Package ‘thurstonianIRT’

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**thurstonianIRT-package**

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**thurstonianIRT-package**

_The 'thurstonianIRT' package._

---

**Description**

This package fits Thurstonian Item Response Theory (IRT) models using 'Stan', 'lavaan', or 'Mplus'. To bring your data into the right format, use the `make_TIRT_data` function. Models can then be fitted via `fit_TIRT_stan`, `fit_TIRT_lavaan`, or `fit_TIRT_mplus` depending on the desired model fitting engine. Data from Thurstonian IRT models can be simulated via `sim_TIRT_data`.

**References**


### cor_matrix

#### Set up Correlation Matrices

**Description**

Set up Correlation Matrices

**Usage**

```r
cor_matrix(cors, dim, dimnames = NULL)
```

**Arguments**

- `cors`: vector of unique correlations
- `dim`: Dimension of the correlation matrix
- `dimnames`: Optional dimnames of the correlation matrix

**Value**

A correlation matrix of dimension `dim`.

**Examples**

```r
cor_matrix(c(0.2, 0.3, 0.5), dim = 3)
```

### fit_TIRT_lavaan

#### Fit Thurstonian IRT models in lavaan

**Description**

Fit Thurstonian IRT models in lavaan

**Usage**

```r
fit_TIRT_lavaan(data, estimator = "ULSMV", ...)
```

**Arguments**

- `data`: An object of class 'TIRTdata'. see `make_TIRT_data` for documentation on how to create one.
- `estimator`: Name of the estimator that should be used. See `lavOptions`.
- `...`: Further arguments passed to `lavaan`. 
Value

A 'TIRTfit' object.

Examples

```r
# load the data
data("triplets")

# define the blocks of items
blocks <-
  set_block(c("i1", "i2", "i3"), traits = c("t1", "t2", "t3"),
            signs = c(1, 1, 1)) +
  set_block(c("i4", "i5", "i6"), traits = c("t1", "t2", "t3"),
            signs = c(-1, 1, 1)) +
  set_block(c("i7", "i8", "i9"), traits = c("t1", "t2", "t3"),
            signs = c(1, 1, -1)) +
  set_block(c("i10", "i11", "i12"), traits = c("t1", "t2", "t3"),
            signs = c(1, -1, 1))

# generate the data to be understood by 'thurstonianIRT'
triplets_long <- make_TIRT_data(
  data = triplets, blocks = blocks, direction = "larger",
  format = "pairwise", family = "bernoulli", range = c(0, 1)
)

# fit the data using lavaan
fit <- fit_TIRT_lavaan(triplets_long)
print(fit)
predict(fit)
```

---

**fit_TIRT_mplus**  
Fit Thurstonian IRT models in Mplus

**Description**

Fit Thurstonian IRT models in Mplus

**Usage**

```r
fit_TIRT_mplus(data, ...)
```

**Arguments**

- `data`  
  An object of class 'TIRTdata'. see `make_TIRT_data` for documentation on how to create one.

- `...`  
  Further arguments passed to `mplusModeler`.
Value

A 'TIRTfit' object.

Examples

# load the data
data("triplets")

# define the blocks of items
blocks <-
  set_block(c("i1", "i2", "i3"), traits = c("t1", "t2", "t3"),
  signs = c(1, 1, 1)) +
set_block(c("i4", "i5", "i6"), traits = c("t1", "t2", "t3"),
  signs = c(-1, 1, 1)) +
set_block(c("i7", "i8", "i9"), traits = c("t1", "t2", "t3"),
  signs = c(1, 1, -1)) +
set_block(c("i10", "i11", "i12"), traits = c("t1", "t2", "t3"),
  signs = c(1, -1, 1))

# generate the data to be understood by 'thurstonianIRT'
triplets_long <- make_TIRT_data(
  data = triplets, blocks = blocks, direction = "larger",
  format = "pairwise", family = "bernoulli", range = c(0, 1)
)

## Not run:
# fit the data using Mplus
fit <- fit_TIRT_mplus(triplets_long)
print(fit)
predict(fit)

## End(Not run)

---

fit_TIRT_stan  Fit Thurstonian IRT models in Stan

Description

Fit Thurstonian IRT models in Stan

Usage

fit_TIRT_stan(data, init = 0, ...)

