Package 'bspam'

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Type Package

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Title Speed-Accuracy Psychometric Modeling for Binomial Count Outcome Data with R

Version 1.2.2

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Description This is an R package that contains functions to fit the speed-accuracy psychometric model for count outcome data (Potgieter, Kamata & Kara, 2017; Kara, Kamata, Potgieter & Nese, 2020), where the accuracy is modeled by a binomial count latent variable model. For example, the use of this modeling technique allows model-based calibration and scoring for oral reading fluency (ORF) assessment data.

License GPL (>= 3)

Depends R (>= 3.5.0)

Imports tibble, rootSolve, tidyverse, tidyr, magrittr, doParallel, foreach, futile.logger, mvtnorm, nleqslv, tryCatchLog, parallel, miscTools, psych

Suggests rjags, rstan, testthat (>= 3.5.0)

URL https://github.com/kamataak/bspam

BugReports https://github.com/kamataak/bspam/issues

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R topics documented:

`bspam-package` *bspam : A package for fitting the speed-accuracy psychometric model for repeatedly measured count outcome data.*

Description

Purpose of this package

'bspam' is an R package that contains functions to fit the speed-accuracy psychometric model for repeatedly measured count outcome data (Potgieter, Kamata & Kara, 2017; Kara, Kamata, Potgieter & Nese, 2020), where the accuracy is modeled by a binomial count latent variable model. For example, the use of this modeling technique allows model-based calibration and scoring for oral reading fluency (ORF) assessment data.

Design philosophy

Write Design philosophy

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bayes *Bayes function when running mcem with bayes setting*

Description

Bayes function when running mcem with bayes setting

Usage

```
bayes(
  person.data = NA,
  person.id = "",
  task.id = "",
  max.counts = "",
  obs.counts = "",
  time = "",
  parallel = T,
  n.chains = NA,
  thin = 1,
  iter = NA,
  burn = NA
)
```

Arguments

person.data	- student reading data
person.id	The column name in the data that represents the unique individual identifier.
task.id	The column name in the data that represents the unique task identifier.
max.counts	The column name in the data that represents the number of words in a task.
obs.counts	The column name in the data that represents the words read correctly for each case.
time	The column name in the data that represents the time, in seconds, for each case.
parallel	parallel=T, #logical, run in parallel? "T" or "F"
n.chains	int., number of the chains
thin	int, thinning interval, a.k.a, period of saving samples
iter	int., number of the iterations after the burn-in period
burn	int., number of the burn-in iterations

Value

list

`bayes.wcpm` *Bayes function when running mcem with bayes setting*

Description

Bayes function when running mcem with bayes setting

Usage

```
bayes.wcpm(
  calib.data = NA,
  person.data = NA,
  person.id = NULL,
  task.id = NULL,
  occasion = NULL,
  group = NULL,
  max.counts = NULL,
  obs.counts = NULL,
  time = NULL,
  cases = NULL,
  external = NULL,
  type = NULL,
  parallel = T,
  n.chains = NA,
  iter = NA,
  burn = NA,
  thin = 1
)
```

Arguments

`calib.data`	- fit.model class object
`person.data`	- individual reading data
`person.id`	The column name in the data that represents the unique individual identifier.
`task.id`	The column name in the data that represents the unique task identifier.
`occasion`	The column name in the data that represents the unique occasion.
`group`	The column name in the data that represents the unique group.
`max.counts`	The column name in the data that represents the number of words in a task.
`obs.counts`	The column name in the data that represents the words read correctly for each case.
`time`	The column name in the data that represents the time, in seconds, for each case.
`cases`	- student id vectors, will directly use passage data if no calib.data provided
`external`	- if not NULL, will use not student read passages for estimating
`type`	- output type, "general" and "orf", default "general" only output tau & theta. "orf" will output wcpm
`parallel`	parallel=T, #logical, run in parallel? "T" or "F"
`n.chains`	int., number of the chains

iter	int., number of the iterations after the burn-in period
burn	int., number of the burn-in iteration
thin	int, thinning interval, a.k.a, period of saving samples

Value

list

`fit.model` *Estimate the model parameters*

Description

This is an interface function to estimate the model parameters based on the task-level (i.e., passage-level in ORF assessment context) accuracy and speed data by implementing the Monte Carlo EM algorithm described in Potgieter et al. (2017) or fully Bayesian method described in Kara et al. (2020).

