Package 'lsasim'

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Title Functions to Facilitate the Simulation of Large Scale Assessment Data

Version 2.1.4

BugReports https://github.com/tmatta/lsasim/issues

Description Provides functions to simulate data from large-scale educational assessments, including background questionnaire data and cognitive item responses that adhere to a multiple-matrix sampled design. The theoretical foundation can be found on Matta, T.H., Rutkowski, L., Rutkowski, D. et al. (2018) <doi:10.1186/s40536-018-0068-8>.

Imports mvtnorm, cli, methods, polycor

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Author Tyler Matta [aut],
Leslie Rutkowski [aut],
David Rutkowski [aut],
Yuan-Ling Linda Liaw [aut],
Kondwani Kajera Mughogho [ctb],
Waldir Leoncio [aut, cre],
Sinan Yavuz [ctb],
Paul Bailey [ctb]

Maintainer Waldir Leoncio <w.l.netto@medisin.uio.no>

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`.onAttach` *Prints welcome message on package load*

Description

Prints "This is lsasim <version number>" on package load

Usage

```
.onAttach(libname, pkgname)
```

Arguments

`libname`	no idea, but will break devtools::document() if removed
`pkgname`	name of the package

Note

This function was adapted from the lavaan package, so credit for it goes to lavaan's creator, Yves Rosseel

References

Yves Rosseel (2012). lavaan: An R Package for Structural Equation Modeling. Journal of Statistical Software, 48(2), 1-36. URL http://www.jstatsoft.org/v48/i02/.

`anova.lsasimcluster` *Generate an ANOVA table for LSASIM clusters*

Description

Prints Analysis of Variance table for ‘cluster_gen‘ output.

Usage

```
## S3 method for class 'lsasimcluster'
anova(object, print = TRUE, calc.se = TRUE, ...)
```

Arguments

`object`	list output of ‘cluster_gen‘
`print`	if ‘TRUE‘, output will be a list containing estimators; if ‘FALSE‘ (default), output are formatted tables of this information
`calc.se`	if ‘TRUE‘, will try to calculate the standard error of the intreaclass correlation
`...`	additional objects of the same type (see ‘help("anova")‘ for details)

Value

Printed ANOVA table or list of parameters

Note

If the rhos for different levels are varied in scale, the generated rho will be less accurate.

References

Snijders, T. A. B., & Bosker, R. J. (1999). Multilevel Analysis. Sage Publications.

`attribute_cluster_labels`
Attribute Labels in Hierarchical Structure

Description

Attributes cluster and respondent labels in the context of ‘cluster_gen‘.

Usage

```
attribute_cluster_labels(n)
```

Arguments

n	numeric vector or list

Value

list containing appropriate labels for the clusters and their respondents

See Also

cluster_gen

---

beta_gen *Generate regression coefficients*

Description

Uses the output from questionnaire_gen to generate linear regression coefficients.

Usage

```
beta_gen(
  data,
  MC = FALSE,
  MC_replications = 100,
  CI = c(0.005, 0.995),
  output_cov = FALSE,
  rename_to_q = FALSE,
  verbose = TRUE
)
```

Arguments

data	output from the questionnaire_gen function with full_output = TRUE and theta = TRUE
MC	if TRUE, performs Monte Carlo simulation to estimate regression coefficients
MC_replications	for MC = TRUE, this represents the number of Monte Carlo subsamples calculated
CI	confidence interval for Monte Carlo simulations
output_cov	if TRUE, will also output the covariance matrix of YXW
rename_to_q	if TRUE, renames the variables from "x" and "w" to "q"
verbose	if 'FALSE', output messages will be suppressed (useful for simulations). Defaults to 'TRUE'

Details

This function was primarily conceived as a subfunction of `questionnaire_gen`, when `family = "gaussian"`, `theta = TRUE`, and `full_output = TRUE`. However, it can also be directly called by the user so they can perform further analysis.

This function primarily calculates the true regression coefficients (β) for the linear influence of the background questionnaire variables in θ. From a statistical perspective, this relationship can be modeled as follows, where $E(\theta|\boldsymbol{X}, \boldsymbol{W})$ is the expectation of θ given $\boldsymbol{X} = \{X_1, \ldots, X_P\}$ and $\boldsymbol{W} = \{W_1, \ldots, W_Q\}$:

$$E(\theta|\boldsymbol{X}, \boldsymbol{W}) = \beta_0 + \sum_{p=1}^{P} \beta_p X_p + \sum_{q=1}^{Q} \beta_{P+q} W_q$$

The regression coefficients are calculated using the true covariance matrix either provided by the user upon calling of `questionnaire_gen` or randomly generated by that function if none was provided. In any case, that matrix is not sample-dependent, though it should be similar to the one observed in the generated data (especially for larger samples). One convenient way to check for this similarity is by running the function with `MC = TRUE`, which will generate a numeric estimate; the `MC_replications` argument can be then increased to improve the estimates at a often-noticeable cost in processing time. If `MC = FALSE`, the `MC_replications` will have no effect on the results. In any case, each subsample will always have the same size as the original sample.

If the background questionnaire contains categorical variables (W), the original covariance matrix cannot be used because it contains the covariances involving $Z\ N(0, 1)$, which is the random variable that gets categorized into W. The case where W is always binomial is trivial, but if at least one W has more than two categories, the structure of the covariance matrix changes drastically. In this case, this function recalculates all covariances between θ, X and each category of W using some auxiliary internal functions which rely on the appropriate distribution (either multivariate normal or truncated normal). To avoid multicollinearity, the first categories of each W are dropped before the regression coefficients are calculated.

Value

By default, this function will output a vector of the regression coefficients, including intercept. If `MC == TRUE`, the output will instead be a matrix comparing the true regression coefficients obtained from the covariance matrix with expected values obtained from a Monte Carlo simulation, complete with 99% confidence interval.

If `output_cov = TRUE`, the output will be a list with two elements: the first one, `betas`, will contain the same output described in the previous paragraph. The second one, called `vcov_YXW`, contains the covariance matrix of the regression coefficients.

Note

The equation in this page is best formatted in PDF. We recommend issuing ‘help("beta_gen", help_type = "PDF")‘ in your terminal and opening the ‘beta_gen.pdf‘ file generated in your working directly. You may also set ‘help_type = "HTML"‘, but the equations will have degraded formatting.

See Also

questionnaire_gen

Examples

```
data <- questionnaire_gen(100, family="gaussian", theta = TRUE,
                          full_output = TRUE, n_X = 2, n_W = list(2, 2, 4))
beta_gen(data, MC = TRUE)
```

`block_design` *Assignment of test items to blocks*

Description

`block_design` creates a length-2 list containing:

- a matrix that identifies which items correspond to which blocks and
- a table of block descriptive statisics.

Usage

```
block_design(n_blocks = NULL, item_parameters, item_block_matrix = NULL)
```

Arguments

`n_blocks`	an integer indicating how many blocks to create.
`item_parameters`	a data frame of item parameters.
`item_block_matrix`	a matrix of indicators to assign items to blocks.

Warning

The default `item_block_matrix` spirals the items across the `n_blocks` and requires `n_blocks` >= 3. If `n_blocks` < 3, `item_block_matrix` must be specified.

The columns of `item_block_matrix` represent each block while the rows represent the total number of items. `item_block_matrix[1, 1] = 1` indicates that block 1 contains item 1 while `item_block_matrix[1, 2] = 0` indicates that block 2 does not contain item 1.

Examples

```
item_param <- data.frame(item = seq(1:25), b = runif(25, -2, 2))
ib_matrix <- matrix(nrow = 25, ncol = 5, byrow = FALSE,
  c(1,1,1,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,
    0,0,0,0,1,1,1,1,1,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,
    0,0,0,0,0,0,0,0,0,0,1,1,1,1,1,0,0,0,0,0,0,0,0,0,0,
    0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,1,1,1,1,1,0,0,0,0,
    0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,1,1,1))
block_design(n_blocks = 5, item_parameters = item_param, item_block_matrix = ib_matrix)
block_design(n_blocks = 5, item_parameters = item_param)
```

booklet_design *Assignment of item blocks to test booklets*

Description

block_design creates a data frame that identifies which items corresponds to which booklets.

Usage

```
booklet_design(item_block_assignment, book_design = NULL)
```

Arguments

item_block_assignment	a matrix that identifies which items correspond to which block.
book_design	a matrix of indicators to assign blocks to booklets.

Details

If using booklet_design in tandem with block_design, item_block_assignment is the the first element of the returned list of block_design.

The columns of item_block_assignment represent each block while the rows represent the number of items in each block. Becuase the number of items per block can vary, the number of rows represents the block with the most items. The contets of item_block_assignment is the actual item numbers. The remainer of shorter blocks are filled with zeros.

The columns of book_design represent each book while the rows represent each block.