Arguments

data An object of class 'TIRTdata'. see make_TIRT_data for documentation on how to create one.
init

Initial values of the parameters. Defaults to 0 as it proved to be most stable.

...

Further arguments passed to \texttt{rstan::sampling}.

Value

A 'TIRTfit' object.

Examples

# load the data
data("triplets")

# define the blocks of items
blocks <-
  set_block(c("i1", "i2", "i3"), traits = c("t1", "t2", "t3"),
            signs = c(1, 1, 1)) +
  set_block(c("i4", "i5", "i6"), traits = c("t1", "t2", "t3"),
            signs = c(-1, 1, 1)) +
  set_block(c("i7", "i8", "i9"), traits = c("t1", "t2", "t3"),
            signs = c(1, 1, -1)) +
  set_block(c("i10", "i11", "i12"), traits = c("t1", "t2", "t3"),
            signs = c(1, -1, 1))

# generate the data to be understood by 'thurstonianIRT'
triplets_long <- make_TIRT_data(
  data = triplets, blocks = blocks, direction = "larger",
  format = "pairwise", family = "bernoulli", range = c(0, 1)
)

# fit the data using Stan
fit <- fit_TIRT_stan(triplets_long, chains = 1)
print(fit)
predict(fit)

gof.TIRTfit

\textit{Extract corrected goodness of fit statistics}

Description

By default \texttt{lavaan} will return a value for degrees of freedom that ignores redundancies amongst the estimated model thresholds. This function corrects the degrees of freedom, and then recalculates the associated chi-square test statistic p-value and root mean square error of approximation (RMSEA).
Usage

```r
## S3 method for class 'TIRTfit'
gof(object, ...)

gof(object, ...)
```

Arguments

- `object`: A `TIRTfit` object.
- `...`: currently unused.

Details

Note this function is currently only implemented for `lavaan`.

Value

A vector containing the chi-square value, adjusted degrees of freedom, p-value, and RMSEA.

Examples

```r
# load the data
data("triplets")

# define the blocks of items
blocks <-
  set_block(c("i1", "i2", "i3"), traits = c("t1", "t2", "t3"),
            signs = c(1, 1, 1)) +
  set_block(c("i4", "i5", "i6"), traits = c("t1", "t2", "t3"),
            signs = c(-1, 1, 1)) +
  set_block(c("i7", "i8", "i9"), traits = c("t1", "t2", "t3"),
            signs = c(1, 1, -1)) +
  set_block(c("i10", "i11", "i12"), traits = c("t1", "t2", "t3"),
            signs = c(1, -1, 1))

# generate the data to be understood by 'thurstonianIRT'
triplets_long <- make_TIRT_data(
  data = triplets, blocks = blocks, direction = "larger",
  format = "pairwise", family = "bernoulli", range = c(0, 1))

# fit the data using lavaan
fit <- fit_TIRT_lavaan(triplets_long)
gof(fit)
```
**make_lavaan_code**  
*Generate lavaan code for Thurstonian IRT models*

**Description**

Generate lavaan code for Thurstonian IRT models

**Usage**

```r
make_lavaan_code(data)
```

**Arguments**

- `data` An object of class 'TIRTdata'. see `make_TIRT_data` for documentation on how to create one.

**Value**

A character string of lavaan code for a Thurstonian IRT model.

**Examples**

```r
lambdas <- c(runif(6, 0.5, 1), runif(6, -1, -0.5))
sim_data <- sim_TIRT_data(  
  npersons = 100,  
  ntraits = 3,  
  nblocks_per_trait = 4,  
  gamma = 0,  
  lambda = lambdas,  
  Phi = diag(3)  
)
cat(make_lavaan_code(sim_data))
```

**make_mplus_code**  
*Generate Mplus code for Thurstonian IRT models*

**Description**

Generate Mplus code for Thurstonian IRT models

**Usage**

```r
make_mplus_code(data, iter = 1000, eta_file = "eta.csv")
```
make_sem_data

Arguments

data An object of class 'TIRTdata'. see make_TIRT_data for documentation on how to create one.
iter Maximum number of iterations of the model fitting algorithm.
eta_file optional file name in which predicted trait scores should be stored.

