Package 'pcIRT'

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Type Package

Title IRT Models for Polytomous and Continuous Item Responses

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Description Estimates the multidimensional polytomous Rasch model (Rasch, 1961) with conditional maximum likelihood estimation.

License GPL-3

URL https://github.com/christinehohensinn/pcIRT

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`pcIRT-package` *IRT Models for Polytomous and Continuous Item Responses*

Description

The multidimensional polytomous Rasch model (Rasch, 1961) can be estimated with pcIRT. It provides functions to set linear restrictions on the item category parameters of this models. With this functions it is possible to test whether item categories can be collapsed or set as linear dependent. Thus it is also possible to test whether the multidimensional model can be reduced to a unidimensional model that is whether item categories represent a unidimensional continuum. For this case the scoring parameter of the categories is estimated.

Details

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Author(s)

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References

Andersen, E. B. (1995). Polytomous Rasch models and their estimation. In G. H. Fischer and I. Molenaar (Eds.). Rasch Models - Foundations, Recent Developements, and Applications. Springer.

Fischer, G. H. (1974). Einfuehrung in die Theorie psychologischer Tests [Introduction to test theory]. Bern: Huber.

Hohensinn, C. (2018). pcIRT: An R Package for Polytomous and Continuous Rasch Models. Journal of Statistical Software, Code Snippets, 84(2), 1-14. doi:10.18637/jss.v084.c02

Mueller, H. (1987). A Rasch model for continuous ratings. Psychometrika, 52, 165-181.

Rasch, G. (1961). On general laws and the meaning of measurement in psychology, Proceedings Fourth Berekely Symposium on Mathematical Statistiscs and Probability 5, 321-333.

See Also

MPRM CRSM

Examples

```
#simulate data set according to the multidimensional polytomous Rasch model (MPRM)
simdat <- simMPRM(rbind(matrix(c(-1.5,0.5,0.5,1,0.8,-0.3, 0.2,-1.2), ncol=4),0), 500)

#estimate MPRM item parameters
res_mprm <- MPRM(simdat$datmat)

summary(res_mprm)
```

CRSM *Estimation of continuous rating scale model (Mueller, 1987)*

Description

Estimation of the rating scale model for continuous data by Mueller (1987).

Usage

```
CRSM(data, low, high, start, conv = 1e-04)

## S3 method for class 'CRSM'
print(x, ...)

## S3 method for class 'CRSM'
summary(object, ...)
```

Arguments

`data`	Data matrix or data frame; rows represent observations (persons), columns represent the items.
`low`	The minimum value of the response scale (on which the data are based).
`high`	The maximum value of the response scale (on which the data are based).
`start`	Starting values for parameter estimation. If missing, a vector of 0 is used as starting values.
`conv`	Convergence criterium for parameter estimation.
`x`	object of class `CRSM`
`...`	...
`object`	object of class `CRSM`

Details

$$P_{vi}(a \leq X \leq b) = \frac{\int_a^b exp[x\mu + x(2c - x)\theta]dx}{\int_{c-\frac{d}{2}}^{c+\frac{d}{2}} exp[t\mu + t(2c - t)\theta]dt}$$

Parameters are estimated by a pairwise conditional likelihood estimation (a pseudo-likelihood approach, described in Mueller, 1999).

The parameters of the continuous rating scale model are estimated by a pairwise cml approach using Newton-Raphson iterations for optimizing.

Value

`data`	data matrix according to the input
`data_p`	data matrix with data transformed to a response interval between 0 and 1
`itempar`	estimated item parameters
`itempar_se_low`	estimated lower boundary for standard errors of estimated item parameters
`itempar_se_up`	estimated upper boundary for standard errors of estimated item parameters
`itempar_se`	estimated mean standard errors of estimated item parameters
`disppar`	estimated dispersion parameter
`disppar_se_low`	estimated lower boundary for standard errors of estimated dispersion parameter
`disppar_se_up`	estimated upper boundary for standard errors of estimated dispersion parameter
`itempar_se`	estimated mean standard errors of estimated item parameter
`disp_est`	estimated dispersion parameters for all item pairs
`iterations`	Number of Newton-Raphson iterations for each item pair
`low`	minimal data value entered in call
`high`	maximal data value entered in call
`call`	call of the CRSM function

Author(s)

Christine Hohensinn

References

Mueller, H. (1987). A Rasch model for continuous ratings. Psychometrika, 52, 165-181.