Usage

```
fit.model(
  data = NA,
  person.data = NA,
  person.id = "",
  task.id = "",
  max.counts = "",
  obs.counts = "",
  time = "",
  k.in = 5,
  reps.in = 2,
  ests.in = NA,
  est = "mcem",
  se = "none",
  verbose = FALSE
)
```

Arguments

data	A data frame. A wide-format response data generated by the `prep` function. If this argument is used, the next 6 arguments `person.data`, `person.id`, `task.id`,`max.counts`, `obs.counts`, `time` should be skipped.
person.data	A data frame. A long-format response data object. If this this argument is used, the previous argument `data` should be skipped.
person.id	Quoted variable name in `person.data` that indicates the unique person identifier.
task.id	Quoted variable name in `person.data` that indicates the unique task identifier. In the ORF assessment context, it is the passage identifier.
max.counts	Quoted variable name in `person.data` that indicates the number of attempts in the task. In the ORF assessment context, it is the number of words in the passage.

obs.counts	Quoted variable name in person.data that indicates the number of successful attempts in each task. In the ORF assessment context, it is the number of words read correctly for the passage.
time	Quoted variable name in person.data that indicates the time in seconds took to complete the task. In the ORF context, it is the time took to complete reading the passage.
k.in	Numeric, indicating the number of imputations. Default is 5.
reps.in	Numeric, indicating the number of Monte-Carlo iterations. Default is 2.
ests.in	An optional list of numeric vectors, indicating initial values of the model parameters. If this argument is not given, mom function will be called to generate the initial values.
est	Quoted string, indicating the choice of the estimator. It has to be one of "mcem", "bayes". Default is "mcem".
se	Quoted string, indicating the choice of the standard errors. It has to be one of "none", "analytic", "bootstrap". Default is "none".
verbose	Boolean. If TRUE, the summary will be output. Default is FALSE.

Details

Additional details...

Value

MCEM list, bayes list

Note

More & more additional note...

References

Potgieter, N., Kamata, A., & Kara, Y. (2017). An EM algorithm for estimating an oral reading speed and accuracy model. Manuscript submitted for publication.

Kara, Y., Kamata, A., Potgieter, C., & Nese, J. F. (2020). Estimating model-based oral reading fluency: A bayesian approach with a binomial-lognormal joint latent model. Educational and Psychological Measurement, 1–25.

See Also

scoring for scoring.

Examples

```
# example code
MCEM_run <- fit.model(person.data = passage2,
                      person.id = "id.student",
                      task.id = "id.passage",
                      max.counts = "numwords.pass",
                      obs.counts = "wrc",
                      time = "sec",
                      k.in = 5,
                      reps.in = 50,
```

```
                    est = "mcem")
```

fit.model.testlet	*This program is free software; you can redistribute it and/or modify it under the terms of the GNU General Public License as published by the Free Software Foundation; either version 3 of the License, or (at your option) any later version. This program is distributed in the hope that it will be useful, but WITHOUT ANY WARRANTY; without even the implied warranty of MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE. See the GNU General Public License for more details. A copy of the GNU General Public License is available at http://www.gnu.org/licenses/*

Description

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Usage

```
fit.model.testlet(
  data = NULL,
  person.id = "",
  sub.task.id = "",
  obs.count = "",
  time = "",
  task.id = "",
  max.counts = ""
)
```

Arguments

data	A data frame. It has the information of student, passage, sentence, obs.count and time.
person.id	each student's id.
sub.task.id	each sentence's id.
obs.count	The column name in the data that represents the words read correctly for each sentence
time	The column name in the data that represents the reading time for the sentence.
task.id	The column name in the data that represents the unique passage identifier.
max.counts	The column name in the data that represents the number of words in a sentence.

