Package ‘psychomix’

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Title Psychometric Mixture Models
Description Psychometric mixture models based on flexmix infrastructure. At the moment Rasch mixture models
with different parametrizations of the score distribution (saturated vs. mean/variance specification)
and Bradley-Terry mixture models are implemented. Both mixture models can be estimated with or without
concomitant variables. See vignette("raschmix", package = "psychomix") for de-
tails on the Rasch mixture
models.
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**btmix**

**Finite Mixtures of Bradley-Terry Models**

**Description**

Fit finite mixtures of Bradley-Terry models for paired comparisons data via maximum likelihood with the EM algorithm.

**Usage**

```r
btmix(formula, data, k, subset, weights, 
  nrep = 3, cluster = NULL, control = NULL, 
  verbose = TRUE, drop = TRUE, unique = FALSE, which = NULL, 
  type = c("loglin", "logit"), ref = NULL, undecided = NULL, 
  position = NULL, ...)
```

```r
FLXMCbtreg(formula = ~ ., type = c("loglin", "logit"), ref = NULL, 
  undecided = NULL, position = NULL, ...)
```

**Arguments**

- **formula**: Symbolic description of the model (of type \( y \sim 1 \) or \( y \sim x \)).
- **data, subset**: Arguments controlling formula processing.
- **k**: A vector of integers indicating the number of components of the finite mixture; passed in turn to the \( k \) argument of `stepFlexmix`.
- **weights**: An optional vector of weights to be used in the fitting process; passed in turn to the weights argument of `flexmix`.
- **nrep**: Number of runs of the EM algorithm.
- **cluster**: Either a matrix with \( k \) columns of initial cluster membership probabilities for each observation; or a factor or integer vector with the initial cluster assignments of observations at the start of the EM algorithm. Default is random assignment into \( k \) clusters.
- **control**: An object of class "FLXcontrol" or a named list; controls the EM algorithm and passed in turn to the control argument of `flexmix`.
- **verbose**: A logical; if TRUE progress information is shown for different starts of the EM algorithm.
- **drop**: A logical; if TRUE and \( k \) is of length 1, then a single `raschmix` object is returned instead of a `stepRaschmix` object.
unique A logical; if TRUE, then unique() is called on the result; for details see stepFlexmix.
which number of model to get if k is a vector of integers longer than one. If character, interpreted as number of components or name of an information criterion.
type Character. Should an auxiliary log-linear Poisson model or logistic binomial be employed for estimation? The latter is only available if not undecided effects are estimated.
ref Character or numeric. Which object parameter should be the reference category, i.e., constrained to zero?
undecided Logical. Should an undecided parameter be estimated?
position Logical. Should a position effect be estimated?

Details

Internally stepFlexmix is called with suitable arguments to fit the finite mixture model with the EM algorithm.

flxmlbtreg is the flexmix-driver for Bradley-Terry mixture models.

The interface is designed along the same lines as raschmix which is introduced in detail in Frick et al. (2012). However, the btmix function has not yet been fully tested and may change in future versions.

Value

Either an object of class "btmix" containing the best model with respect to the log-likelihood (if k is a scalar) or the one selected according to which (if specified and k is a vector of integers longer than 1) or an object of class "stepBtmix" (if which is not specified and k is a vector of integers longer than 1).

References


See Also

flexmix, stepFlexmix

Examples

```r
## Data
data("GermanParties2009", package = "psychotools")

## omit single observation with education = 1
gp <- subset(GermanParties2009, education != "1")
gp$education <- factor(gp$education)

## Bradley-Terry mixture models
set.seed(1)
## fit models for k = 1, ..., 4 with concomitant variables
cm <- btmix(preference ~ gender + education + age + crisis,
            data = gp, k = 1:4, nrep = 3)

## inspect results
plot(cm)

## select model
cm4 <- getModel(cm, which = "4")

## inspect mixture and effects
library("lattice")
xyplot(cm4)
effectsplot(cm4)

## effect of education
eff4 <- allEffects(cm4)
effectsplot(eff4, selection = "education")
```

---

**btmix-class**

*Class “btmix”*

**Description**

A fitted *btmix* model.

