most probable category

show_labels Logical. If TRUE, displays rank labels on each point using ggrepel to avoid overlaps. Defaults to FALSE since the legend already provides rank information.

Details

The Rank Reference Vector is the transpose of the Field Reference Profile (FRP). While FRP shows one plot per field, RRV displays all ranks in a single plot with fields on the x-axis. Each line represents a latent rank, showing its performance pattern across fields.

Binary Data (2 categories):

- Y-axis shows "Correct Response Rate" (0.0 to 1.0)
- Values represent the probability of correct response

Polytomous Data (3+ categories):

- Y-axis shows "Expected Score" (1 to max category)
- Values are calculated using the stat parameter
- Higher scores indicate better performance

RRV is used when latent ranks are ordinal (ordered). For unordered latent classes, use plotCRV_gg instead.

Value

A single ggplot object showing the Rank Reference Vector.

See Also

plotCRV_gg, plotFRP_gg, plotScoreField_gg

Examples

```
# Binary biclustering
library(exametrika)
result <- Biclustering(J15S500, nfld = 3, ncls = 5)
plotRRV_gg(result)


# Ordinal biclustering (polytomous)
data(J35S500)
result_ord <- Biclustering(J35S500, ncls = 5, nfld = 5, method = "R")
plotRRV_gg(result_ord) # Default: mean
plotRRV_gg(result_ord, stat = "median")
plotRRV_gg(result_ord, stat = "mode")

# Custom styling
plotRRV_gg(result_ord,
  title = "Rank Performance Across Fields",
  colors = c("#1b9e77", "#d95f02", "#7570b3", "#e7298a", "#66a61e"),
  legend_position = "bottom"
```

```
)
```

`plotScoreField_gg` *Plot Score-Field Heatmap (ScoreField) for Polytomous Biclustering*

Description

Creates a heatmap visualization showing the expected scores for each field across latent classes or ranks in polytomous biclustering models (nominalBiclustering, ordinalBiclustering, ratedBiclustering).

The expected score for each field-class/rank combination is calculated as the sum of (category x probability) across all categories.

Usage

```
plotScoreField_gg(
  data,
  title = TRUE,
  colors = NULL,
  show_legend = TRUE,
  legend_position = "right",
  show_values = TRUE,
  text_size = 3.5
)
```

Arguments

`data`	An exametrika model object from nominalBiclustering, ordinalBiclustering, or ratedBiclustering.
`title`	Logical or character. If TRUE (default), displays an automatic title. If FALSE, no title is displayed. If a character string, uses it as the title.
`colors`	Character vector of colors for the gradient, or NULL (default) to use a colorblind-friendly yellow-orange-red palette. If provided, should be a vector of at least 2 colors for the gradient.
`show_legend`	Logical. If TRUE (default), displays the color scale legend.
`legend_position`	Character. Position of the legend: "right" (default), "left", "top", "bottom", or "none".
`show_values`	Logical. If TRUE (default), displays the expected score values as text on each cell of the heatmap.
`text_size`	Numeric. Size of the text labels showing values (default: 3.5). Only used when show_values = TRUE.

Details

This function is designed for polytomous (multi-valued) biclustering models where items have more than two response categories. It displays the expected score (weighted sum of category probabilities) for each field across all latent classes or ranks.

The heatmap uses:

- **Y-axis**: Fields (F1, F2, ...)
- **X-axis**: Latent Classes (C1, C2, ...) or Ranks (R1, R2, ...)
- **Color**: Expected score magnitude (lighter = lower, darker/redder = higher)
- **Text**: Actual expected score values (optional, controlled by show_values)

Higher expected scores indicate that students in that class/rank are expected to achieve higher scores in that field.

Value

A ggplot2 object representing the Score-Field heatmap.

See Also

plotFCRP_gg for field category response profiles, plotFCBR_gg for field cumulative boundary reference, plotArray_gg for array plots, plotScoreRank_gg for score-rank heatmaps

Examples

```
library(exametrika)
# Ordinal Biclustering example
result <- Biclustering(J35S500, ncls = 5, nfld = 5, method = "R")

# Basic plot
plotScoreField_gg(result)

# Custom title and hide values
plotScoreField_gg(result,
  title = "Expected Scores by Field and Rank",
  show_values = FALSE
)

# Custom color gradient
plotScoreField_gg(result,
  colors = c("white", "blue", "darkblue"),
  legend_position = "bottom"
)

# Nominal Biclustering example
data(J20S600)
result_nom <- Biclustering(J20S600, ncls = 5, nfld = 4)
plotScoreField_gg(result_nom)
```

plotScoreFreq_gg *Plot Score Frequency Distribution from exametrika*

Description

This function takes exametrika LRAordinal or LRArated output as input and generates a Score Frequency Distribution plot using ggplot2. The plot shows the density distribution of scores with vertical dashed lines indicating the thresholds between adjacent latent ranks.