The default book_design assigns two blocks to every booklet in a spiral design. The number of default booklets is equal to the number of blocks and must be >= 3. If ncol(item_block_assignment) < 3, book_design must be specified.

Examples

```
i_blk_mat <- matrix(seq(1:40), ncol = 5)
blk_book <- matrix(c(1, 0, 1, 0, 0, 0, 1, 0, 1, 0, 0, 0, 1, 0, 1,
                     0, 0, 0, 1, 1, 0, 1, 1, 0, 0, 1, 0, 0, 1, 0),
                     ncol = 5, byrow = TRUE)
booklet_design(item_block_assignment = i_blk_mat, book_design = blk_book)
booklet_design(item_block_assignment = i_blk_mat)
```

booklet_sample *Assignment of test booklets to test takers*

Description

booklet_sample randomly assigns test booklets to test takers.

Usage

```
booklet_sample(
  n_subj,
  book_item_design,
  book_prob = NULL,
  resample = FALSE,
  e = 0.1,
  iter = 20
)
```

Arguments

n_subj	an integer, the number of subjects (test takers).
book_item_design	a data frame containing the items that belong to each booklet with booklets as columns and booklet item numbers as rows. See 'Details'.
book_prob	a vector of probability weights for obtaining the booklets being sampled. The default equally weights all books.
resample	logical indicating if booklets should be re-sampled to minimize differences. Can only be used when book_prob = NULL.
e	a number between 0 and 1 exclusive, re-sampling stopping criteria, the difference between the most sampled and least sampled booklets.
iter	an integer defining the number of iterations to reach e.

Details

If using booklet_sample in tandem with booklet_design, book_item_design is the the first element of the returned list of block_design.

Examples

```
it_bk <- matrix(c(1, 2, 1, 4, 5, 4, 7, 8, 7, 10, 3, 10, 2, 6, 3, 5, 9, 6, 8, 0, 9),
           ncol = 3, byrow = TRUE)
booklet_sample(n_subj = 10, book_item_design = it_bk, book_prob = c(.2, .5, .3))
```

brr *Generate replicates of a dataset using Balanced Repeated Replication*

Description

Generate replicates of a dataset using Balanced Repeated Replication

Usage

```
brr(
  data,
  k = 0,
  pseudo_strata = ceiling(nrow(data)/2),
  reps = NULL,
  max_reps = 80,
  weight_cols = "none",
  id_col = 1,
  drop = TRUE
)
```

Arguments

data	dataset
k	deflating weight factor. $0 \leq k \leq 1$.
pseudo_strata	number of pseudo-strata
reps	number of replicates
max_reps	maximum number of replicates (only functional if 'reps = NULL')
weight_cols	vector of weight columns
id_col	number of column in dataset containing subject IDs. Set 0 to use the row names as ID
drop	if 'TRUE', the observation that will not be part of the subsample is dropped from the dataset. Otherwise, it stays in the dataset but a new weight column is created to differentiate the selected observations

Value

a list containing all the BRR replicates of 'data'

Note

PISA uses the BRR Fay method with $k = 0.5$.

References

OECD (2015). Pisa Data Analysis Manual. Adams, R., & Wu, M. (2002). PISA 2000 Technical Report. Paris: Organisation for Economic Co-operation and Development (OECD). Rust, K. F., & Rao, J. N. K. (1996). Variance estimation for complex surveys using replication techniques. Statistical methods in medical research, 5(3), 283-310.

See Also

jackknife

`calc_n_tilde` *Calculate ñ*

Description

Calculates n tilde

Usage

```
calc_n_tilde(M, N, n_j)
```

Arguments

`M`	total number of population (i.e., sum of n_j over all j)
`N`	number of each class j
`n_j`	vector with size of each class j

References

Snijders, T. A. B., & Bosker, R. J. (1999). Multilevel Analysis. Sage Publications.

See Also

?lsasim:::summary.lsasimcluster

`calc_replicate_weights` *Calculate replicate weights and summary statistics*

Description

Takes the output of ‘cluster_gen‘ to calculate the replicate weights as well as some summary statistics

Usage

```
calc_replicate_weights(data, method, k = 0)
```

Arguments

`data`	list of background questionnaire data (typically generated by ‘cluster_gen‘)
`method`	replication method. Can be "Jackknife", "BRR" or "BRR Fay"
`k`	deflating weight factor (used only when ‘method = "BRR Fay")

Details

Replicate weights can be calculated using the Jackknife for unstratified two-stage sample designs or Balanced Repeated Replication (BRR) with or without Fay’s modification. According to OECD (2015), PISA uses the Fay method with a factor of 0.5. This is why ‘k = .5‘ by default.

Value

list with data and, if requeted, some statistics

Note

This function is essentially a big wrapper for ‘replicate_var‘, applying that function on each element of an output of ‘cluster_gen‘.

References

OECD (2015). Pisa Data Analysis Manual. Rust, K. F., & Rao, J. N. K. (1996). Variance estimation for complex surveys using replication techniques. Statistical methods in medical research, 5(3), 283-310.

See Also

cluster_gen jackknife, jackknife_var

Examples

```
data <- cluster_gen(c(3, 50))
calc_replicate_weights(data, "Jackknife")
calc_replicate_weights(data, "BRR")
calc_replicate_weights(data, "BRR Fay")
```

`calc_se_rho` *Calculate Standard Error of Intraclass Correlation*

Description

Calculate Standard Error of Intraclass Correlation

Usage

```
calc_se_rho(rho, n_j, N)
```

Arguments

`rho`	intraclass correlation
`n_j`	number of elements in class j
`N`	number of classes j

References

Snijders, T. A. B., & Bosker, R. J. (1999). Multilevel Analysis. Sage Publications.

See Also

anova.lsasimcluster

`calc_var_between` *Calculate variance between classes*

Description

Calculate variance between classes

Usage

```
calc_var_between(n_j, y_bar_j, y_bar, n_tilde, N)
```

Arguments

n_j	number of elements in class j
y_bar_j	mean of variable of interest per class j
y_bar	mean of variable of interest across classes
n_tilde	function of the variance of n_N, M and N. See documentation and code of `lsasim:::summary.lsasimcluster` for details
N	number of classes j

References

Snijders, T. A. B., & Bosker, R. J. (1999). Multilevel Analysis. Sage Publications.

See Also

anova.lsasimcluster

---

calc_var_tot *Calculate the total variance*

Description

Calculate the total variance

Usage

```
calc_var_tot(M, N, n_tilde, s2_within, s2_between)
```

Arguments

M	total sample size
N	number of classes j
n_tilde	function of the variance of n_N, M and N. See documentation and code of `lsasim:::summary.lsasimcluster` for details
s2_within	Within-class variance
s2_between	Between-class variance

References

Snijders, T. A. B., & Bosker, R. J. (1999). Multilevel Analysis. Sage Publications.

See Also

anova.lsasimcluster

calc_var_within *Calculate variance within classes*

Description

Calculate variance within classes

Usage

```
calc_var_within(n_j, s2_j, M, N)
```

Arguments

n_j	number of elements in class j
s2_j	variance of all elements in class j
M	total sample size
N	number of classes j

References

Snijders, T. A. B., & Bosker, R. J. (1999). Multilevel Analysis. Sage Publications.

See Also

anova.lsasimcluster

check_condition *Check if an error condition is satisfied*

Description

Check if an error condition is satisfied

Usage

```
check_condition(condition, message, fatal = TRUE)
```

Arguments

condition	logical test which if TRUE will cause the function to return an error message
message	error message to be displayed if condition is met.
fatal	if TRUE, error message is fatal, i.e., it will abort the parent function which called check_condition.

check_ignored_parameters *Checks if provided parameters are ignored*

Description

Internal function to match non-null parameters with a vector of ignored parameters

Usage

```
check_ignored_parameters(provided_parameters, ignored_parameters)
```

Arguments

provided_parameters	vector of provided parameters
ignored_parameters	vector of ignored parameters

Value

Warning message listing ignored parameters

check_n_N_class *Check class of n or N*

Description

Check the class of an object (usually n and N from 'cluster_gen')

Usage

```
check_n_N_class(x)
```

Arguments

x	either n or N from 'cluster_gen'

Note

This function is primarily used as a way to simplify the classification of n and N in the 'cluster_gen' function.

See Also

cluster_gen

check_valid_structure *Check if List is Valid*

Description

Checks if a list has a proper structure to be transformed into a hierarchical structure

Usage

```
check_valid_structure(n)
```

Arguments

n	list

Value

Error if the structure is improper. Otherwise, there's no output.