**Slots**

- **model**: A FLXMC object for a Bradley-Terry mixture model
- **prior**: Numeric vector with prior probabilities of classes.
posterior: Named list with elements scaled and unscaled, both matrices with one row per observation and one column per class.
iter: Number of EM iterations.
k: Number of classes after EM.
k0: Number of classes at start of EM.
cluster: Class assignments of observations.
size: Class sizes.
logLik: Log-likelihood at EM convergence.
df: Total number of parameters of the model.
components: List describing the fitted components using FLXcomponent objects.
formula: Object of class "formula".
control: Object of class "FLXcontrol".
call: The function call used to create the object.
group: Object of class "factor".
converged: Logical, TRUE if EM algorithm converged.
concomitant: Object of class "FLXP".
weights: Optional weights of the observations.
flx.call: Internal call to stepFlexmix
nobs: Number of observations.
labels: Labels of objects compared.
mscale: Measurement scale of paired comparisons data.
undecided: logical. Should an undecided parameter be estimated?
ref: character or numeric. Which object parameter should be the reference category, i.e., constrained to zero?
type: character. Should an auxiliary log-linear Poisson model or logistic binomial be employed for estimation? The latter is only available if not undecided effects are estimated.

Extends
Class flexmix, directly.

Accessor Functions
The following functions should be used for accessing the corresponding slots:
cluster: Cluster assignments of observations.
posterior: A matrix of posterior probabilities for each observation.
btmix-methods

Methods for btmix Objects

Description

Methods for btmix-class objects.

Usage

## S4 method for signature 'btmix'
worth(object, component = NULL)

Arguments

object An object of class "btmix".
component Indicates which components are returned. Default is all components.

Details

worth returns the worth parameters from the Bradley-Terry model.

effectsplot

Effects Displays for Concomitant Variables in Finite Mixture Models

Description

Generic function for visualizing the effects of concomitant variables in finite mixture models.

Usage

effectsplot(object, ...)

Arguments

object Fitted model object.
... Arguments passed to plot.eff, plot.efflist, or plot.effpoly.
Details

effectsplot is set up to be both an S3 and S4 generic. The idea is that it provides the glue needed
to extract the concomitant part from a mixture model: First, the concomitant model is refitted as
a multinom object or glm object (in case of a mixture with two components). Second, effect or
allEffects from the effects package is called to extract the effects of the concomitants. Third, the
corresponding plot methods from the effects package create the display.

Currently, this is implemented for raschmix and btmix objects. The interface is not yet fully tested
and may change in future versions.

References


See Also

effect, allEffects, multinom, glm

Examples

```r
## Not run:
## data on party preferences in Germany
## (omit single observation with education = 1)
data("GermanParties2009", package = "psychotools")
gp <- subset(GermanParties2009, education != "1")
gp$education <- factor(gp$education)

## fit Bradley-Terry mixture, see ?btmix for more details
## and a fully-worked example
set.seed(2)
cm4 <- btmix(preference ~ gender + education + age + crisis, data = gp, k = 4, nrep = 1)

## inspect mixture and effects
library("lattice")
xyplot(cm4)
effectsplot(cm4)

## effect of education
eff4 <- allEffects(cm4)
effectsplot(eff4, selection = "education")

## End(Not run)
```
raschmix

Description

Fit finite mixtures of Rasch models for item response data via conditional maximum likelihood with the EM algorithm.

Usage

raschmix(formula, data, k, subset, weights, scores = c("saturated", "meanvar"),
restricted = FALSE, nrep = 3, cluster = NULL, control = NULL, verbose = TRUE,
drop = TRUE, unique = FALSE, which = NULL, reltol = 1e-10, deriv = "sum",
hessian = FALSE, restart = TRUE, model = NULL, gradvol = reltol, ...)

FLXMrasch(formula = . ~ ., scores = "saturated", delta = NULL, nonExtremeProb = 1,
ref = 1, reltol = 1e-10, deriv = "sum", hessian = FALSE,
restart = TRUE, ...)