Mueller, H. (1999). Probabilistische Testmodelle fuer diskrete und kontinuierliche Ratingskalen. [Probabilistic models for discrete and continuous rating scales]. Bern: Huber.

`dLRT` *Dimensionality test for the multidimensional polytomous Rasch model*

Description

This function tests whether the multidimensional polytomous Rasch model can be reduced to a unidimensional polytomous model.

Usage

```
dLRT(MPRMobj)

## S3 method for class 'dLR'
print(x, ...)

## S3 method for class 'dLR'
summary(object, ...)
```

Arguments

`MPRMobj`	Object of class `MPRM`
`x`	object of class `dLR`
`...`	...
`object`	object of class `dLR`

Details

For this test, a unidimensional model assuming the categories as linearly dependent is computed. Subsequently a Likelihood Ratio test is conducted.

Value

`emp_Chi2`	χ^2 distributed value of the Likelihood Ratio test
`df`	degrees of freedom of the test statistic
`pval`	p value of the test statistic

Author(s)

Christine Hohensinn

References

Fischer, G. H. (1974). Einfuehrung in die Theorie psychologischer Tests [Introduction to test theory]. Bern: Huber.

See Also

MPRM LRT

Examples

```
#simulate data set
simdat <- simMPRM(rbind(matrix(c(-1.5,0.5,0.5,1,0.8,-0.3, 0.2,-1.2),
   ncol=4),0), 500)

#estimate MPRM item parameters
res_mprm <- MPRM(simdat$datmat)

res_dlrt <- dLRT(res_mprm)
summary(res_dlrt)
```

DRM *Estimation of dichotomous logistic Rasch model (Rasch, 1960)*

Description

This function estimates the dichotomous Rasch model by Rasch (1960).

Usage

```
DRM(data, desmat, start, control)

## S3 method for class 'DRM'
print(x, ...)

## S3 method for class 'DRM'
summary(object, ...)
```

Arguments

data	Data matrix or data frame; rows represent observations (persons), columns represent the items.
desmat	Design matrix; if missing, the design matrix for a dichotomous Rasch model will be created automatically.
start	starting values for parameter estimation. If missing, a vector of 0 is used as starting values.
control	list with control parameters for the estimation process e.g. the convergence criterion. For details please see the help pages to the R built-in function `optim`
x	object of class DRM
...	...
object	object of class DRM

Details

Parameters are estimated by CML.

Value

`data`	data matrix according to the input
`design`	design matrix either according to the input or according to the automatically generated matrix
`logLikelihood`	conditional log-likelihood
`estpar`	estimated basic item parameters
`estpar_se`	estimated standard errors for basic item parameters
`itempar`	estimated item parameters
`itempar_se`	estimated standard errors for item parameters
`hessian`	Hessian matrix
`convergence`	convergence of solution (see help files in `optim`)
`fun_calls`	number of function calls (see help files in `optim`)

Author(s)

Christine Hohensinn

References

Fischer, G. H. (1974). Einfuehrung in die Theorie psychologischer Tests [Introduction to test theory]. Bern: Huber.

Rasch, G. (1960). Probabalistic models for some intelligence and attainment tests. Danmarks paedagogiske institut.

Examples

```
#estimate Rasch model parameters
data(reason)
res_drm <- DRM(reason.test[,1:11])

summary(res_drm)
```

extraversion *Data set extraversion*

Description

This object contains data from an extraversion scale . The data set consists of 8 items and 150 persons.

Format

A matrix with 8 variables and 150 observations.

Source

Study

gmc.CRSM *Graphical model check*

Description

A graphical model check is performed for the multidimensional polytomous Rasch model or the continuous Rating Scale Model.

Usage

```
## S3 method for class 'CRSM'
gmc(object, splitcrit = "score", ...)

gmc(object, ...)

## S3 method for class 'aLR'
gmc(object, ...)
```

Arguments

`object`	Object of class `aLR` for graphical model check of the MPRM or object of class `CRSM` for graphical model check of the CRSM
`splitcrit`	Vector or the character vector `"score"` to define the split criterion. The default split criterion `"score"` splits the sample according to the median of the raw score. Vector can be numeric, factor or character. (see details)
`...`	...