See Also

check_condition

cluster_gen *Generate cluster sample*

Description

Generate cluster sample

Usage

```
cluster_gen(
  n,
  N = 1,
  cluster_labels = NULL,
  resp_labels = NULL,
  cat_prop = NULL,
  n_X = NULL,
  n_W = NULL,
  c_mean = NULL,
  sigma = NULL,
  cor_matrix = NULL,
  separate_questionnaires = TRUE,
  collapse = "none",
  sum_pop = sapply(N, sum),
```

```
  calc_weights = TRUE,
  sampling_method = "mixed",
  rho = NULL,
  theta = FALSE,
  verbose = TRUE,
  print_pop_structure = verbose,
  ...
)
```

Arguments

n	numeric vector with the number of sampled observations (clusters or subjects) on each level
N	list of numeric vector with the population size of each *sampled* cluster element on each level
cluster_labels	character vector with the names of each cluster level
resp_labels	character vector with the names of the questionnaire respondents on each level
cat_prop	list of cumulative proportions for each item. If theta = TRUE, the first element of cat_prop must be a scalar 1, which corresponds to the theta.
n_X	list of 'n_X' per cluster level
n_W	list of 'n_W' per cluster level
c_mean	vector of means for the continuous variables or list of vectors for the continuous variables for each level. Defaults to 0, but can change if 'rho' is set.
sigma	vector of standard deviations for the continuous variables or list of vectors for the continuous variables for each level. Defaults to 1, but can change if 'rho' is set.
cor_matrix	Correlation matrix between all variables (except weights). By default, correlations are randomly generated.
separate_questionnaires	if 'TRUE', each level will have its own questionnaire
collapse	if 'TRUE', function output contains only one data frame with all answers. It can also be "none", "partial" and "full" for finer control on 3+ levels
sum_pop	total population at each level (sampled or not)
calc_weights	if 'TRUE', sampling weights are calculated
sampling_method	can be "SRS" for Simple Random Sampling or "PPS" for Probabilities Proportional to Size
rho	estimated intraclass correlation
theta	if TRUE, the first continuous variable will be labeled 'theta'. Otherwise, it will be labeled 'q1'.
verbose	if 'TRUE', prints output messages
print_pop_structure	if 'TRUE', prints the population hierarchical structure (as long as it differs from the sample structure)
...	Additional parameters to be passed to 'questionnaire_gen()'

Details

This function relies heavily in two subfunctions—‘cluster_gen_separate‘ and ‘cluster_gen_together‘—which can be called independently. This does not make ‘cluster_gen‘ a simple wrapper function, as it performs several operations prior to calling its subfunctions, such as randomly generating ‘n_X‘ and ‘n_W‘ if they are not determined by user. ‘n‘ can have unitary length, in which case all clusters will have the same size. ‘N‘ is *not* the population size across all elements of a level, but the population size for each element of one level. Regarding the additional parameters to be passed to ‘questionnaire_gen()‘, they can be passed either in the same format as ‘questionnaire_gen()‘ or as more complex objects that contain information for each cluster level.

Value

list with background questionnaire data, grouped by level or not

Note

For the purpose of this function, levels are counted starting from the top nesting/clustering level. This means that, for example, schools are the first cluster level, classes are the second, and students are the third and final level. This behavior can be customized by naming the ‘n‘ argument or providing custom labels in ‘cluster_labels‘ and ‘resp_labels‘.

Manually setting both ‘c_mean‘ and ‘rho‘, while possible, may yield unexpected results due to how those parameters work together. A high intraclass correlation (‘rho‘) teoretically means that each group will end up with different means so they can be better separated. If ‘c_mean‘ is left untouched (i.e., at the default value of zero), then ‘c_mean‘ will freely change between clusters in order to result in the expected intraclass correlation. For large samples, ‘c_mean‘ will in practice correspond to the grand mean across that level, as the means of each element will be different no matter the sample size.

Moreover, if ‘c_mean‘, ‘sigma‘ and ‘rho‘ are passed to the function, the means will be recalculated as a function of the other two parameters. The three are interdependent and cannot be passed simultaneously.

If in addition to ‘rho‘ the user also determine different means for each level, the only way the math can check out is if the variance in each group becomes very high. For examples of this scenario and the one described in the previous paragraph, check out the final section of this page.

The ‘ranges()‘ function should always be put inside a ‘list()‘,as putting it inside a vector (‘c()‘) will cancel its effect. For more details, please read the documentation of the ‘ranges()‘ function.

The only arguments that can be used to label each level are ‘n‘, ‘N‘, ‘cluster_labels‘ and ‘resp_labels‘. Labeling other arguments such as ‘c_mean‘ and ‘cat_prop‘ has no effect on the final results, but it is a recommended way for users to keep track of which value corresponds to which element in a complex hierarchical structure.

One of the extra arguments that can be passed by this function is ‘family‘. If `family == "gaussian"`, the questionnaire will be generated assuming that all the variables are jointly-distributed as a multivariate normal. The default behavior is `family == NULL`, where the data is generated using the polychoric correlation matrix, with no distributional assumptions.

See Also

cluster_estimates cluster_gen_separate cluster_gen_together questionnaire_gen

Examples

```
# Simple structure of 3 schools with 5 students each
cluster_gen(c(3, 5))

# Complex structure of 2 schools with different number of students,
# sampling weights and custom number of questions
n <- list(3, c(20, 15, 25))
N <- list(5, c(200, 500, 400, 100, 100))
cluster_gen(n, N, n_X = 5, n_W = 2)

# Condensing the output
set.seed(0); cluster_gen(c(2, 4))
set.seed(0); cluster_gen(c(2, 4), collapse=TRUE) # same, but in one dataset

# Condensing the output: 3 levels
str(cluster_gen(c(2, 2, 1), collapse="none"))
str(cluster_gen(c(2, 2, 1), collapse="partial"))
str(cluster_gen(c(2, 2, 1), collapse="full"))

# Controlling the intra-class correlation and the grand mean
x <- cluster_gen(c(5, 1000), rho = .9, n_X = 2, n_W = 0, c_mean = 10)
sapply(1:5, function(s) mean(x$school[[s]]$q1))  # means per school != 10
mean(sapply(1:5, function(s) mean(x$school[[s]]$q1))) # closer to c_mean

# Making the intraclass variance explode by forcing "incompatible" rho and c_mean
x <- cluster_gen(c(5, 1000), rho = .5, n_X = 2, n_W = 0, c_mean = 1:5)
anova(x)
```

---

cluster_gen_separate *Generate cluster samples with individual questionnaires*

Description

This is a subfunction of 'cluster_gen' that performs cluster sampling, with the twist that each cluster level has its own questionnaire.

Usage

```
cluster_gen_separate(
  n_levels,
  n,
  N,
  sum_pop,
  calc_weights,
  sampling_method,
  cluster_labels,
  resp_labels,
  collapse,
  n_X,
```

```
  n_W,
  cat_prop,
  c_mean,
  sigma,
  cor_matrix,
  rho,
  theta,
  whitelist,
  verbose,
  ...
)
```

Arguments

n_levels	number of cluster levels
n	numeric vector with the number of sampled observations (clusters or subjects) on each level
N	list of numeric vector with the population size of each *sampled* cluster element on each level
sum_pop	total population at the lowest level (sampled or not)
calc_weights	if 'TRUE', sampling weights are calculated
sampling_method	can be "SRS" for Simple Random Sampling or "PPS" for Probabilities Proportional to Size, "mixed" to use SRS for students and PPS otherwise or a vector with the sampling method for each level
cluster_labels	character vector with the names of each cluster level
resp_labels	character vector with the names of the questionnaire respondents on each level
collapse	if 'TRUE', function output contains only one data frame with all answers
n_X	list of 'n_X' per cluster level
n_W	list of 'n_W' per cluster level
cat_prop	list of cumulative proportions for each item. If theta = TRUE, the first element of cat_prop must be a scalar 1, which corresponds to the theta.
c_mean	vector of means for the continuous variables or list of vectors for the continuous variables for each level
sigma	vector of standard deviations for the continuous variables or list of vectors for the continuous variables for each level
cor_matrix	Correlation matrix between all variables (except weights)
rho	estimated intraclass correlation
theta	if TRUE, the first continuous variable will be labeled 'theta'. Otherwise, it will be labeled 'q1'.
whitelist	used when 'n = select(...)', determines which PSUs get to generate questionnaires
verbose	if 'TRUE', prints output messages
...	Additional parameters to be passed to 'questionnaire_gen()'

See Also

cluster_gen cluster_gen_together

`cluster_gen_together` *Generate cluster samples with lowest-level questionnaires*

Description

This is a subfunction of ‘cluster_gen‘ that performs cluster sampling where only the lowest-level individuals (e.g. students) fill out questionnaires.