Arguments

formula Symbolic description of the model (of type y ~ 1 or y ~ x).
data, subset Arguments controlling formula processing.
k A vector of integers indicating the number of components of the finite mixture; passed in turn to the k argument of stepFlexmix.
weights An optional vector of weights to be used in the fitting process; passed in turn to the weights argument of flexmix.
scores Indicates which model should be fitted for the score probabilities: either a saturated model with a separate parameter for each score probability, or, for meanvar, a multinomial logit model with a location and a scale parameter.
restricted Logical. Should the score distributions be restricted to being equal across components? See Frick et al. (2014) for details.
nrep Number of runs for the starting values for the EM algorithm (if cluster = "mrm") or number of runs of the EM algorithm itself.
cluster Either a matrix with k columns of initial cluster membership probabilities for each observation; or a factor or integer vector with the initial cluster assignments of observations at the start of the EM algorithm. If cluster = "mrm", the mrm function is used to generate starting values. Default is random assignment into k clusters.
control An object of class "FLXcontrol" or a named list; controls the EM algorithm and passed in turn to the control argument of flexmix.
verbose A logical; if TRUE progress information is shown for different starts of the EM algorithm.
raschmix

drop  A logical; if TRUE and k is of length 1, then a single raschmix object is returned instead of a stepRaschmix object.

unique  A logical; if TRUE, then unique() is called on the result; for details see stepFlexmix.

which  number of model to get if k is a vector of integers longer than one. If character, interpreted as number of components or name of an information criterion.

nonExtremeProb  A numeric giving the probability of scoring either none or all items.

ref  Reference category for the saturated score model.

reLtol, gradtol, hessian  Control parameters passed to RaschModel.fit for the M-step. The gradtol argument is deprecated and reltol should be used instead.

restart  Logical. Should the estimation of the item parameters be restarted in each iteration? If FALSE, the estimates from the previous M-step are used as starting values.

delta  Parameters of score model. If NULL, a score model is estimated.

model  An object inheriting from class "FLXM" for the flexmix-driver, as typically produced by FLXMCrasch. By default FLXMCrasch is called automatically with the parameters computed from raschmix.

...  Currently not used.

Details

raschmix is intended as a convenience interface to the stepFlexmix function from the flexmix package (Leisch 2004, Grün and Leisch 2008). The formula argument of raschmix is used to describe the model in terms of both items and concomitant variables, if any. On the left-hand side of the formula the item are specified, either as a matrix y or as single items y1 + y2 + y3 + .... On the right-hand side, the concomitant variables are specified. If no concomitant variables are to be included in the model, the right-hand side of the is just written as ~ 1. See Frick et al. (2012) for a detailed introduction.

raschmix processes this model description and calls stepFlexmix with the suitable driver FLXMCrasch. Usually, the driver does not need to be called by itself, but it is of course also possible to call stepFlexmix directly with this driver to fit Rasch mixture models.

The Rasch mixture model with saturated score distribution as proposed by Rost (1990) is also known as "Mixed Rasch Model". The mean-variance score distribution was suggested by Rost and von Davier (1995). A more recent extension is the restricted score specification by Frick et al. (2014) who also provide an extensive comparison using Monte Carlo studies.

Value

Either an object of class "raschmix" containing the best model with respect to the log-likelihood (if k is a scalar) or the one selected according to which (if specified and k is a vector of integers longer than 1) or an object of class "stepRaschmix" (if which is not specified and k is a vector of integers longer than 1).
References


See Also

flexmix, stepFlexmix, simRaschmix

Examples

```r
library(flexmix)
library(raschmix)

# Data

# simulate response from Rost's scenario 2 (with 2 latent classes)
set.seed(1)
r2 <- simRaschmix(design = "rost2")

# plus informative and non-informative concomitants
d <- data.frame(
  x1 = rbinom(nrow(r2), prob = c(0.4, 0.6)[attr(r2, "cluster")], size = 1),
  x2 = rnorm(nrow(r2))
)
d$resp <- r2

# fit model with 2 latent classes (here the number is known a priori)
m <- raschmix(r2, k = 2, scores = "saturated")
summary(m)

# see below for examples which do not use this a priori information
## (these take a little longer to compute)
```
# Rasch mixture model with saturated score model
# (Rost, 1990)

## fit models for k = 1, 2, 3
m1 <- raschmix(r2, k = 1:3, score = "saturated"
## equivalently: m1 <- raschmix(resp ~ 1, data = d, k = 1:3, score = "saturated"