Details

Additional details...

Value

list

Note

Additional note...

Examples

```
# example code
fit.model.testlet <- function(data=NULL, person.id="", sub.task.id="",obs.count="", time="", task.id="", max.
```

---

get.cases *Returns cases (person and occasion) applied in [fit.model] function.*

Description

Returns cases (person and occasion) applied in [fit.model] function.

Usage

```
get.cases(data)
```

Arguments

data	= person response data

Value

cases vector

---

get.perfectcases *Returns perfect cases*

Description

This is a utility function that returns a list of perfect cases for which all responses were correct for all assigned tasks.

Usage

```
get.perfectcases(data)
```

Arguments

data	A data frame. A wide-format response data generated by the prep function.

Value

A vector of perfectly accurate cases.

getBootstrapSE *Get bootstrap SE case is a single stu_season_id*

Description

Added MAP function 07/14/2021 Modified a bug of MLE 07/23/2021 Modified EAP 10/28/2021

Usage

```
getBootstrapSE(
  object,
  person.data,
  case = NA,
  perfect.cases,
  est = "map",
  kappa = 1,
  bootstrap = 100,
  external = NULL
)
```

Arguments

object	- mcem class object
person.data	- individual response data
case	- case number
perfect.cases	- perfect accurate case
est	- SE type.(MLE, EAP, and MAP.) default MAP
kappa	- Default kappa = 1, better be 5
bootstrap	- K number of bootstrap, default is 100
external	- if not NULL, will use unread task for estimating

Value

SE dataset

get_errlist *To get a string of error passages that have no at least two readers*

Description

To get a string of error passages that have no at least two readers

Usage

```
get_errlist(passage)
```

Arguments

passage

Value

a string of error passages

---

log.initiating *This file includes the log functions of bspam package.*

Description

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Usage

```
## S3 method for class 'initiating'
log()
```

Details

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This is log.initiating function, which is used to log output.

MCEM *Passage calibration data set*

Description

Passage calibration data set

Usage

MCEM

Format

An object of class mcem of length 2.

`passage.calib.bayes` *Passage calibration data with bayes*

Description

A data set calibrated with bayes.

Usage

```
passage.calib.bayes
```

Format

two lists: $pass.param with 150 rows and $hyper.param with 4 variables

$pass.param

a parameter controlling binomial success probabilities

b parameter controlling binomial success probabilities

alpha parameter controlling reading times

beta parameter controlling reading times

se_a standard error of a

se_b standard error of b

se_alpha standard error of alpha

se_beta standard error of beta

passage.id passage ID

nwords.p the total

$hyper.param

vartau variance of latent reading ability tau

rho correlation between two latent variables

se_vartau standard error of vartar

se_rho standard error of rho

Source

https://jnese.github.io/core-blog/

References

Nese, J. F. T. & Kamata, A. (2014-2018). Measuring Oral Reading Fluency: Computerized Oral Reading Evaluation (Project No. R305A140203) [Grant]. Institute of Education Sciences, U.S. Department of Education. https://ies.ed.gov/funding/grantsearch/details.asp?ID=1492

`passage.calib.mcem` *Task calibration example output object by MCEM*

Description

This is an example output object from running the `fit.model` function by using the MCEM estimator. It is a result of calibrating an oral reading fluency data set from Nese and Kamata (2014-2018) with xxxx students on 150 passages.