Usage

```
cluster_gen_together(
  n_levels,
  n,
  N,
  sum_pop,
  calc_weights,
  sampling_method,
  cluster_labels,
  resp_labels,
  collapse,
  n_X,
  n_W,
  cat_prop,
  c_mean,
  sigma,
  cor_matrix,
  rho,
  verbose,
  ...
)
```

Arguments

`n_levels`	number of cluster levels
`n`	numeric vector with the number of sampled observations (clusters or subjects) on each level
`N`	list of numeric vector with the population size of each *sampled* cluster element on each level
`sum_pop`	total population at the lowest level (sampled or not)
`calc_weights`	if ‘TRUE‘, sampling weights are calculated
`sampling_method`	can be "SRS" for Simple Random Sampling or "PPS" for Probabilities Proportional to Size

cluster_labels	character vector with the names of each cluster level
resp_labels	character vector with the names of the questionnaire respondents on each level
collapse	if 'TRUE', function output contains only one data frame with all answers
n_X	list of 'n_X' per cluster level
n_W	list of 'n_W' per cluster level
cat_prop	list of cumulative proportions for each item. If theta = TRUE, the first element of cat_prop must be a scalar 1, which corresponds to the theta.
c_mean	vector of means for the continuous variables or list of vectors for the continuous variables for each level
sigma	vector of standard deviations for the continuous variables or list of vectors for the continuous variables for each level
cor_matrix	correlation matrix or list of correlation matrices per PSU
rho	intraclass correlation (scalar, vector or list)
verbose	if 'TRUE', prints output messages
...	Additional parameters to be passed to 'questionnaire_gen()'

See Also

cluster_gen cluster_gen_separate cluster_gen_together

---

cluster_message *Print messages about clusters*

Description

Prints messages about the cluster scheme before generating questionnaire responses.

Usage

```
cluster_message(
  n_obs,
  resp_labels,
  cluster_labels,
  n_levels,
  separate_questionnaires,
  type,
  detail = FALSE
)
```

Arguments

n_obs	list with the number of elements per level
resp_labels	character vector with the names of the questionnaire respondents on each level
cluster_labels	character vector with the names of each cluster level
n_levels	number of cluster levels
separate_questionnaires	if 'TRUE', each level will have its own questionnaire
type	Type of top-level message
detail	if 'TRUE', prints further details about each level composition

Value

Messages.

---

convert_vector_to_list

Convert Vector to Expanded List

Description

Converts a vector to list where each element is replicated a certain number of times depending on the previous vector. Also work for ranged lists

Usage

```
convert_vector_to_list(x, x_max = x, verbose = TRUE)
```

Arguments

x	vector or ranged list to be converted
x_max	reference vector or ranged list with max values for x
verbose	if 'TRUE', sends messages to user about what's being done

Value

expanded/replicated version of x

cor_gen *Generation of random correlation matrix*

Description

Creates a random correlation matrix.

Usage

```
cor_gen(n_var, cov_bounds = c(-1, 1))
```

Arguments

n_var	integer number of variables.
cov_bounds	a vector containing the bounds of the covariance matrix.

Details

The result from cor_gen can be used directly with the cor_matrix argument of questionnaire_gen.

Examples

```
cor_gen(n_var = 10)
```

cov_gen *Generation of covariance matrices*

Description

Construct covariance matrices for the generation of simulated test data.

Usage

```
cov_gen(pr_grp_1, n_fac, n_ind, Lambda = 0:1)
```

Arguments

pr_grp_1	proportion of observations in group 1. Can be a scalar or a vector
n_fac	number of factors
n_ind	number of indicators per factor
Lambda	either a matrix containing the factor loadings or a vector containing the lower and upper limits for a randomly-generated Lambda matrix

Value

A list containing three covariance matrices: vcov_yxw, vcov_yxz and vcov_yfz

Examples

```
vcov <- cov_gen(pr_grp_1 = .5, n_fac = 3, n_ind = 2)
str(vcov)
```

---

cov_yfz_gen *Generate latent regression covariance matrix*

Description

Generates covariance matrix between Y, F and Z

Usage

```
cov_yfz_gen(n_ind, n_fac, Phi, n_z, sd_z, w_names, pr_grp_1)
```

Arguments

n_ind	number of indicator variables
n_fac	number of factors
Phi	latent regression correlation matrix
n_z	number of background variables
sd_z	standard deviation of background variables
w_names	names of W variables
pr_grp_1	scalar or list of proportions of the first group

---

cov_yxw_gen *Setup full YXW covariance matrix*

Description

Setup full YXW covariance matrix

Usage

```
cov_yxw_gen(n_ind, n_z, Phi, n_fac, Lambda)
```

Arguments

n_ind	number of indicator variables
n_z	number of background variables
Phi	latent regression correlation matrix
n_fac	number of factor variables
Lambda	matrix containing the factor loadings

---

cov_yxz_gen *Generate analytical covariance matrix*

Description

Generate analytical covariance matrix

Usage

```
cov_yxz_gen(vcov_yxw, w_names, Phi, pr_grp_1, n_ind, n_fac, Lambda, var_z)
```

Arguments

vcov_yxw	covariance matrix between Y, X and W
w_names	name of the W variables
Phi	latent regression correlation matrix
pr_grp_1	scalar or list of proportions of the first group
n_ind	number of indicator variables
n_fac	number of factors
Lambda	matrix containing the factor loadings
var_z	vector of variances of the background variables

---

customize_summary *Customize Summary*

Description

Adds standard deviations and removes quantiles from a ‘summary()‘ output

Usage

```
customize_summary(df_summary, df, numeric_cols, factor_cols, digits = 3)
```

Arguments

df_summary	dataframe containing summary statistics
df	original data frame
numeric_cols	indices of the numeric columns
factor_cols	indices of the factor columns
digits	controls the number of digits in the output

See Also

summary ?lsasim:::summary.lsasimcluster

---

draw_cluster_structure

Draw Cluster Structure

Description

This function creates a visual representation of the hierarchical structure

Usage

```
draw_cluster_structure(n, labels = NULL, resp = NULL, output = "tree")
```

Arguments

n	same from cluster_gen
labels	corresponds to cluster_labels from cluster_gen
resp	corresponds to resp_labels from cluster_gen
output	"tree" draws a tree-like structure on the console, "text" prints the structure as a character vector

Value

Prints structure to console.

Note

This function is useful for checking how a ‘list()‘ object looks as a hierarchical structure, usually to be used as the ‘n‘ and/or ‘N‘ arguments of the ‘cluster_gen‘ function.

Examples

```
n <- c(2, 4, 3)
draw_cluster_structure(n)
draw_cluster_structure(n, output="text")
```

gen_cat_prop *Generates cat_prop for questionnaire_gen*

Description

Generates cat_prop for questionnaire_gen

Usage

```
gen_cat_prop(n_X, n_W, n_cat_W)
```

Arguments

n_X	number of continuous variables
n_W	number of categorical variables
n_cat_W	number of categories per categorical variable

gen_variable_n *Randomly generate the quantity of background variables*

Description

Randomly generate the quantity of background variables

Usage

```
gen_variable_n(n_vars, n_X, n_W, theta = FALSE)
```

Arguments

n_vars	number of variables in total (n_X + n_W + theta)
n_X	number of continuous variables
n_W	number of categorical variables
theta	number of latent variables

Value

vector with n_vars, n_X and n_W

gen_X_W_cluster *Generate n_X and n_W for clusters*

Description

Generates n_X and n_W for ‘cluster_gen‘ based on a correlation matrix

Usage

```
gen_X_W_cluster(n_levels, separate, class_cor)
```

Arguments

n_levels	number of levels
separate	to the ‘separate_questionnaires‘ argument of ‘cluster_gen‘
class_cor	corresponds to the ‘class_cor‘ argument of ‘cluster_gen‘

intraclass_cor *Intraclass correlation*

Description

Calculates the intraclass correlation of clustered data

Usage

```
intraclass_cor(tau2_hat, sigma2_hat)
```

Arguments

tau2_hat	estimate of the true between-class correlation
sigma2_hat	estimate of the true within-class correlation

References

Snijders, T. A. B., & Bosker, R. J. (1999). Multilevel Analysis. Sage Publications.

See Also

cluster_gen ?lsasim:::summary.lsasimcluster

irt_gen *Simulate item responses from an item response model*

Description

Creates a data frame of item parameters.

Usage

```
irt_gen(theta, a_par = 1, b_par, c_par = 0, D = 1)
```

Arguments

theta	numeric ability estimate.
a_par	numeric discrimination parameter.
b_par	numeric or vector of numerics difficulty parameter(s).
c_par	numeric guessing parameter.
D	numeric parameter to specify logisitic (1) or normal (1.7).

Examples

```
irt_gen(theta = 0.2, b_par = 0.6)
irt_gen(theta = 0.2, a_par = 1.15, b_par = 0.6)
irt_gen(theta = 0.2, a_par = 1.15, b_par = 0.6, c_par = 0.2)
```

item_gen *Generation of item parameters from uniform distributions*

Description

Creates a data frame of item parameters.