Value

A list of Mplus code snippets to be interpreted by the MplusAutomation package.

Examples

sim_data <- sim_TIRT_data(
  npersons = 100,
  ntraits = 3,
  nblocks_per_trait = 4,
  gamma = 0,
  lambda = c(runif(6, 0.5, 1), runif(6, -1, -0.5)),
  Phi = diag(3)
)

# show the created Mplus code
lapply(make_mplus_code(sim_data), cat)

make_sem_data

Prepare data for Thurstonian IRT models fitted with lavaan or Mplus

Description

Prepare data for Thurstonian IRT models fitted with lavaan or Mplus

Usage

make_sem_data(data)

Arguments

data An object of class 'TIRTdata'. see make_TIRT_data for documentation on how to create one.

Value

A data.frame ready to be passed to lavaan or Mplus.
Examples

```r
# simulate some data
sdata <- sim_TIRT_data(
  npersons = 100,
  ntraits = 3,
  nblocks_per_trait = 4,
  gamma = 0,
  lambda = c(runif(6, 0.5, 1), runif(6, -1, -0.5)),
  Phi = diag(3)
)

# create data ready for use in SEM software
sem_data <- make_sem_data(sdata)
head(sem_data)
```

`make_stan_data`  
Prepare data for Thurstonian IRT models fitted with Stan

**Description**

Prepare data for Thurstonian IRT models fitted with Stan

**Usage**

```r
make_stan_data(data)
```

**Arguments**

data  
An object of class `data.frame` containing data of all variables used in the model.

**Value**

A list of data ready to be passed to Stan.

```r
#` @examples # simulate some data sim_data <- sim_TIRT_data( npersons = 100, ntraits = 3, nblocks_per_trait = 4, gamma = 0, lambda = c(runif(6, 0.5, 1), runif(6, -1, -0.5)), Phi = diag(3) )

# create data ready for use in Stan stan_data <- make_stan_data(sim_data) str(stan_data)
```
make_TIRT_data

Prepare data for Thurstonian IRT models

Description

Prepare data for Thurstonian IRT models

Usage

make_TIRT_data(
  data,
  blocks,
  direction = c("larger", "smaller"),
  format = c("ranks", "pairwise"),
  family = "bernoulli",
  partial = FALSE,
  range = c(0, 1)
)

Arguments

data An object of class data.frame containing data of all variables used in the model.
blocks Object of class TIRTblocks generated by set_block indicating which items belong to which block, trait and more. Ignored if data already contains information on the blocks.
direction Indicates if "larger" (the default) or "smaller" input values are considered as indicating the favored answer.
format Format of the item responses. Either "ranks" for responses in ranked format or "pairwise" for responses in pairwise comparison format. If "ranks", each item must have its own column in the data frame which contains its ranks within the block. If "pairwise", each existing item combination must have its own column named after the combination of the two compared items.
family Name of assumed the response distribution. Either "bernoulli", "cumulative", or "gaussian".
partial A flag to indicate whether partial comparisons are allowed for responses stored in the "ranks" format.
range Numeric vector of length two giving the range of the responses when using the "pairwise" format. Defaults to c(0, 1) for use with dichotomous responses.

Value

A data.frame in a specific format and with attributes ready for use with other functions of the ThurstonianIRT package.
Examples

```r
# load the data
data("triplets")

# define the blocks of items
blocks <-
  set_block(c("i1", "i2", "i3"), traits = c("t1", "t2", "t3"),
            signs = c(1, 1, 1)) +
  set_block(c("i4", "i5", "i6"), traits = c("t1", "t2", "t3"),
            signs = c(-1, 1, 1)) +
  set_block(c("i7", "i8", "i9"), traits = c("t1", "t2", "t3"),
            signs = c(1, 1, -1)) +
  set_block(c("i10", "i11", "i12"), traits = c("t1", "t2", "t3"),
            signs = c(1, -1, 1))

# generate the data to be understood by 'thurstonianIRT'
triplets_long <- make_TIRT_data(
  data = triplets, blocks = blocks, direction = "larger",
  format = "pairwise", family = "bernoulli", range = c(0, 1)
)

# fit the data using Stan
fit <- fit_TIRT_stan(triplets_long, chains = 1)
print(fit)
predict(fit)
```