## inspect results
m1
plot(m1)

## select best BIC model
BIC(m1)
m1b <- getModel(m1, which = "BIC")
summary(m1b)

## compare estimated with true item parameters
parameters(m1b, "item") ## 9 items, item_1 = 0
worth(m1b) ## 10 items, sum = 0
attr(r2, "difficulty")

## graphical comparison
plot(m1b, pos = "top")
for(i in 1:2) lines(attr(r2, "difficulty")[,i], lty = 2, type = "b")

## extract estimated raw score probabilities
## (approximately equal across components and roughly uniform)
scoreProbs(m1b)

## note: parameters() and worth() take "component" argument
parameters(m1b, "item", component = 2)
parameters(m1b, "score", component = 1)
worth(m1b, component = 2:1)

## inspect posterior probabilities
histogram(m1b)
head(posterior(m1b)) ## for first observations only

## compare resulting clusters with true groups
table(model = clusters(m1b), true = attr(r2, "cluster"))

## optionally: leverage mRm package for faster computation of
## starting values
## Not run:
library("mRm")
## fit 2-component model
m1b_mrm <- raschmix(r2, k = 2, score = "saturated", cluster = "mrm")
## essentially identical to previous solution
table(clusters(m1b), clusters(m1b_mrm))
worth(m1b) - worth(m1b_mrm)
## Rasch mixture model with mean/variance score distribution
## (Rost & von Davier, 1995)

### More parsimonious parameterization,

### Fit multinomial logit model for score probabilities

```r
m2 <- raschmix(r2, k = 1:3, score = "meanvar")
plot(m2)
m2b <- getModel(m2, which = "BIC")
```

### Compare number of estimated parameters

```r
dim(parameters(m2b))
dim(parameters(m1b))
```

### Graphical comparison with true parameters

```r
plot(m2b, pos = "top")
for(i in 1:2) lines(attr(r2, "difficulty"), lty = 2, type = "b")
```

### Results from non-parametric and parametric specification

### Essentially identical

```r
max(abs(worth(m1b) - worth(m2b, component = 2:1)))
```

### Concomitant variables

### Employ concomitant variables (x1 = informative, x2 = not)

```r
cm2 <- raschmix(resp ~ x1 + x2, data = d, k = 2:3, score = "meanvar")
```

### BIC selection

```r
rbind(m2 = BIC(m2), cm2 = c(NA, BIC(cm2)))
cm2b <- getModel(cm2, which = "BIC")
```

### Concomitant coefficients

```r
parameters(cm2b, which = "concomitant")
```

### End(Not run)
## raschmix-class

### Description

A fitted raschmix model.

### Slots

- **model**: A FLXMC object for a Rasch mixture model
- **prior**: Numeric vector with prior probabilities of classes.
- **posterior**: Named list with elements scaled and unscaled, both matrices with one row per observation and one column per class.
- **iter**: Number of EM iterations.
- **k**: Number of classes after EM.
- **k0**: Number of classes at start of EM.
- **cluster**: Class assignments of observations.
- **size**: Class sizes.
- **loglik**: Log-likelihood at EM convergence.
- **df**: Total number of parameters of the model.
- **components**: List describing the fitted components using FLXcomponent objects.
- **formula**: Object of class "formula".
- **control**: Object of class "FLXcontrol".
- **call**: The function call used to create the object.
- **group**: Object of class "factor".
- **converged**: Logical, TRUE if EM algorithm converged.
- **concomitant**: Object of class "FLXp".
- **weights**: Optional weights of the observations.
- **scores**: Type of score model employed.
- **restricted**: Logical. Is the score model equal across components?
- **deriv**: Type of derivatives used for computing gradient and Hessian matrix. Analytical with sum algorithm ("sum"), analytical with difference algorithm ("diff", faster but numerically unstable), or numerical.
extremeScoreProbs: Estimated probability of solving either all or no items.
rawScoresData: Table of raw scores from the data.
flx.call: Internal call to stepFlexmix
nobs: Number of observations without missing values, excluding observations with an extreme score.
identified.items: Factor indicating which items are identified.

Extends

Class flexmix, directly.

Accessor Functions

The following functions should be used for accessing the corresponding slots:

cluster: Cluster assignments of observations.
posterior: A matrix of posterior probabilities for each observation.

---------

raschmods-Methods Methods for raschmod Objects
---------

Description

Methods for raschmod-class objects.