Usage

```
item_gen(
  b_bounds,
  a_bounds = NULL,
  c_bounds = NULL,
  thresholds = 1,
  n_1pl = NULL,
  n_2pl = NULL,
  n_3pl = NULL
)
```

Arguments

b_bounds	a vector containing the bounds of the the uniform distribution for sampling the difficulty parameters.
a_bounds	a vector containing the bounds of the the uniform distribution for sampling the discrimination parameters.
c_bounds	a vector containing the bounds of the the uniform distribution for sampling the guessing parameters.
thresholds	if numeric, number of thresholds for 1- and/or 2- parameter dichotomous items, if vector, each element is the number of thresholds corresponding to the vector of n_1pl and/or n_2pl.
n_1pl	if integer, number of 1-parameter dichotomous items, if vector, each element is the number of partial credit items corresponding to thresholds number.
n_2pl,	if integer, number of 2-parameter dichotomous items, if vector, each element is the number of generalized partial credit items corresponding to thresholds number.
n_3pl	integer, number of 3-parameter items.

Details

The data frame includes two variables p and k which indicate the number of parameters and the number of thresholds, respectively

Examples

```
item_gen(b_bounds = c(-2, 2), a_bounds = c(.75, 1.25),
  thresholds = c(1, 2, 3), n_1pl = c(5, 5, 5), n_2pl = c(0, 0, 5))
item_gen(b_bounds = c(-2, 2), a_bounds = c(.75, 1.25), c_bounds = c(0, .25),
  n_2pl = 5, n_3pl = 5)
```

---

jackknife *Generate replicates of a dataset using Jackknife*

Description

Generate replicates of a dataset using Jackknife

Usage

```
jackknife(data, weight_cols = "none", drop = TRUE)
```

Arguments

data	dataset
weight_cols	vector of weight columns
drop	if 'TRUE', the observation that will not be part of the subsample is dropped from the dataset. Otherwise, it stays in the dataset but a new weight column is created to differentiate the selected observations

Value

a list containing all the Jackknife replicates of ‘data‘

See Also

brr

Examples

```
x <- data.frame(
    number = 1:5,
    letter = LETTERS[1:5],
    stringsAsFactors = FALSE
)
jackknife(x)
jackknife(x, drop = FALSE)
```

`label_respondents` *Label respondents*

Description

This function nerated level label combinations for each respondent

Usage

```
label_respondents(
  n_obs,
  cluster_labels = names(n_obs),
  add_last_level = FALSE,
  apply_labels = TRUE
)
```

Arguments

`n_obs`	list with the number of elements per level
`cluster_labels`	character vector with the names of each cluster level
`add_last_level`	if ‘TRUE‘ (not default), adds the last level to the output table
`apply_labels`	if ‘TRUE‘, applies labels (column names) to data cells

Value

Data frame with the combinations of IDs from all levels

lambda_gen *Randomly generate a matrix of factor loadings*

Description

Randomly generate a matrix of factor loadings

Usage

```
lambda_gen(n_ind, n_fac, limits, row_names, col_names)
```

Arguments

n_ind	number of indicators per factor
n_fac	number of factors
limits	vector with lower and upper limits for the uniformly-generated Lambdas
row_names	vector with row names
col_names	vector with col names

lsasim *lsasim: A package for simulating large scale assessment data*

Description

lsasim simulates data that mimics large-scale assessments (LSAs), including background questionnaire data and cognitive item responses that adhere to a multiple-matrix sampled design

Functions to Facilitate the Simulation of Large Scale Assessment Data

Core functions

- block_design Assignment of test items to blocks.
- booklet_design Assignment of item blocks to test booklets.
- booklet_sample Assignment of test booklets to test takers.
- item_gen Generation of random correlation matrix.
- proportion_gen Generation of random cumulative proportions.
- questionnaire_gen Generation of ordinal and continuous variables.
- response_gen Generation of item response data using a rotated block design.
- cluster_gen Generation of background questionnaires from a cluster sampling scheme.

Useful ancillary functions

- `irt_gen` Generate item responses from an IRT model. Used by `response_gen`.
- `beta_gen` Calculates analytical and numeric regression coefficients for the background questionnaire responses as functions of the latent variable. Used by `questionnaire_gen`

Note

This package contains vignettes. If you are installing lsasim from GitHub, remember to use 'build_vignettes=TRUE' in your 'remotes::install_github()' call. Afterwards, you can browse the vignettes by issuing 'browseVignettes("lsasim")' in your R terminal.

Author(s)

Maintainer: Waldir Leoncio <w.l.netto@medisin.uio.no>

Authors:

- Tyler Matta <tyler.matta@gmail.com>
- Leslie Rutkowski <leslie.rutkowski@cemo.uio.no>
- David Rutkowski <david.rutkowski@cemo.uio.no>
- Yuan-Ling Linda Liaw <y.l.liaw@cemo.uio.no>

Other contributors:

- Kondwani Kajera Mughogho <k.k.mughogho@cemo.uio.no> [contributor]
- Sinan Yavuz [contributor]
- Paul Bailey [contributor]

See Also

Useful links:

- Report bugs at https://github.com/tmatta/lsasim/issues

`pisa2012_math_block` *PISA 2012 mathematics item - item block indicator matrix*

Description

A dataset containing indicators associating those PISA 2012 mathematics items to the PISA 2012 mathematics item blocks.

Usage

```
pisa2012_math_block
```

Format

A data frame with 109 rows and 12 variables:

item_name Item name.

item_no Item numbers.

block1 Indicator specifying those items in block 1.

block2 Indicator specifying those items in block 2.

block3 Indicator specifying those items in block 3.

block4 Indicator specifying those items in block 4.

block5 Indicator specifying those items in block 5.

block6 Indicator specifying those items in block 6.

block7 Indicator specifying those items in block 7.

block8 Indicator specifying those items in block 8.

block9 Indicator specifying those items in block 9.

block10 Indicator specifying those items in block 10.

Source

PISA 2012 Technical Report, ANNEX A. Table A.1: PISA 2012 Main Survey mathematics item classification. Pages 406 - 409. https://www.oecd.org/pisa/pisaproducts/PISA-2012-technical-report-final.pdf

---

pisa2012_math_booklet *PISA 2012 mathematics item block - test booklet indicator matrix*

Description

A dataset containing indicators associating those PISA 2012 mathematics item blocks to the PISA 2012 mathematics standard test booklet set.

Usage

```
pisa2012_math_booklet
```

Format

A data frame with 13 rows and 10 variables:

booklet Booklet name.

b1 Indicator specifying those test booklets that use item block 1.

b2 Indicator specifying those test booklets that use item block 2.

b3 Indicator specifying those test booklets that use item block 3.

b4 Indicator specifying those test booklets that use item block 4.

b5 Indicator specifying those test booklets that use item block 5.

b6 Indicator specifying those test booklets that use item block 6.

b7 Indicator specifying those test booklets that use item block 7.

b8 Indicator specifying those test booklets that use item block 8.

b9 Indicator specifying those test booklets that use item block 9.

Source

PISA 2012 Technical Report, Chapter 2: Test Design and Test Development. Figure 2.1: Cluster rotation design used to form standard test booklets for PISA 2012. Page 31. https://www.oecd.org/pisa/pisaproducts/PISA-2012-technical-report-final.pdf

---

pisa2012_math_item *Item parameter estimates for 2012 PISA mathematics assessment*

Description

A dataset containing the estimated item parameters for the PISA 2012 mathematics assessment.

Usage

```
pisa2012_math_item
```

Format

A data frame with 109 rows and 5 variables:

item_name Item name.

item Item number.

b b parameter estimate.

d1 d1 parameter estimate (for partial credit items).

d2 d2 parameter estimate (for partial credit items).

Source

PISA 2012 Technical Report, ANNEX A. Table A.1: PISA 2012 Main Survey mathematics item classification. Pages 406 - 409. https://www.oecd.org/pisa/pisaproducts/PISA-2012-technical-report-final.pdf

`pisa2012_q_cormat` *Correlation matrix from the PISA 2012 background questionnaire*

Description

A correlation matrix for the selected background questionnaires and mathematics plausible value.

Usage

```
pisa2012_q_cormat
```

Format

An 19 by 19 matrix.

Details

A heterogenous correlation matrix, consisting of polyserial correlations between numeric and ordinal variables, and polychoric correlations between ordinal variables.

Row/Col	Name	Label	Type
1	ST93Q01	Perseverance	Ordinal
2	ST93Q03	Perseverance	Ordinal
3	ST93Q04	Perseverance	Ordinal
4	ST93Q06	Perseverance	Ordinal
5	ST93Q07	Perseverance	Ordinal
6	ST94Q05	Openness for Problem Solving	Ordinal
7	ST94Q06	Openness for Problem Solving	Ordinal
8	ST94Q09	Openness for Problem Solving	Ordinal
9	ST94Q10	Openness for Problem Solving	Ordinal
10	ST94Q14	Openness for Problem Solving	Ordinal
11	ST88Q01	Attitude toward School	Ordinal
12	ST88Q02	Attitude toward School	Ordinal
13	ST88Q03	Attitude toward School	Ordinal
14	ST88Q04	Attitude toward School	Ordinal
15	ST89Q02	Attitude toward School	Ordinal
16	ST89Q03	Attitude toward School	Ordinal
17	ST89Q04	Attitude toward School	Ordinal
18	ST89Q05	Attitude toward School	Ordinal
19	1PV1MATH	Mathematics Plausible Value 1	Continuous

Warning

These data are for illustration purposes only. Handling of missing data may not be suitable for valid inferences.