Details

The graphical model check plots the item parameter estimates of two subsamples to check the homogeneity. This is according to the subsample split in Andersen's Likelihood Ratio test. For conducting the graphical model check of the MPRM, at first, a `LRT` has to be computed and the resulting object is the input for the `gmc` function.

For plotting a graphical model check for the CRSM, the model has to be estimated with `CRSM` and subsequently the resulting object is the input for the `gmc` function. For the CRSM a split criterion has to be input as vector.

Author(s)

Christine Hohensinn

References

Wright, B.D., and Stone, M.H. (1999). Measurement Essentials. Wilmington: Wide Range Inc.

See Also

`LRT` `CRSM`

`iccplot.CRSM` *Item Characteristic Curve*

Description

The item characteristic curve is performed for the multidimensional polytomous Rasch model or the continuous Rating Scale Model.

Usage

```
## S3 method for class 'CRSM'
iccplot(object, items = "all", ...)

## S3 method for class 'DRM'
iccplot(object, items = "all", ...)

## S3 method for class 'MPRM'
iccplot(object, items = "all", ...)

iccplot(object, ...)
```

Arguments

`object`	Object of class `CRSM` for ICC of the CRSM or object of class `MPRM` for ICC plot of the MPRM or object of class `DRM` for ICC plot of the DRM
`items`	Character vector `"all"` to display ICC curves for all items. By entering a numeric vector, a subset of items can be chosen for which ICC plots are drawn.
`...`	...

Details

The item characteristic curve (ICC) plots the response probability depending on person and item parameter. For plotting the ICC, the object resulting from MPRM `MPRM` or CRSM `CRSM` or DRM `DRM` is the input for the `iccplot` function. The default argument `items="all"` displays ICC curves for all items in the object. With a numeric vector `items`, a subset of items can be selected for which ICC plots are displayed.

Author(s)

Christine Hohensinn

See Also

`MPRM` `CRSM` `DRM`

LRT.DRM — *Computes Andersen's Likelihood Ratio Test for the multidimensional polytomous Rasch model*

Description

Andersen's Likelihood Ratio Test is a model test for Rasch models (based on CML estimation) and splits the data set into subsamples to test the person homogeneity

Usage

```
## S3 method for class 'DRM'
LRT(object, splitcrit = "score", ...)

## S3 method for class 'MPRM'
LRT(object, splitcrit = "score", ...)

LRT(object, ...)

## S3 method for class 'aLR'
print(x, ...)

## S3 method for class 'aLR'
summary(object, ...)
```

Arguments

`object`	Object of class `MPRM` or `DRM` or `aLR`
`splitcrit`	Vector or the character vector `"score"` to define the split criterion. The default split criterion `"score"` splits the sample according to the median of the raw score. Vector can be numeric, factor or character. (see details)
`x`	Object of class aLR
`...`	further arguments

Details

The default split criterion `"score"` computes the raw score of every person according to the category values in the data set. The sample is split by the median of this raw score.

Value

`emp_Chi2`	χ^2 distributed value of the Likelihood Ratio test
`df`	degrees of freedom of the test statistic
`pval`	p value of the test statistic
`itempar`	estimated item parameters for each subsample
`item_se`	estimated standard errors for the item parameters for each subsample

Author(s)

Christine Hohensinn

References

Andersen, E. B. (1973). A goodness of fit test for the Rasch model. Psychometrika, 38, 123- 140.

Fischer, G. H. (1974). Einfuehrung in die Theorie psychologischer Tests [Introduction to test theory]. Bern: Huber.

See Also

`MPRM` `dLRT`

Examples

```
#simulate data set
simdat <- simMPRM(rbind(matrix(c(-1.5,0.5,0.5,1,0.8,-0.3, 0.2,-1.2),
                  ncol=4),0), 500)

#estimate MPRM item parameters
res_mprm <- MPRM(simdat$datmat)

#compute Andersen's Likelihood Ratio test
res_lrt <- LRT(res_mprm)
summary(res_lrt)
```

MPRM — *Estimation of Multidimensional Polytomous Rasch model (Rasch, 1961)*

Description

This function estimates the multidimensional polytomous Rasch model by Rasch (1961). The model estimates item category parameters β for each item and each category and takes each category of data as another dimension. The functions allows setting linear restrictions on item category parameters β.