### predict.TIRTfit

**Predict trait scores of Thurstonian IRT models**

#### Description

Predict trait scores of Thurstonian IRT models

#### Usage

```r
## S3 method for class 'TIRTfit'
predict(object, newdata = NULL, ...)  
```

#### Arguments

- **object**: An object of class TIRTfit.
- **newdata**: Optional TIRTdata object (created via `make_TIRT_data`) containing data of new persons for which trait scores should be predicted based on the fitted model. If NULL (the default), trait scores are predicted for the persons whose data was used to originally fit the model.
- **...**: Further arguments passed to the underlying methods.
Details

When predicting trait scores of new persons (via newdata), posterior medians of item parameters are used for predictions. This implies that the uncertainty in the new trait scores is underestimated as the uncertainty in the (posterior distribution of) item parameters is ignored.

Value

A data frame with predicted trait scores.

set_block

Prepare blocks of items

Description

Prepare blocks of items and incorporate information about which item belongs to which trait. A block of items is a set of two or more items presented and answered together by fully ranking them or selecting the most and/or least favorit in a forced choice format. A whole test usually contains several blocks and items may reappear in different blocks.

Usage

set_block(items, traits, names = items, signs = 1)

empty_block()

Arguments

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<th>Argument</th>
<th>Description</th>
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</thead>
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<tr>
<td>items</td>
<td>Names of item comparisons to be combined into one block. Should correspond to variables in the data.</td>
</tr>
<tr>
<td>traits</td>
<td>Names of the traits to which each item belongs</td>
</tr>
<tr>
<td>names</td>
<td>Optional names of the items in the output. Can be used to equate parameters of items across blocks, if the same item was used in different blocks.</td>
</tr>
<tr>
<td>signs</td>
<td>Expected signs of the item loadings (1 or -1).</td>
</tr>
</tbody>
</table>

See Also

set_blocks_from_df

Examples

```
set_block(
    items = c("i1", "i2", "i3"),
    traits = c("A", "B", "C")
) +
set_block(
    items = c("i4", "i5", "i6"),
    traits = c("A", "B", "C")
)
```
set_blocks_from_df

Prepare blocks of items from a data frame

Description

Prepare blocks of items and incorporate information about which item belongs to which trait from a pre-existing dataframe. This is a wrapper function for set_block, eliminating the need to manually set each item, trait, name and sign (loading) info per block.

Usage

```r
set_blocks_from_df(
  data,
  blocks = "block",
  items = "item",
  traits = "trait",
  names = items,
  signs = "sign"
)
```

Arguments

- `data`: A `data.frame` containing all the required columns (see the arguments below) to specify the item blocks.
- `blocks`: Name of column vector denoting the block each item corresponds to. Each block must have an equal number of items.
- `items`: Name of column vector denoting items to be combined into one block. Should correspond to variables in the data.
- `traits`: Names of column vector denoting the traits to which each item belongs.
- `names`: Optional column vector of item names in the output. Can be used to equate parameters of items across blocks, if the same item was used in different blocks.
- `signs`: Name of column vector with expected signs of the item loadings (1 or -1).

Details

A block of items is a set of two or more items presented and answered together by fully ranking them or selecting the most and/or least favorite in a forced choice format. A whole test usually contains several blocks and items may reappear in different blocks.

See Also

- `set_block`
Examples

```r
block_info <- data.frame(
  block = rep(1:4, each = 3),
  items = c("i1", "i2", "i3", "i4", "i5", "i6",
            "i7", "i8", "i9", "i10", "i11", "i12"),
  traits = rep(c("t1", "t2", "t3"), times = 4),
  signs = c(1, 1, 1, -1, 1, 1, 1, -1, 1, -1, 1, -1)
)

blocks <- set_blocks_from_df(
  data = block_info,
  blocks = "block",
  items = "items",
  traits = "traits",
  signs = "signs"
)
```

Description

Simulate Thurstonian IRT data

Usage

```r
sim_TIRT_data(npersons, ntraits, lambda, gamma,
        psi = NULL, Phi = NULL, eta = NULL,
        family = "bernoulli", nblocks_per_trait = 5,
        nitems_per_block = 3, comb_blocks = c("random", "fixed")
)
```

Arguments

- `npersons`: Number of persons.
- `ntraits`: Number of traits.
- `lambda`: Item factor loadings.
Baseline attractiveness parameters of the first item versus the second item in the pairwise comparisons. Can be thought of as intercept parameters.