Usage

```
passage.calib.mcem
```

Format

A list of two elements: `$pass.param` is a dataframe with 150 rows and 10 variables, and `$hyper.param` is a dataframe with 1 row and 4 variables

`$pass.param`

`a` parameter controlling binomial success probabilities

`b` parameter controlling binomial success probabilities

`alpha` parameter controlling reading times

`beta` parameter controlling reading times

`se_a` standard error of a

`se_b` standard error of b

`se_alpha` standard error of alpha

`se_beta` standard error of beta

`passage.id` passage ID

`nwords.p` the total number of words in the passage

`$hyper.param`

`vartau` variance of latent reading ability tau

`rho` correlation between two latent variables

`se_vartau` standard error of vartar

`se_rho` standard error of rho

Source

https://jnese.github.io/core-blog/

passage2 *Passage-level Oral Reading Fluency assessment data set*

Description

This is an example data set. It is a passage-level Oral Reading Fluency assessment data set for 85 students who were assigned to read 2 to 12 passages among the same 12 passages. The data is a small subset of the data collected by Nese and Kamata (2014-2018).

Usage

```
\code{data(passage2)}
```

Format

A data frame with 847 rows and 7 variables.

`id.student` unique student identifier

`occasion` identifier for longitudinal assessment occasions; here a triannual assessment administered in the fall, winter, and spring of a school year

`grade` student grade level

`id.passage` unique passage identifier

`numwords.pass` total number of words in the passage

`wrc` words read correct

`sec` seconds to read the passage

Source

https://jnese.github.io/core-blog/

References

Nese, J. F. T. & Kamata, A. (2014-2018). Measuring Oral Reading Fluency: Computerized Oral Reading Evaluation (Project No. R305A140203) [Grant]. Institute of Education Sciences, U.S. Department of Education. https://ies.ed.gov/funding/grantsearch/details.asp?ID=1492

plot.mcem *Plot function to show graph of mcem class*

Description

Usage

```
## S3 method for class 'mcem'
plot(object, X)
```

Arguments

object	= mcem object
X	= dataset to plot
...	= parameter

Details

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---

prep *This file includes utilities of bspam package.*

Description

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Usage

```
prep(
  data = data,
  person.id = "",
  task.id = "",
  occasion = "",
  group = "",
  max.counts = "",
  obs.counts = "",
  time = ""
)
```

Arguments

data	= student response data

Details

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prep function prepares input data for fit.model function

Value

data list (data.long: data frame, data.wide: list of Y, logT10, N, I)

preplong *Prepares data in a long format for [wcpm]*

Description

Prepares data in a long format for [wcpm]

Usage

```
preplong(
  data,
  person.id = "",
  task.id = "",
  occasion = "",
  group = "",
  max.counts = "",
  obs.counts = "",
  time = ""
)
```

Arguments

data	= person response data

Value

data frame

prepwide *Prepares data in a wide format for [mcem].*

Description

This function will return a list with 5 elements: Y: a matrix of words read correctly, where rows represent cases (student and occasion) and columns represent passages logt10: a [tibble::tibble()] of words read correctly N: the number of cases per passage I: the number of passages

Usage

```
prepwide(data, person.id, task.id, max.counts, obs.counts, time)
```

Arguments

data	A data frame.
time	The column name in the data that represents the time, in seconds, for each case.
studentid	The column name in the data that represents the unique student identifier.
passageid	The column name in the data that represents the unique passage identifier.
numwords.p	The column name in the data that represents the number of words in a passage.
wrc	The column name in the data that represents the words read correctly for each case.

`run.mcem` *Base function for fitting the speed-accuracy model by MCEM*

Description

This is a base function for fitting the speed-accuracy model to estimate the model parameters by the Monte Carlo EM algorithm described in Potgieter et al. (2017). This function is used by the `fit.model` function, which is recommended for the users to use.