Usage

```
MPRM(data, desmat, ldes, lp, start, control)

## S3 method for class 'MPRM'
print(x, ...)

## S3 method for class 'MPRM'
summary(object, ...)
```

Arguments

`data`	Data matrix or data frame; rows represent observations (persons), columns represent the items
`desmat`	Design matrix
`ldes`	a numeric vector of the same length as the number of item category parameters indicating which parameters are set linear dependent of which other parameters (see details)
`lp`	a numeric vector with length equal to the number of item parameters set linear dependent. The vector indicates the number of scoring parameters (see details)
`start`	Starting values for parameter estimation. If missing, a vector of 0 is used as starting values.
`control`	list with control parameters for the estimation process e.g. the convergence criterion. For details please see the help pages to the R built-in function `optim`
`x`	object of class `MPRM`
`...`	...
`object`	object of class `MPRM`

Details

Parameter estimations is done by CML method.

The parameters of the multidimensional polytomous Rasch model (Rasch, 1961) are estimated by CML estimation. For the CML estimation no assumption on the person parameter distribution is necessary. Furthermore linear restrictions can be set on the multidimensional polytomous Rasch model. Item category parameters can be set as being linear dependent to other item category parameters and the scoring parameter (as the multiple of the linear dependen parameters) is estimated. The restrictions are set by defining the arguments `ldes` and `lp`. `ldes` is a numerical vector of the same length as item category parameters in the general MPRM. A 0 in this vector indicates that no restriction is set. Putting in another number sets the item category parameter according to the vector position as linear dependent to that item category parameter with the position of the number included. For example, if item category parameter of item 1 and category 2 (that is position 2 in the vector `ldes`) should be linear dependent to the item category parameter of item 1 and category 1 (that is position 1 in the vector `ldes`), than the number 1 has to be on the second element of vector `ldes`. With the vector `lp` it is set, how many different scoring parameters have to be estimated and (if there are more than two) which of them should be equal. For example if 5 item category parameters are set linear dependent (by `ldes`) and according to the `ldes` vector the first, third and fourth have the same scoring parameters and the second and fifth have another scoring parameter, than `lp` must be a vector `lp = c(1,2,1,1,2)`.

It is necessary that the design matrix is specified in accordance with the restrictions in `ldes` and `lp`.

Value

`data`	data matrix according to the input
`design`	design matrix according to the input
`logLikelihood`	conditional log-likelihood
`estpar`	estimated basic item category parameters
`estpar_se`	estimated standard errors for basic item category parameters
`itempar`	estimated item category parameters
`itempar_se`	estimated standard errors for item category parameters
`linpar`	estimated scoring parameters
`linpar_se`	estimated standard errors for scoring parameters
`hessian`	Hessian matrix
`convergence`	convergence of solution (see help files in `optim`)
`fun_calls`	number of function calls (see help files in `optim`)

Author(s)

Christine Hohensinn

References

Andersen, E. B. (1974). Das mehrkategorielle logistische Testmodell [The polytomous logistic test model] In. W. F. Kempf (Ed.), Probabilistische Modelle in der Sozialpsychologie [Probabilistic model in social psychology]. Bern: Huber.

Fischer, G. H. (1974). Einfuehrung in die Theorie psychologischer Tests [Introduction to test theory]. Bern: Huber.

Rasch, G. (1961). On general laws and the meaning of measurement in psychology, Proceedings Fourth Berekely Symposium on Mathematical Statistiscs and Probability 5, 321-333.