Optional item uniquenesses. If not provided, they will be computed as \( \psi = 1 - \lambda^2 \) in which case lambda are taken to be the standardized factor loadings.

Optional trait correlation matrix from which to sample person factor scores. Only used if \( \eta \) is not provided.

Name of assumed the response distribution. Either "bernoulli", "cumulative", or "gaussian".

Number of blocks per trait.

Number of items per block.

Indicates how to combine traits to blocks. "fixed" implies a simple non-random design that may combine certain traits which each other disproportionately often. We thus recommend to use a "random" block design (the default) that combines all traits with all other traits equally often on average.

A data.frame of the same structure as returned by `make_TIRT_data`. Parameter values from which the data were simulated are stored as attributes of the returned object.

```r
# simulate some data
sdata <- sim_TIRT_data(
  npersons = 100,
  ntraits = 3,
  nblocks_per_trait = 4,
  gamma = 0,
  lambda = c(runif(6, 0.5, 1), runif(6, -1, -0.5)),
  Phi = diag(3)
)

# take a look at the data
head(sdata)
str(attributes(sdata))

# fit a Thurstonian IRT model using lavaan
fit <- fit_TIRT_lavaan(sdata)
print(fit)
```
Description

This data set contains synthetic data of 200 participants on 4 triplets. In each triplet, participants had to rank the three alternative items according to their preference. Responses were then converted into a set of dichotomous pairwise responses between all the three alternatives. More details can be found in Brown and Maydeu-Olivares (2011).

Usage

\textit{triplets}

Format

A data frame of 200 observations containing information on 12 variables. Overall, the 12 items measure 3 different traits. Items 1, 4, 7, and 10 load on trait 1, items 2, 5, 8, and 11 load on trait 2, and items 3, 6, 9, and 12 load on trait 3. Moreover, items 4, 9, and 11 are inverted.

- \textit{i1i2} Response preferences between item 1 and 2.
- \textit{i1i3} Response preferences between item 1 and 3.
- \textit{i2i3} Response preferences between item 2 and 3.
- \textit{i4i5} Response preferences between item 4 and 5.
- \textit{i4i6} Response preferences between item 4 and 6.
- \textit{i5i6} Response preferences between item 5 and 6.
- \textit{i7i8} Response preferences between item 7 and 8.
- \textit{i7i9} Response preferences between item 7 and 9.
- \textit{i8i9} Response preferences between item 8 and 9.
- \textit{i10i11} Response preferences between item 10 and 11.
- \textit{i10i12} Response preferences between item 10 and 12.
- \textit{i11i12} Response preferences between item 11 and 12.

Source

Examples

# load the data
data("triplets")

# define the blocks of items
blocks <-
  set_block(c("i1", "i2", "i3"), traits = c("t1", "t2", "t3"),
            signs = c(1, 1, 1)) +
  set_block(c("i4", "i5", "i6"), traits = c("t1", "t2", "t3"),
            signs = c(-1, 1, 1)) +
  set_block(c("i7", "i8", "i9"), traits = c("t1", "t2", "t3"),
            signs = c(1, 1, -1)) +
  set_block(c("i10", "i11", "i12"), traits = c("t1", "t2", "t3"),
            signs = c(1, -1, 1))

# generate the data to be understood by 'thurstonianIRT'
tdat <- make_TIRT_data(
  triplets, blocks, direction = "larger",
  format = "pairwise", family = "bernoulli", range = c(0, 1)
)

# fit the data using Stan
fit <- fit_TIRT_stan(tdat, chains = 1)
print(fit)
predict(fit)
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