Usage

```
plotScoreFreq_gg(
  data,
  title = TRUE,
  colors = NULL,
  linetype = c("solid", "dashed"),
  show_legend = FALSE,
  legend_position = "right"
)
```

Arguments

data	An object of class `c("exametrika", "LRAordinal")` or `c("exametrika", "LRArated")` from `exametrika::LRA()`.
title	Logical or character. If `TRUE` (default), display an auto-generated title. If `FALSE`, no title. If a character string, use it as a custom title.
colors	Character vector of length 2. First element is the color for the density curve, second is the color for the threshold lines. If `NULL` (default), a colorblind-friendly palette is used.
linetype	Character or numeric vector of length 2. First element is the line type for the density curve, second for the threshold lines. Default is `c("solid", "dashed")`.
show_legend	Logical. If `TRUE`, display the legend. Default is `FALSE`.
legend_position	Character. Position of the legend. One of `"right"` (default), `"top"`, `"bottom"`, `"left"`, `"none"`.

Details

The Score Frequency Distribution visualizes how student scores are distributed and where the boundaries between latent ranks fall. The threshold between rank i and rank $i + 1$ is calculated as the midpoint between the maximum score in rank i and the minimum score in rank $i + 1$.

This plot is useful for understanding how latent ranks correspond to observed score ranges.

Value

A single ggplot object showing the score frequency distribution with rank threshold lines.

See Also

plotLRD_gg, plotRMP_gg

Examples

```
library(exametrika)
result <- LRA(J5S1000, nrank = 4, dataType = "ordinal")
plot <- plotScoreFreq_gg(result)
plot
```

---

plotScoreRank_gg *Plot Score-Rank Heatmap from exametrika*

Description

This function takes exametrika LRAordinal or LRArated output as input and generates a Score-Rank heatmap using ggplot2. The heatmap shows the distribution of students across scores (y-axis) and latent ranks (x-axis), with darker cells indicating higher frequency.

Usage

```
plotScoreRank_gg(
  data,
  title = TRUE,
  colors = NULL,
  show_legend = TRUE,
  legend_position = "right"
)
```

Arguments

data	An object of class c("exametrika", "LRAordinal") or c("exametrika", "LRArated") from exametrika::LRA().
title	Logical or character. If TRUE (default), display an auto-generated title. If FALSE, no title. If a character string, use it as a custom title.
colors	Character vector of length 2. Low and high colors for the gradient. If NULL (default), white-to-black grayscale is used (matching exametrika's original output).
show_legend	Logical. If TRUE (default), display the color scale legend.
legend_position	Character. Position of the legend. One of "right" (default), "top", "bottom", "left", "none".

Details

The Score-Rank heatmap visualizes the joint distribution of observed scores and estimated latent ranks. Each cell represents the number of students with a given score assigned to a given rank. Darker cells indicate higher frequency.

The data is taken from `data$ScoreRank`, a matrix where rows represent scores and columns represent latent ranks.

Value

A single ggplot object showing the Score-Rank heatmap.

See Also

`plotScoreFreq_gg`, `plotLRD_gg`

Examples

```
library(exametrika)
result <- LRA(J5S1000, nrank = 4, dataType = "ordinal")
plot <- plotScoreRank_gg(result)
plot
```

---

plotTIC_gg *Plot Test Information Curve (TIC) from exametrika*

Description

This function takes exametrika IRT or GRM output as input and generates a Test Information Curve (TIC) using ggplot2. TIC shows the total information provided by all items at each ability level.

Usage

```
plotTIC_gg(
  data,
  xvariable = c(-4, 4),
  title = TRUE,
  colors = NULL,
  linetype = "solid",
  show_legend = FALSE,
  legend_position = "right"
)
```

Arguments

data	An object of class `c("exametrika", "IRT")` from `exametrika::IRT()` or `c("exametrika", "GRM")` from `exametrika::GRM()`.
xvariable	A numeric vector of length 2 specifying the range of the x-axis (ability). Default is `c(-4, 4)`.
title	Logical or character. If `TRUE` (default), display an auto-generated title. If `FALSE`, no title. If a character string, use it as a custom title.
colors	Character vector. Color(s) for the curve. If `NULL` (default), a colorblind-friendly palette is used.
linetype	Character or numeric specifying the line type. Default is `"solid"`.
show_legend	Logical. If `TRUE`, display the legend. Default is `FALSE`.
legend_position	Character. Position of the legend. One of `"right"` (default), `"top"`, `"bottom"`, `"left"`, `"none"`.