See Also

MPRM

Examples

```
#simulate data set according to the general MPRM
simdat <- simMPRM(rbind(matrix(c(-1.5,0.5,0.5,1,0.8,-0.3, 0.2,-1.2),
 ncol=4),0), 500)

#estimate the MPRM without any restrictions
res_mprm <- MPRM(simdat$datmat)

#estimate a MPRM with linear restrictions;
#for item 1 and 2 the second category is set linear dependent to the first
#category
ldes1 <- rep(0,length(res_mprm$itempar))
ldes1[c(2,5)] <- c(1,4)
lp1 <- rep(1,2)
#take the design matrix from the general MPRM and modify it according to the
#linear restriction
design1 <- res_mprm$design
design1[2,1] <- 1
design1[5,3] <- 1
design1[11,c(1,3)] <- -1
design1 <- design1[,-c(2,4)]

res_mprm2 <- MPRM(simdat$datmat, desmat=design1, ldes=ldes1, lp=lp1)

summary(res_mprm2)
```

`person_par.CRSM` *Estimation of person parameters*

Description

This function performs the estimation of person parameters for the multidimensional polytomous Rasch model or the continuous Rating Scale model.

Usage

```
## S3 method for class 'CRSM'
person_par(object, ...)

## S3 method for class 'MPRM'
person_par(object, ..., set0 = FALSE)

person_par(object, ...)
```

Arguments

`object`	Object of class `MPRM` or `CRSM`
`...`	...
`set0`	if `set0=TRUE` for those raw scores patterns with 0 observations (except in the reference category) the person parameter value is set minimal. With this procedure it is possible to estimate at least the remaining person parameters of these raw score pattern. Note: only relevant for person parameter estimation of MPRM. The person parameters for each raw score vector are constrained to sum zero

Details

The estimation is performed by Maximum Likelihood Estimation. Thus, parameters for extreme scores are not calculated!

Value

`ptable`	table showing for each (observed) raw score the corresponding estimated person parameter and standard error
`pparList`	for each person raw score, estimated person parameter and the standard error is displayed
`fun_calls`	number of function calls
`call`	function call

Author(s)

Christine Hohensinn

References

Fischer, G. H. (1974). Einfuehrung in die Theorie psychologischer Tests [Introduction to test theory]. Bern: Huber.

Mueller, H. (1999). Probabilistische Testmodelle fuer diskrete und kontinuierliche Ratingskalen. [Probabilistic models for discrete and continuous rating scales]. Bern: Huber.

See Also

`CRSM`

`print.wt` *Test for the scoring weights in the unidimensional polytomous Rasch model*

Description

This functions tests the fit of fixed scoring parameters in a unidimensional polytomous Rasch model.

Usage

```
## S3 method for class 'wt'
print(x, ...)

## S3 method for class 'wt'
summary(object, ...)

weight_test(MPRMobj, score_param)
```

Arguments

`x`	object of class `wt`
`...`	...
`object`	object of class `wt`
`MPRMobj`	Object of class `MPRM`
`score_param`	Numerical vector with the scoring parameters that are tested

Details

If the unidimensional polytomous Rasch model fits the data, the weight test can be performed to test whether assumed scoring parameters are appropriate. An unconstrained unidimensional polytomous Rasch model is calculated including estimation of scoring parameters. Furthermore a constrained unidimensional polytomous Rasch model is estimated with fixed scoring parameters (according to the input). Subsequently a Likelihood Ratio test tests the fit of the fixed scoring parameters.

Value

`emp_Chi2`	χ^2 distributed value of the Likelihood Ratio test
`df`	degrees of freedom of the test statistic
`pval`	p value of the test statistic
`unconstrLoglikelihood`	log-likelihood of the unconstrained model
`constrLoglikelihood`	log-likelihood of the constrained model
`unconstrNrPar`	number of estimated parameters in the unconstrained model

`constrNrPar` number of estimated parameters in the constrained model

`unconstrItempar`
estimated item parameters of the unconstrained model

`constrItempar` estimated item parameters of the constrained model

`unconstrScoreParameter`
estimated scoring parameters of the unconstrained model

Author(s)

Christine Hohensinn

References

Fischer, G. H. (1974). Einfuehrung in die Theorie psychologischer Tests [Introduction to test theory]. Bern: Huber.

See Also

`MPRM` `dLRT`

Examples

```
#simulate data set
simdat <- simMPRM(rbind(matrix(c(-1.5,0.5,0.5,1,0.8,-0.3, 0.2,-1.2),
                  ncol=4),0), 500)

#estimate MPRM item parameters
res_mprm <- MPRM(simdat$datmat)

#tests the scoring parameter 0.5 for the unidimensional polytomous model
res_weight <- weight_test(res_mprm,  score_param=c(0.5))
summary(res_weight)
```

`reason.test` *Data set META reasoning test.*

Description

This object contains data from the reasoning test 'META' by Gatternig and Kubinger (1994). The test includes 11 encoding tasks.