Usage

```
run.mcem(Y, logT10, N, I, k.in = 5, reps.in = 2, ests.in = NA, verbose = FALSE)
```

Arguments

`Y`	Numeric data matrix of accuracy scores in the size of n x I, where n is the number of tasks and I is the number of persons. Missing data are allowed.
`logT10`	Numeric data matrix of time in the size of n x I matrix, where n and I are defined above. The time data should be in the scale of log10(times). Missing data are allowed.
`N`	Numeric vector of passage lengths in the length of n.
`I`	Numeric, indicating the number of tasks.
`k.in`	Numeric, indicating the number of imputations. Default is 5.
`reps.in`	Numeric, indicating the number of Monte-Carlo iterations. Default is 2.
`ests.in`	An optional list of numeric vectors, indicating initial values of the model parameters. If this argument is not given, `mom` function will be called to generate the initial values.
`verbose`	Boolean. If TRUE, the summary will be output. Default is FALSE.

Details

If the user is desired to use this function, note that the response data file needs to be in the wide format, which can be reshaped from a long-format response data by the `prep.wide` function.

Value

mcem list

Note

Update Memo: 04/29/2021 Modified the mcem function based on Nelis's updated. 10/28/2021 Modified the mcem output

References

Potgieter, N., Kamata, A., & Kara, Y. (2017). An EM algorithm for estimating an oral reading speed and accuracy model. Manuscript submitted for publication.

See Also

`prep.wide` `fit.model`.

`run.scoring` *This is run.scoring function.*

Description

Update Memo: 04/29/2021 Modified the wcpm function based on Nelis's updated. 06/01/2021 Modified based on Nelis's MAP function. 06/01/2021 Modified based on Sarunya's BiEAP function. 06/20/2021 Modified based on Nelis's updated for MLE and EAP 06/21/2021 Modified a bug of MAP function. 07/12/2021 Modified est.eqs function based on Nelis's code. 07/13/2021 Added Map function for bootstrap. 07/30/2021 Modified wcpm function based on Sarunya's update

Usage

```
run.scoring(
  object,
  person.data,
  task.data,
  cases,
  perfect.cases,
  est = "map",
  lo = -4,
  hi = 4,
  q = 100,
  kappa = 1,
  external = NULL,
  type = NULL
)
```

Arguments

`object`	= fit.model object, if not be given will occur error and stop running
`person.data`	= individual response task data
`task.data`	= estimate parameters data
`cases`	= individual occasion id vector
`perfect.cases`	= perfect accurate case
`est`	= estimator, c("mle", "map", "eap", "bayes"), default "map"
`lo`	= default -4
`hi`	= default 4
`q`	= default 100
`kappa`	= default 1
`external`	= if not NULL, will use not student read passages for estimating
`type`	- output type, "general" and "orf", default "general" only output tau & theta. "orf" will output wcpm

Value

wcpm list

scoring *Estimate factor scores with task-level model*

Description

This is an interface function to estimated factor scores based on the task-level (i.e., passage-level in ORF assessment context) accuracy and speed data. It implements likelihood-based approaches (MLE, MAP, or EAP) described in Qiao et al. (under review) or fully Bayesian method described in Kara et al. (2020).

Usage

```
scoring(
  calib.data = NA,
  person.data = NA,
  person.id = "",
  task.id = "",
  occasion = "",
  group = "",
  max.counts = "",
  obs.counts = "",
  time = "",
  cases = NULL,
  est = "map",
  se = "analytic",
  failsafe = 0,
  bootstrap = 100,
  external = NULL,
  type = "general"
)
```

Arguments

calib.data	A class object. Output from calibration phase by fit.model function
person.data	A data frame. A long-format response data object.
person.id	Quoted variable name in person.data that indicates the unique individual identifier.
task.id	Quoted variable name in person.data that represents the unique task identifier. In the ORF assessment context, it is the passage identifier.
occasion	The column name in the data that represents the unique occasion.
group	The column name in the data that represents the unique group.
max.counts	Quoted variable name in person.data that represents the number of attempts in the task. In the ORF assessment context, it is the number of words in the passage.
obs.counts	The column name in the data that represents the words read correctly for each case.
time	The column name in the data that represents the time, in seconds, for each case.
cases	A vector of individual id for which scoring is desired. If no information is is specified, it will estimate scores for all cases in the person.data.