Usage

```r
## S4 method for signature 'raschmod'
summary(object, eps = 1e-4, ...)

## S4 method for signature 'raschmod'
parameters(object,
    which = c("model", "item", "score", "concomitant"),
    difficulty = TRUE, component = NULL, simplify = TRUE)

## S4 method for signature 'raschmod'
worth(object, difficulty = TRUE, component = NULL)

scoreProbs(object, component = NULL, simplify = TRUE)
```
Arguments

Object
An object of class "raschmix".

eps
Probabilities below this threshold are treated as zero in the summary method.

Which
Indicates which type of parameters are used. model refers to both item and score
parameters, item and score to their corresponding parameters separately. The
parameters of the concomitant model are accessed through concomitant.

difficulty
Indicates whether item difficulty (default) or easiness parameters are used.

cmpnent
Indicates which components are returned. Default is all components.
simplify
Should the result be simplified if possible?

Details

worth transforms the item parameters so that the sum over all item parameters (within each com-
ponent) is zero.

scoreProbs does not include any aliased parameters if a certain raw score is not present in the data.

Description

The plot method for raschmix-class objects gives a base plot of the item parameter profiles in
each class. A letter plot of the item parameters is returned by xyplot. A rootogram or histogram
of the posterior probabilities is plotted via histogram.

Usage

## S4 method for signature 'raschmix,missing'
plot(x, y, component = NULL, difficulty = TRUE,
center = TRUE, index = TRUE, names = NULL,
abbreviate = FALSE, ref = TRUE, col = "black",
refcol = "lightgray", linecol = NULL, lty = 2, cex = 1,
pch = 19, type = NULL, ylim = NULL, xlab = "Items",
ylab = NULL, legend = TRUE, pos = "topright", ...)

## S3 method for class 'raschmix'
histogram(x, data, root = TRUE, ...)

## S3 method for class 'raschmix'
xyplot(x, data, component = NULL, item = NULL,
difficulty = TRUE, plot.type = c("multiple", "single"),
auto.key = NULL, type = "b", lty = NULL, xlab = "Item", ylab = NULL,
panel = NULL, scales = NULL, ...)
Arguments

x  An object of class "raschmix".
y  Not used.
component  A vector indicating which components should be plotted.
difficulty  Logical. Should item difficulty parameters be used?
center  Logical. Should the item parameters be centered around 0?
index  Logical. Should the index be used for labelling the items?
names  Optional vector of names used for labeling of the items.
abbreviate  Logical. Should the labels of the items be abbreviated?
ref  Logical. Should a reference line be drawn?
col  Point color. If col is a vector, it is interpreted as the color of the components respectively. Individual coloring within components is possible if col is given as a matrix with each column representing one component.
refcol  Color of the reference line.
linecol  Line color. Defaults to the point color.
lty, cex, pch, type, ylim, xlab, ylab  Further standard graphical parameters.
legend  Logical. Should a legend be included?
pos  Position of the legend.
...  Further graphical parameters.
data  Ignored.
root  Logical. Should a rootogram be drawn?
item  A vector indicating which items should be plotted.
plot.type  Should the item profiles be drawn in multiple panels or a single panel?
auto.key, panel, scales  Further graphical parameters for lattice

Details

For a graphical representation of the item parameter in each class use plot (for a base graph) or xyplot (for a lattice plot).

For a graphical representation of the quality of the mixture use histogram. For details see plot-methods.

References


**Description**
Generate simulated data from mixtures of Rasch models. The latent classes of the mixture can differ regarding size as well as item and person parameters of the corresponding Rasch model.

**Usage**
```
simRaschmix(design, extremes = FALSE, attributes = TRUE, ...)
```

**Arguments**
- `design` Type of data generating process. Can be provided as a character or a named list. See Details.
- `extremes` Logical. Should observations with none or all items solved be included in the data?
- `attributes` Logical. Should the true group membership as well as true item and person parameters be attached to the data as attributes "cluster", "difficulty", and "ability"?
- `...` Currently not used.

**Details**
The design of the data generating process (DGP) can be provided in essentially three different ways.

If the design argument is one of "rost1", "rost2" or "rost3", responses from the three DGPs introduced in Rost (1990) will be drawn.