Source

Raw data can be found at https://www.oecd.org/pisa/pisaproducts/pisa2012database-downloadabledata.htm Codebook can be found at https://www.oecd.org/pisa/pisaproducts/PISA12_stu_codebook.pdf

---

`pisa2012_q_marginal` *Marginal proportions from the PISA 2012 background questionnaire*

Description

Marginal proportions from the PISA 2012 background questionnaire

Usage

```
pisa2012_q_marginal
```

Format

A list of 19 named numeric vectors.

Details

A list containing the marginal cumulative proportions for each response category from the PISA 2012 background questionnaire. Elements 1 - 18 are the marginal proportions for the selected items from the background questionnaire. Element 19 is the marginal proportion for the selected mathematics plausible value.

Row/Col	Name	Label	Length
1	ST93Q01	Perseverance	5
2	ST93Q03	Perseverance	5
3	ST93Q04	Perseverance	5
4	ST93Q06	Perseverance	5
5	ST93Q07	Perseverance	5
6	ST94Q05	Openness for Problem Solving	5
7	ST94Q06	Openness for Problem Solving	5
8	ST94Q09	Openness for Problem Solving	5
9	ST94Q10	Openness for Problem Solving	5
10	ST94Q14	Openness for Problem Solving	5
11	ST88Q01	Attitude toward School	4
12	ST88Q02	Attitude toward School	4
13	ST88Q03	Attitude toward School	4
14	ST88Q04	Attitude toward School	4
15	ST89Q02	Attitude toward School	4
16	ST89Q03	Attitude toward School	4
17	ST89Q04	Attitude toward School	4
18	ST89Q05	Attitude toward School	4
19	1PV1MATH	Mathematics Plausible Value 1	1

Warning

These data are for illustration purposes only. Handling of missing data may not be suitable for valid inferences.

Source

Raw data can be found at https://www.oecd.org/pisa/pisaproducts/pisa2012database-downloadabledata.htm Codebook can be found at https://www.oecd.org/pisa/pisaproducts/PISA12_stu_codebook.pdf

---

pluralize *Pluralize words*

Description

Pluralize a word

Usage

```
pluralize(word, n = rep(2, length(word)))
```

Arguments

word	vector of characters to be pluralized
n	vector of number of times each word appears (to determine if the plural or single form will be returned)

Value

'word', either pluralized or not (depending on 'n')

---

print_anova *Print the ANOVA table*

Description

Print the ANOVA table

Usage

```
print_anova(
  s2_within,
  s2_between,
  s2_total,
  sigma2_hat,
  tau2_hat,
  rho_hat,
  se_rho,
  n_tilde,
  M,
  N
)
```

Arguments

s2_within	Within-class variance
s2_between	Between-class variance
s2_total	Total variance
sigma2_hat	estimate of the true within-class correlation
tau2_hat	estimate of the true between-class correlation
rho_hat	estimated intraclass correlation
se_rho	standard errors of 'rho_hat'
n_tilde	function of the variance of n_N, M and N. See documentation and code of `lsasim:::summary.lsasimcluster` for details
M	total sample size
N	number of classes j

References

Snijders, T. A. B., & Bosker, R. J. (1999). Multilevel Analysis. Sage Publications.

See Also

anova

---

proportion_gen *Generation of random cumulative proportions*

Description

Creates a list of vectors, each containing the randomly generated cumulative proportions of a discrete variable.

Usage

```
proportion_gen(cat_options, n_cat_options)
```

Arguments

cat_options	vector of response types.
n_cat_options	vector of number of items of the corresponding response type.

Details

cat_options and n_cat_options must be the same length. cat_options = 1 is a continuous variable.

The result from proportion_gen can be used directly with the cat_prop argument of questionnaire_gen.

Examples

```
proportion_gen(cat_options = c(1, 2, 3), n_cat_options = c(2, 2, 2))
proportion_gen(cat_options = c(1, 3), n_cat_options = c(4, 5))
```

---

pt_bis_conversion *Analytical point-biserial conversion*

Description

Analytical point-biserial conversion

Usage

```
pt_bis_conversion(bis_cor, pr_group1)
```

Arguments

bis_cor	biserial correlations
pr_group1	probability of group 1

questionnaire_gen *Generation of ordinal and continuous variables*

Description

Creates a data frame of discrete and continuous variables based on several arguments.

Usage

```
questionnaire_gen(
  n_obs,
  cat_prop = NULL,
  n_vars = NULL,
  n_X = NULL,
  n_W = NULL,
  cor_matrix = NULL,
  cov_matrix = NULL,
  c_mean = NULL,
  c_sd = NULL,
  theta = FALSE,
  family = NULL,
  full_output = FALSE,
  verbose = TRUE
)
```

Arguments

n_obs	number of observations to generate.
cat_prop	list of cumulative proportions for each item. If theta = TRUE, the first element of cat_prop must be a scalar 1, which corresponds to the theta.
n_vars	total number of variables in the questionnaire, including the continuous and the discrete covariates (X and W, respectively), as well as the latent trait (Y, which is equivalent to θ).
n_X	number of continuous background variables. If not provided, a random number of continuous variables will be generated.
n_W	either a scalar corresponding to the number of categorical background variables or a list of scalars representing the number of categories for each categorical variable. If not provided, a random number of categorical variables will be generated.
cor_matrix	latent correlation matrix. The first row/column corresponds to the latent trait (Y). The other rows/columns correspond to the continuous (X or Z) or the discrete (W) background variables, in the same order as cat_prop.
cov_matrix	latent covariance matrix, formatted as cor_matrix.
c_mean	is a vector of population means for each continuous variable (Y and X). Defaults to 0.

c_sd	is a vector of population standard deviations for each continuous variable (Y and X). Defaults to 1.
theta	if TRUE, the first continuous variable will be labeled 'theta'. Otherwise, it will be labeled 'q1'.
family	distribution of the background variables. Can be NULL (default) or 'gaussian'.
full_output	if TRUE, output will be a list containing the questionnaire data as well as several objects that might be of interest for further analysis of the data.
verbose	if 'FALSE', output messages will be suppressed (useful for simulations). Defaults to 'TRUE'

Details

In essence, this function begins by checking the validity of the arguments provided and randomly generating those that are not. Then, it will call one of two internal functions, `questionnaire_gen_polychoric` or `questionnaire_gen_family`. The former corresponds to the exact functionality of questionnaire_gen on lsasim 1.0.1, where the polychoric correlations are used to generate the background questionnaire data. If `family != NULL`, however, `questionnaire_gen_family` is called to generate data based on a joint probability distribution. Additionally, if `full_output == TRUE`, the external function `beta_gen` is called to generate the correlation coefficients based on the true covariance matrix. The latter argument also changes the class of the output of this function.

What follows are some notes on the input parameters.

`cat_prop` is a list where `length(cat_prop)` is the number of items to be generated. Each element of the list is a vector containing the marginal cumulative proportions for each category, summing to 1. For continuous items, the associated element in the list should be 1.

`cor_matrix` and `cov_matrix` are the correlation and covariance matrices that are the same size as `length(cat_prop)`. The correlations related to the correlation between variables on the latent scale.

`c_mean` and `c_sd` are each vectors whose length is equal to the number of continuous variables as specified by `cat_prop`. The default is to keep the continuous variables with mean zero and standard deviation of one.

`theta` is a logical indicator that determines if the first continuous item should be labeled *theta*. If `theta == TRUE` but there are no continuous variables generated, a random number of background variables will be generated.

If `cat_prop` is a named list, those names will be used as variable names for the returned `data.frame`. Generic names will be provided to the variables if `cat_prop` is not named.

As an alternative to providing `cat_prop`, the user can call this function by specifying the total number of variables using `n_vars` or the specific number of continuous and categorical variables through `n_X` and `n_W`. All three arguments should be provided as scalars; `n_W` may also be provided as a list, where each element contains the number of categories for one background variable. Alternatively, `n_W` may be provided as a one-element list, in which case it will be interpreted as all the categorical variables having the same number of categories.

If `family == "gaussian"`, the questionnaire will be generated assuming that all the variables are jointly-distributed as a multivariate normal. The default behavior is `family == NULL`, where the data is generated using the polychoric correlation matrix, with no distributional assumptions.

When data is generated using the Gaussian distribution, the matrices provided correspond to the relations between the latent variable θ, the continuous covariates X and the continuous covariates—Z $N(0, 1)$—that will later be discretized into categorical covariates W. That is why there will be a difference between labels and lengths between `cov_matrix` and `vcov_YXW`. For more information, check the references cited later in this document.