est	Quoted string, indicating the choice of the estimator. It has to be one of code/"mle", "map", "eap", "bayes". Default is "map".
se	Quoted string, indication the choice of the standard errors. It has to be one of code/"analytic", "bootstrap". Default is "analytic".
failsafe	Numeric, indicating the number of retries for bootstrap, which can be set between 0 and 50. Default is 0.
external	An optional vector of task ID's in strings. If NULL (default), the wcpm scores are derived with the tasks the individuals were assigned to. If not NULL, wcpm scores are derived with the tasks provided in the vector, rather than the tasks the individuals were assigned.
type	Quoted string, indication of the choice of output. If "general" (default), wcpm scores are not reported. If "orf", wcpm scores will be reported.
bootstrp	Numeric, indicating the number of bootstrap iterations. Default is 100.

Details

Additional details...

Value

scoring list or Bootstrap dataset

Note

More additional note...

References

Qiao, X, Potgieter, N., & Kamata, A. (2023). Likelihood Estimation of Model-based Oral Reading Fluency. Manuscript submitted for publication.

Kara, Y., Kamata, A., Potgieter, C., & Nese, J. F. (2020). Estimating model-based oral reading fluency: A bayesian approach with a binomial-lognormal joint latent model. Educational and Psychological Measurement, 1–25.

See Also

fit.model for model parameter estimation.

Examples

```
# example code
WCPM_all <- scoring(calib.data=MCEM_run,
                    person.data = passage2,
                    person.id = "id.student",
                    occasion = "occasion",
                    group = "grade",
                    task.id = "id.passage",
                    max.counts = "numwords.pass",
                    obs.counts = "wrc",
                    time = "sec",
                    est = "map",
                    se = "analytic",
                    type="general")
```

sentence.data *Sentence-level student data set*

Description

A data set consisted of reading time data for 4 passages and 23 sentences from 58 students.

Usage

```
sentence.data
```

Format

1334 rows and 8 variables:

id.student unique student identifier

grade student grade level

id.passage unique passage identifier

ind.passage passage index

id.sentence sentence identifier

numwords.sent total number of words in the sentence

wrc words read correct

sec seconds to read the sentence

Source

https://jnese.github.io/core-blog/

summary.bootstrap *summary the information of bootstrap class*

Description

Usage

```
## S3 method for class 'bootstrap'
summary(
  object,
  digits = 4,
  geterror = FALSE,
  verbose = TRUE,
  factor.scores = FALSE
)
```

Arguments

object	= bootstrap object
digits	= print out numeric with specific digits
geterror,	summary error case, default FALSE
verbose	show summary on screen, default TRUE
factor.scores	- theta and tau output flag, default is FALSE

Details

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Value

table

---

summary.fit.model *summary the information of fit.model class*

Description

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Usage

```
## S3 method for class 'fit.model'
summary(object, digits = 4, ...)
```

Arguments

object	= object
digits	= print out numeric with specific digits
...	= parameter

Details

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Value

printing information

summary.scoring *summary the information of wcpm class*

Description

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Usage

```
## S3 method for class 'scoring'
summary(
  object,
  digits = 4,
  verbose = TRUE,
  factor.scores = TRUE,
  show = "short"
)
```

Arguments

object	= object
digits	= print out numeric with specific digits
verbose	- boolean, if TRUE, shows the summary, default is TRUE
factor.scores	- theta and tau output flag, default is TRUE # before was FALSE
show	- output flag, "long" and "short", default "short" only output estimate result. "long" will output estimate result and data.

Details

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Value

scoring dataset with task information and estimated score

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