Alternatively, the design can be provided as a named list with elements `nobs`, `weights`, `ability`, and `difficulty`. The weights can be provided in three formats: If provided as a vector of probabilities (summing to 1), class membership will be drawn with these probabilities. If weights is a vector of integer weights (summing to `nobs`, or an integer division thereof), Class sizes will be either the weights directly or a multiple thereof. As a third alternative, the weights can be provided as a function of the number of observations (`nobs`). The ability specification can also be provided in three formats: If provided as a matrix of dimension 2xk with mean and standard deviation for each of the k clusters, the ability parameters are drawn from a normal distribution with the corresponding parameters. Second, ability can be an array of dimension (., 2, k) with abilities and corresponding weights/probabilities per cluster. Third, it can also be provided as a list of k functions which take the number of observations as an argument. The specification of the item difficulty can be provided either as a matrix with k columns with the item difficulties per cluster or as a matrix with `nobs` rows with the item difficulties per subject.

As a third option, design may also be a named list containing a vector of ability parameters and a matrix `difficulty` of dimension (number of observation x number of items).
Value

A matrix of item responses with dimension (number of observations x number of items). If attributes = TRUE, the matrix has attributes cluster, ability, and difficulty. The class memberships cluster are only returned when not provided implicitly through and a vector of abilities and a difficulty matrix with entries for each subject.

References


See Also

raschmix

Examples

```
set.seed(1990)

## DGP 1 with just one latent class
r1 <- simRaschmix(design = "rost1")
# less than 1800 observations because the extreme scorers have been removed
attr(r1, "ability")
table(rowSums(r1))

## DGP 2 with 2 equally large latent classes
r2 <- simRaschmix(design = "rost2", extreme = TRUE)
# exactly 1800 observations including the extreme scorers
attr(r2, "ability")
table(rowSums(r2))

## DGP 3 with 3 latent classes
r3 <- simRaschmix(design = "rost3")
# item parameters in the three latent classes
attr(r3, "difficulty")

set.seed(482)

## number of observations
```
nobs <- 8

## relative weights
weights <- c(1/4, 3/4)
## exact weights: either summing to nobs or an integer division thereof
weights <- c(2, 6)
weights <- c(1, 3)
## weights as function
## here the result is the same as when specifying relative weights
weights <- function(n) sample(size = n, 1:2, prob = c(1/4, 3/4), replace = TRUE)

## class 1: only ability level 0
## class 2: normally distributed abilities with mean = 2 and sd = 1
ability <- cbind(c(0, 0), c(2, 1))
## class 1: 3 ability levels (-1, 0, 1); class 2: 2 ability levels (-0.5, 0.5)
## with equal probabilities and frequencies, respectively
ability <- array(c(cbind(-1:1, rep(1/3, 3)), cbind(-1:1/2, c(0.5, 0, 0.5))),
dim = c(3, 2, 2))
ability <- array(c(cbind(-1:1, rep(1, 3)), cbind(-1:1/2, c(1, 0, 1))),
dim = c(3, 2, 2))
## ability as function
ability <- list(
  function(n) rnorm(n, mean = 0, sd = 0.5),
  function(n) sample(c(-0.5, 0.5), size = n, replace = TRUE)
)

## difficulty per latent class
difficulty <- cbind(-1, 1, rep(0.8), c(rep(0.8), 1, -1))

## simulate data
dat <- simRaschmix(design = list(nobs = nobs, weights = weights,
  ability = ability, difficulty = difficulty))

## inspect attributes and raw scores
table(attr(dat, "cluster"))
hist(attr(dat, "ability"))
barplot(table(rowSums(dat)))
atr(dat, "difficulty")

## specification of DGP only via ability and difficulty
## one vector of abilities of all subjects
ability <- c(rnorm(4, mean = 0, sd = 0.5), sample(c(-0.5, 0.5), size = 4,
  replace = TRUE))
## difficulty per subject
difficulty <- matrix(c(rep(-1, 1, rep(0.8), 4), rep(c(rep(0.8), 1, -1), 4)),
nrow = 8, byrow = TRUE)
## simulate data
dat <- simRaschmix(design = list(ability = ability, difficulty = difficulty))

## inspect attributes and raw scores
hist(attr(dat, "ability"))
barplot(table(rowSums(dat)))
attr(dat, "difficulty")
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