Details

The Test Information Function is the sum of all Item Information Functions. It indicates how precisely the test as a whole measures ability at each point on the theta scale. The reciprocal of test information is approximately equal to the squared standard error of measurement.

The function supports IRT models (2PL, 3PL, 4PL) and GRM.

Value

A single ggplot object showing the Test Information Curve.

See Also

plotICC_gg, plotIIC_gg, plotICRF_gg

Examples

```
library(exametrika)

# IRT example
result_irt <- IRT(J15S500, model = 3)
plot_irt <- plotTIC_gg(result_irt)
plot_irt # Show Test Information Curve

# GRM example
result_grm <- GRM(J5S1000)
plot_grm <- plotTIC_gg(result_grm)
plot_grm # Show Test Information Curve
```

plotTRF_gg *Plot Test Response Function (TRF) from exametrika*

Description

This function takes exametrika IRT output as input and generates a Test Response Function (TRF) using ggplot2. TRF shows the expected total score as a function of ability (theta).

Usage

```
plotTRF_gg(
  data,
  xvariable = c(-4, 4),
  title = TRUE,
  colors = NULL,
  linetype = "solid",
  show_legend = FALSE,
  legend_position = "right"
)
```

Arguments

data	An object of class c("exametrika", "IRT") from exametrika::IRT().
xvariable	A numeric vector of length 2 specifying the range of the x-axis (ability). Default is c(-4, 4).
title	Logical or character. If TRUE (default), display an auto-generated title. If FALSE, no title. If a character string, use it as a custom title.
colors	Character vector. Color(s) for the curve. If NULL (default), a colorblind-friendly palette is used.
linetype	Character or numeric specifying the line type. Default is "solid".
show_legend	Logical. If TRUE, display the legend. Default is FALSE.
legend_position	Character. Position of the legend. One of "right" (default), "top", "bottom", "left", "none".

Details

The Test Response Function is the sum of all Item Characteristic Curves (ICCs). At each ability level, TRF represents the expected number of correct responses across all items. For a test with J items:

$$TRF(\theta) = \sum_{j=1}^{J} P_j(\theta)$$

The y-axis ranges from 0 to the total number of items. The function supports 2PL, 3PL, and 4PL IRT models.

Value

A single ggplot object showing the Test Response Function.

See Also

plotICC_gg, plotTIC_gg

Examples

```
library(exametrika)
result <- IRT(J15S500, model = 3)
plot <- plotTRF_gg(result)
plot # Show Test Response Function
```

---

plotTRP_gg *Plot Test Reference Profile (TRP) from exametrika*

Description

This function takes exametrika output as input and generates a Test Reference Profile (TRP) plot using ggplot2. TRP shows the number of students in each latent class/rank (bar graph) and the expected test score for each class/rank (line graph).

Usage

```
plotTRP_gg(
  data,
  Num_Students = TRUE,
  title = TRUE,
  colors = NULL,
  linetype = "dashed",
  show_legend = FALSE,
  legend_position = "right"
)
```

Arguments

data	An object from exametrika: LCA, LRA, Biclustering, nominalBiclustering, ordinalBiclustering, ratedBiclustering, IRM, LDLRA, LDB, or BINET output.
Num_Students	Logical. If TRUE (default), display the number of students on each bar.
title	Logical or character. If TRUE (default), display the auto-generated title. If FALSE, no title. If a character string, use it as a custom title.
colors	Character vector of length 2. First element is the bar fill color, second is the line/point color. If NULL (default), uses gray for bars and black for line/points.

linetype	Character or numeric specifying the line type for the expected score line. Default is "dashed".
show_legend	Logical. If TRUE, display the legend. Default is FALSE.
legend_position	Character. Position of the legend. One of "right" (default), "top", "bottom", "left", "none".

Details

The Test Reference Profile provides an overview of the latent structure. The bar graph shows how students are distributed across classes/ranks, while the line graph shows the expected test score for each class/rank. In well-fitted models, expected scores should increase monotonically with class/rank number.

Value

A single ggplot object with dual y-axes showing both the student distribution and expected scores.

See Also

plotIRP_gg, plotLCD_gg, plotLRD_gg

Examples

```
library(exametrika)
result <- LRA(J15S500, nrank = 5)
plot <- plotTRP_gg(result)
plot
```

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