Value

By default, the function returns a `data.frame` object where the first column ("subject") is a $1, \ldots, n$ ordered list of the n observations and the other columns correspond to the questionnaire answers. If `theta = TRUE`, the first column after "subject" will be the latent variable θ; in any case, the continuous variables always come before the categorical ones.

If `full_output = TRUE`, the output will be a list containing the following objects:

`bg`	a data frame containing the background questionnaire answers (i.e., the same object as described above).
`c_mean`	identical to the input argument of the same name. Read the Details section for more information.
`c_sd`	identical to the input argument of the same name. Read the Details section for more information.
`cat_prop`	identical to the input argument of the same name. Read the Details section for more information.
`cat_prop_W_p`	a list containing the probabilities for each category of the categorical variables (`cat_prop_W` contains the cumulative probabilities).
`cor_matrix`	identical to the input argument of the same name. Read the Details section for more information.
`cov_matrix`	identical to the input argument of the same name. Read the Details section for more information.
`family`	identical to the input argument of the same name.
`n_obs`	identical to the input argument of the same name.
`n_tot`	named vector containing the number of total variables, the number of continuous background variables (i.e., the total number of background variables except θ) and the number of categorical variables.
`n_W`	vector containing the number of categorical variables.
`n_X`	vector containing the number of continuous variables (except θ).
`sd_YXW`	vector with the standard deviations of all the variables
`sd_YXZ`	vector containing the standard deviations of θ, the background continuous variables (X) and the Normally-distributed variables Z which will generate the background categorical variables (W).
`theta`	identical to the input argument of the same name.
`var_W`	list containing the variances of the categorical variables.
`var_YX`	list containing the variances of the continuous variables (including θ)

`linear_regression`
: This list is printed only if 'theta = TRUE', 'family = "gaussian"' and 'full_output = TRUE'. It contains one vector named 'betas' and one tabled named 'cov_YXW'. The former displays the true linear regression coefficients of $theta$ on the background questionnaire answers; the latter contains the covariance matrix between all these variables.

Note

If `family == NULL`, the number of levels for each categorical variables will be determined by the number of categories observed in the generated data. This means it might be smaller than the number of categories determined by `cat_prop`, which is more likely to happen with small values of `n_obs`. If `family == "gaussian"`, however, the number of levels for the categorical variables will always be equivalent to the number of possible categories, even if they are not observed in the data.

It is important to note that all arguments directly related to variable parameters (e.g. 'cat_prop', 'cov_matrix', 'cor_matrix', 'c_mean', 'c_sd') have the following order: Y, X, W (missing variables are skipped). This must be kept in mind when using real-life data as input to 'questionnaire_gen', as the input might need to be reordered to fit the expectations of the function.

By definition, the expected order of the variables is $theta$, followed by X and then W. The reference category of the categorical variables W is always the first one.

For very small means/sigmas (e.g. 0.005) and multiple levels, estimates may have differing levels of accuracy (e.g. school level estimates will not be as accurate as the student levels ones). In general, one should expect naturally worse estimation on higher hierarchical setups.

References

Matta, T. H., Rutkowski, L., Rutkowski, D., & Liaw, Y. L. (2018). lsasim: an R package for simulating large-scale assessment data. Large-scale Assessments in Education, 6(1), 15.

See Also

beta_gen

Examples

```
# Using polychoric correlations
props <- list(c(1), c(.25, .6, 1))  # one continuous, one with 3 categories
questionnaire_gen(n_obs = 10, cat_prop = props,
                  cor_matrix = matrix(c(1, .6, .6, 1), nrow = 2),
                  c_mean = 2, c_sd = 1.5, theta = TRUE)

# Using the multinomial distribution
# two categorical variables W: one has 2 categories, the other has 3
props <- list(1, c(.25, 1), c(.2, .8, 1))
yw_cov <- matrix(c(1, .5, .5, .5, 1, .8, .5, .8, 1), nrow = 3)
questionnaire_gen(n_obs = 10, cat_prop = props, cov_matrix = yw_cov,
                  family = "gaussian")

# Not providing covariance matrix
questionnaire_gen(n_obs = 10,
```

```
                    cat_prop = list(c(.25, 1), c(.6, 1), c(.2, 1)),
                    family = "gaussian")
```

`questionnaire_gen_family` *Generation of ordinal and continuous variables*

Description

Creates a data frame of discrete and continuous variables based on a latent correlation matrix and marginal proportions.

Usage

```
questionnaire_gen_family(
  n_obs,
  cat_prop,
  cov_matrix,
  family = "gaussian",
  theta = FALSE,
  mean_yx = NULL,
  n_cats
)
```

Arguments

`n_obs`	number of observations to generate.
`cat_prop`	list of cumulative proportions for each item.
`cov_matrix`	covariance matrix. between the latent trait (Y) and the background variables (X and Z).
`family`	distribution of the background variables. Can be NULL or 'gaussian'.
`theta`	if `TRUE` will label the first continuous variable 'theta'.
`mean_yx`	vector with the means of the latent trait (Y) and the continuous background variables with flexible variance (X).
`n_cats`	vector with number of categories for each W.

questionnaire_gen_polychoric *Generation of ordinal and continuous variables*

Description

Creates a data frame of discrete and continuous variables based on a latent correlation matrix and marginal proportions.

Usage

```
questionnaire_gen_polychoric(n_obs, cat_prop, cor_matrix, c_mean, c_sd, theta)
```

Arguments

n_obs	number of observations to generate.
cat_prop	list of cumulative proportions for each item.
cor_matrix	latent correlation matrix.
c_mean	is a vector of population means for each continuous variable.
c_sd	is a vector of population standard deviations for each continuous variable.
theta	if TRUE will label the first continuous variable 'theta'.

ranges *Defines vector as range*

Description

Redefines the class of a vector as "range"

Usage

```
ranges(x, y)
```

Arguments

x	first element
y	second element

Value

'c(x, y)', but with the "range" class

Note

This function was created to be used as an element in the ‘N‘ argument of ‘cluster_gen‘. The name was chosen to avoid conflict with ‘base::range()‘.

‘ranges()‘ should always be used within a ‘list()‘. Inserting a "range" vector inside a common vector (‘c()‘) will result in a common vector. For example, ‘c(3, ranges(8, 10))‘ is the same as ‘c(3, 8, 10)‘, because when faced with conflicting classes in the same element, R will resolve to the simpler case ("numeric", in this case). An easier way to understand this concept is by checking ‘class(c(3, "a"))‘ is "character", meaning the number 3 was devolved into a character "3".

---

recalc_final_weights *Recalculate final weights*

Description

Recalculate final weights given the replicate weights

Usage

```
recalc_final_weights(data, w_cols, replicate_weight = 1, reorder = TRUE)
```

Arguments

data	dataset
w_cols	columns containing the weights
replicate_weight	scalar with the replicate weights
reorder	if ‘TRUE‘, reorders the dataset so that the replicate weights appear before the final weights

Value

input data with recalculated final weights, incorporating the replicate weights

---

replicate_var *Sampling variance of the mean for replications*

Description

Estimates the mean variance for Jackknife, BRR and BRR Fay replication methods

Usage

```
replicate_var(
  data_whole,
  data_rep,
  method,
  k = 0,
  weight_var = NULL,
  stat = weighted.mean,
  vars = NULL,
  full_output = FALSE
)
```

Arguments

data_whole	full, original dataset (the one that generated the replications)
data_rep	list with replications of ‘data_whole‘
method	replication method. Can be "Jackknife", "BRR" or "BRR Fay"
k	deflating weight factor (used only when ‘method = "BRR Fay")
weight_var	variables containing the weights
stat	statistic of interest to calculate (must be a base R function)
vars	vector containing the variables of interest
full_output	if ‘TRUE‘, returns all intermediate objects created

Details

‘data_rep‘ can be obtained from

See Also

jackknife brr

---

response_gen *Generation of item response data using a rotated block design*

Description

Creates a data frame of discrete item responses based on.

Usage

```
response_gen(
  subject,
  item,
  theta,
  a_par = NULL,
  b_par,
  c_par = NULL,
  d_par = NULL,
  item_no = NULL,
  ogive = "Logistic"
)
```

Arguments

subject	integer vector of test taker IDs.
item	integer vector of item IDs.
theta	numeric vector of latent test taker abilities.
a_par	numeric vector of item a parameters for each item.
b_par	numeric vector of item b parameters for each item.
c_par	numeric vector of item c parameters for each item.
d_par	list of numeric vectors of item threshold parameters for each item.
item_no	vector of item numbers the correspond the item parameters
ogive	can be "Normal" or "Logistic".

Details

`subject` and `item` must be equal lengths.

Generalized partial credit models (`!is.null(d_par)`) uses threshold parameterization.