Format

A matrix with 22 variables and 380 observations. Variables 'I1' to 'I11' contain the responses to the eleven items, 'BT1' to 'BT11' the response times for each item in seconds.

Source

Study

References

Gatternig, J. and Kubinger, K. D. (1994). Erkennen von Metaregeln. Frankfurt: Swets.

---

simCRSM *simulate data according to CRSM*

Description

With this function data sets according to the Continous Rating Scale Model are simulated

Usage

```
simCRSM(itempar, disp, perspar, mid = 0.5, len = 1, seed = NULL)
```

Arguments

`itempar`	a numerical vector with item parameters
`disp`	a number setting the dispersion parameter for the item set
`perspar`	a numerical vector with the person parameters
`mid`	the midpoint of the response scale (on which the data set is generated)
`len`	the length of the response scale (on which the data set is generated)
`seed`	a seed for the random number generated can optionally be set

Details

The midpoint and the length of the response scale define the interval of the data set generated. The default of the function generates data according to a response scale between 0 and 1 - that is midpoint 0.5 and length 1.

Value

`datmat`	simulated data set
`true_itempar`	the fixed item parameters according to the input
`true_disppar`	the fixed dispersion parameter according to the input
`true_perspar`	the fixed person parameters according to the input

Author(s)

Christine Hohensinn

References

Mueller, H. (1987). A Rasch model for continuous ratings. Psychometrika, 52, 165-181.

See Also

simMPRM

---

simDRM *simulate data according to Rasch model*

Description

With this function data sets according to the dichotomous Rasch model (DRM) are simulated

Usage

```
simDRM(itempar, persons = 500, seed = NULL)
```

Arguments

itempar	a vector with item difficulty parameters
persons	number of persons for the generated data set
seed	a seed for the random number generated can optionally be set

Details

Data are generated with category values 0 and 1.

Person parameters are generated by a standard normal distribution.

Value

datmat	simulated data set
true_itempar	the fixed item parameters according to the input
true_perspar	the fixed person parameters

Author(s)

Christine Hohensinn

References

Fischer, G. H. (1974). Einfuehrung in die Theorie psychologischer Tests [Introduction to test theory]. Bern: Huber.

See Also

simMPRMsimCRSM

Examples

```
#set item parameters
item_p <- c(-1.5,-0.3,0,0.3,1.5)

#number of persons
pn <- 500

#simulate data set
simdatD <- simDRM(item_p, pn)
```

---

simMPRM *simulate data according to MPRM*

Description

With this function data sets according to the multidimensional polytomous Rasch model (MPRM) are simulated

Usage

```
simMPRM(itempar, persons = 500, seed = NULL)
```

Arguments

itempar	a matrix with item category parameters; each row represents a category and each column an item (see details)
persons	an integer representing the number of persons (observations) of the data set (see details)
seed	a seed for the random number generated can optionally be set

Details

Data are generated with category values starting with 0. Thus the first row of the matrix containing the item parameters is matched to the category value 0 and so on. The last category is the reference category. Please note, that the item category parameters of the last category have to be 0 (due to parameter normalization)!

Person parameters are generated by a standard normal distribution.

Value

datmat	simulated data set
true_itempar	the fixed item parameters according to the input
true_perspar	the fixed person parameters

Author(s)

Christine Hohensinn

References

Fischer, G. H. (1974). Einfuehrung in die Theorie psychologischer Tests [Introduction to test theory]. Bern: Huber.

Rasch, G. (1961). On general laws and the meaning of measurement in psychology, Proceedings Fourth Berekely Symposium on Mathematical Statistiscs and Probability 5, 321-333.

See Also

simCRSM

Examples

```
#set item parameters
item_p <- rbind(matrix(c(-1.5,0.5,0.5,1,0.8,-0.3, 0.2,-1.2), ncol=4),0)

#number of persons
pn <- 500

#simulate data set
simdatM <- simMPRM(item_p, pn)
```

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