Examples

```
set.seed(1234)
s_id <- c(1, 1, 1, 1, 1, 1, 1, 2, 2, 2, 2, 2, 2, 2, 3, 3, 3, 3, 3, 3, 3, 4, 4,
          4, 4, 4, 4, 4, 5, 5, 5, 5, 5, 5, 5, 6, 6, 6, 6, 6, 6, 7, 7, 7, 7, 7,
          7, 7, 8, 8, 8, 8, 8, 8, 9, 9, 9, 9, 9, 9, 9, 10, 10, 10, 10, 10, 10,
          10, 11, 11, 11, 11, 11, 11, 12,12, 12, 12, 12, 12, 12, 13, 13, 13, 13,
          13, 13, 14, 14, 14, 14, 14, 14, 15, 15, 15, 15, 15, 15, 16,16, 16, 16,
          16, 16, 17, 17, 17, 17, 17, 17, 17, 18, 18, 18, 18, 18, 18, 18, 19, 19,
          19, 19, 19, 19,19, 20, 20, 20, 20, 20, 20, 20)
i_id<- c(1, 4, 7, 10, 3, 6, 9, 1, 4, 7, 10, 2, 5, 8, 1, 4, 7, 10, 3, 6, 9, 1, 4,
         7, 10, 3, 6, 9, 1, 4, 7, 10, 3, 6, 9, 2, 5, 8, 3, 6, 9, 1, 4, 7, 10, 2,
         5, 8, 2, 5, 8, 3, 6, 9, 1, 4, 7, 10, 2, 5, 8, 1, 4, 7, 10, 3, 6, 9, 2,
         5, 8, 3, 6, 9, 1, 4, 7, 10, 3, 6, 9, 2, 5, 8, 3, 6, 9, 2, 5, 8, 3, 6, 9,
         2, 5, 8, 3, 6, 9, 2, 5, 8, 3, 6, 9, 1, 4, 7, 10, 2, 5, 8, 1, 4, 7, 10,
         2, 5, 8, 1, 4, 7, 10, 2, 5, 8, 1, 4, 7, 10, 3, 6, 9)
bb <- c(-1.72, -1.85, 0.98, 0.07, 1.00, 0.13, -0.43, -0.29, 0.86, 1.26)
```

```
aa <- c(1.28, 0.78, 0.98, 1.21, 0.83, 1.01, 0.92, 0.76, 0.88, 1.11)
cc <- rep(0, 10)
dd <- list(c(0, 0, -0.13, 0, -0.19, 0, 0, 0, 0, 0),
           c(0, 0,  0.13, 0,  0.19, 0, 0, 0, 0, 0))
response_gen(subject = s_id, item = i_id, theta = rnorm(20, 0, 1),
             b_par = bb, a_par = aa, c_par = cc, d_par = dd)
```

`rzeropois` *Generate data from a Zero-truncated Poisson*

Description

Random generation of one observation of a random variable distributed as a Zero-truncated Poisson

Usage

```
rzeropois(lambda)
```

Arguments

`lambda`	corresponds to the lambda parameter of a Poisson

Details

The zero-truncated Poisson (a.k.a. conditional Poisson or positive Poisson) distribution is a discrete probability distribution whose support is the set of positive integers.

`sample_from` *Sample from population structure*

Description

Generates a sample from a population structure

Usage

```
sample_from(N, n, labels = names(N), verbose = TRUE)
```

Arguments

`N`	list containing the population sampling structure
`n`	numeric vector with the number of sampled observations (clusters or subjects) on each level
`labels`	character vector with the names of the questionnaire respondents on each level
`verbose`	if 'TRUE', prints output messages

sample_within_range *Sample from range*

Description

Creates a uniformly-distributed sample from a 2-length vector

Usage

```
sample_within_range(rg, sample_size = NULL, seed = NULL)
```

Arguments

rg	a "range"-class vector
sample_size	the size of the sample to be generated
seed	pseudo-random number generator seed

Value

A vector containing the generated sample

Note

This function was created primarily to be used to expand an object with the "range" class.

select *Transform regular vector into selection vector*

Description

Attaches a "select" class to a vector

Usage

```
select(...)
```

Arguments

...	parameters to be passed to ‘c()‘

Value

same as ‘x‘, but with a class attribute that classifies ‘x‘ as "select"

Note

This function was created to be used instead of ‘c()‘ in the ‘n‘ argument of ‘cluster_gen‘.

split_cat_prop *Split variables in cat_prop*

Description

Split variables in cat_prop

Usage

```
split_cat_prop(cat_prop, keepYX = FALSE)
```

Arguments

cat_prop	list corresponding to cat_prop from questionnaire_gen
keepYX	if TRUE, output will be a list separating cat_prop_YX and cat_prop_W. IF FALSE, it will be a list with these objects combined (just like cat_prop)

summary.lsasimcluster *Summarizes clusters*

Description

Takes the output of ‘cluster_gen‘ and creates summary statistics of the questionnaire variables

Usage

```
## S3 method for class 'lsasimcluster'
summary(
  object,
  digits = 4,
  print = "partial",
  print_hetcor = TRUE,
  force_matrix = FALSE,
  ...
)
```

Arguments

object	output of ‘cluster_gen‘
digits	loosely controls the number of digits (significant or not) in the output (for ‘print = TRUE‘)
print	"all" will pretty-print a summary of statistics, "partial" will only print cluster-level sumamrizes; "none" outputs statistics as a list
print_hetcor	if ‘TRUE‘ (default), prints the heterogeneous correlation matrix
force_matrix	if ‘TRUE‘, prints the heterogeneous correlation matrix even if warnings are generated
...	additional arguments (unused; added for compatibility with generic)

Value

list of summaries

Note

Setting ‘print="none"‘ allows for saving the results as an R object (list). Otherwise, the results will be simply printed and not saveable.

Changing ‘digits‘ may yield unexpected results for the estimates of continuous variables, given how most of them are printed using the number of significant digits (for more information, see ‘help("summary")‘).

Please note that datasets containing large values for the coefficient of variation (sigma / mu) should yield imprecise results.

See Also

anova.lsasimcluster

Examples

```
n <- c(3, 30)
cls <- cluster_gen(n, n_X = 3, n_W = 5)
summary(cls)
summary(cls, print="none") # allows saving results
```

---

summary_2 *Dataset summary statistics*

Description

Creates summary statistics of a dataset

Usage

```
summary_2(data, digits = 3)
```

Arguments

data	Data frame
digits	number of digits for the output

Note

This function is inspired by base::summary(), but outputs content more relevant to the context of cluster_gen() and summary()

See Also

summary()

trim_sample *Trim sample*

Description

Makes sure n <= N

Usage

```
trim_sample(n, N)
```

Arguments

n	vector or unranged list corresponding to sample structure
N	vector or unranged list corresponding to population structure

See Also

cluster_gen

validate_questionnaire_gen *Wrapper-functions for check_condition*

Description

functions to save space in ther parent functions by moving the validation checks here

Usage

```
validate_questionnaire_gen(
  n_cats,
  n_vars,
  n_X,
  n_W,
  theta,
  cat_prop,
  cor_matrix,
  cov_matrix,
  c_mean,
  c_sd
)
```

Arguments

n_cats	vector with number of categories for each categorical variable (W)
n_vars	number of variables (Y, X and W)
n_X	number of continuous background variables (X)
n_W	number of categorical variables (W)
theta	is there a latent variable (Y)?
cat_prop	list of vectors with the cumulative proportions of the background variables
cor_matrix	correlation matrix of YXW
cov_matrix	covariance matrix of YXW
c_mean	vector of means of all variables (YXW)
c_sd	vector of standard deviations of all variables (YXW)

---

weight_responses *Weight responses*

Description

calculates sampling weights for the questionnaire responses

Usage

```
weight_responses(
  cluster_bg,
  n_obs,
  N,
  lvl,
  sublvl,
  previous_sublvl,
  sampling_method,
  cluster_labels,
  resp_labels,
  sum_pop,
  verbose
)
```

Arguments

cluster_bg	dataset with background questionnaire
n_obs	list with the number of elements per level
N	list of numeric vector with the population size of each *sampled* cluster element on each level
lvl	number of the current level
sublvl	number of the current sublevel (element within level)

previous_sublvl	number of the sublevel of the parent level
sampling_method	can be "SRS" for Simple Random Sampling or "PPS" for Probabilities Proportional to Size
cluster_labels	character vector with the names of each cluster level
resp_labels	character vector with the names of the questionnaire respondents on each level
sum_pop	total population at each level (sampled or not)
verbose	if 'TRUE', prints output messages

Value

Input data frame ('cluster_bg') with three new columns for the sampling weights.

`whitelist_message` *Whitelist message*

Description

Prints out the sampled elements when cluster_gen is called with select. This function is analogous to cluster_message, but is more proper for random sampling.

Usage

```
whitelist_message(w)
```

Arguments

w	whitelist

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