Package 'mixtur'

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Title Modelling Continuous Report Visual Short-Term Memory Studies

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Description A set of utility functions for analysing and modelling data from continuous report short-term memory experiments using either the 2-component mixture model of Zhang and Luck (2008) <doi:10.1038/nature06860> or the 3-component mixture model of Bays et al. (2009) <doi:10.1167/9.10.7>. Users are also able to simulate from these models.

Depends R (>= 4.0)

Imports dplyr, ggplot2, rlang, tidyr

Suggests knitr, rmarkdown

License GPL-3

LazyData true

URL https://github.com/JimGrange/mixtur

BugReports https://github.com/JimGrange/mixtur/issues

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Copyright Some functions have been adapted from Matlab code written by Paul Bays (https://bayslab.com) published under GNU General Public License.

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`bays2009_full` *Full data set from Bays et al. (2009)*

Description

A full data set including data from 12 participants in a continuous report visual short-term memory experiment. The stimuli were coloured squares in the range radians -pi to pi. The experiment had various set sizes and an additional manipulation of duration of the sample array presentation.

Usage

```
bays2009_full
```

Format

A data frame with 7271 rows and 10 variables:

id participant identification

set_size the set size of each trial

duration the duration of the sample array (in milliseconds, ms), with levels 100ms, 500ms, 2000ms

response the participant's recollection of the target orientation in radians (-pi to pi)

target the feature value of the target in radians (-pi to pi)

non_target_1 the feature value of the first non-target in radians (-pi to pi)

non_target_2 the feature value of the second non-target in radians (-pi to pi)

non_target_3 the feature value of the third non-target in radians (-pi to pi)

non_target_4 the feature value of the fourth non-target in radians (-pi to pi)

non_target_5 the feature value of the fifth non-target in radians (-pi to pi)

Source

The data set is publicly available on the Open Science Framework, with thanks to Paul Bays: https://osf.io/c2yx5/

References

Bays, P.M., Catalao, R.F.G., & Husain, M. (2009). The precision of visual working memory is set by allocation of a shared resource. Journal of Vision, 9(10), Article 7.

---

bays2009_sample *Sample data set from Bays et al. (2009)*

Description

A sample data set including data from 12 participants in a continuous report visual short-term memory experiment. The stimuli were coloured squares in the range radians -pi to pi. The sample data set only consists of trials with a set size of 4 and a sample array duration of 500ms.

Usage

```
bays2009_sample
```

Format

A data frame with 7271 rows and 10 variables:

id participant identification

response the participant's recollection of the target orientation in radians (-pi to pi)

target the feature value of the target in radians (-pi to pi)

non_target_1 the feature value of the first non-target in radians (-pi to pi)

non_target_2 the feature value of the second non-target in radians (-pi to pi)

non_target_3 the feature value of the third non-target in radians (-pi to pi)

Source

The data set is publicly available on the Open Science Framework, with thanks to Paul Bays: https://osf.io/c2yx5/

References

Bays, P.M., Catalao, R.F.G., & Husain, M. (2009). The precision of visual working memory is set by allocation of a shared resource. Journal of Vision, 9(10), Article 7.

berry_2019 *Data set from Berry et al. (2019)*

Description

A data set including data from 30 participants in a continuous report visual short-term memory experiment. The stimuli were oriented bars within the range 1-180 degrees. The experiment had a set size of 3.

Usage

```
berry_2019
```

Format

A data frame with 3600 rows and 6 variables:

id participant identification

condition condition of experiment: whether the task was completed under single-task or dual-task conditions

target_ori the orientation of the target in degrees (1-180)

response_ori the participant's recollection of the target orientation in degrees (1-180)

non_target_1 the orientation of the first non-target in degrees (1-180)

non_target_2 the orientation of the second non-target in degrees (1-180)

Source

The data set is publicly available on the Open Science Framework: https://osf.io/59c4g/

References

Berry. E.D.J., Allen, R.J., Waterman, A.H., & Logie, R.H. (2019). The effect of a verbal concurrent task on visual precision in working memory. Experimental Psychology, 66, (77-85).

fit_mixtur *Fit the mixture model.*

Description

This is the function called by the user to fit either the two- or three- component mixture model.

Usage

```
fit_mixtur(
  data,
  model = "3_component",
  unit = "degrees",
  id_var = "id",
  response_var = "response",
  target_var = "target",
  non_target_var = NULL,
  set_size_var = NULL,
  condition_var = NULL,
  return_fit = FALSE
)
```

Arguments

data	A data frame with columns containing (at the very least) trial-level participant response and target values This data can either be in degrees (1-360 or 1-180) or radians. If the 3-component mixture model is to be fitted to the data, the data frame also needs to contain the values of all non-targets. In addition, the model can be fit to individual individual participants, individual set-sizes, and individual additional conditions; if the user wishes for this, then the data frame should have columns coding for this information.
model	A string indicating the model to be fit to the data. Currently the options are "2_component", "3_component", "slots", and "slots_averaging".
unit	A string indicating the unit of measurement in the data frame: "degrees" (measurement is in degrees, from 1 to 360); "degrees_180 (measurement is in degrees, but limited to 1 to 180); or "radians" (measurement is in radians, from pi to 2 * pi, but could also be already in the range -pi to pi).
id_var	The quoted column name coding for participant id. If the data is from a single participant (i.e., there is no id column) set to NULL.
response_var	The quoted column name coding for the participants' responses
target_var	The quoted column name coding for the target value.
non_target_var	The quoted variable name common to all columns (if applicable) storing non-target values. If the user wishes to fit the 3-component mixture model, the user should have one column coding for each non-target's value in the data frame. If there is more than one non-target, each column name should begin with a common term (e.g., the "non_target" term is common to the non-target columns "non_target_1", "non_target_2" etc.), which should then be passed to the function via the non_target_var variable.
set_size_var	The quoted column name (if applicable) coding for the set size of each response.
condition_var	The quoted column name (if applicable) coding for the condition of each response.
return_fit	If set to TRUE, the function will return the log-likelihood of the model fit, Akiakie's Information Criterion (AIC), Bayesian Information Criterion (BIC), as well as the number of trials used in the fit.

Value

Returns a data frame with best-fitting parameters per participant (if applicable), set-size (if applicable), and condition (if applicable). If `return_fit` was set to `TRUE`, the data frame will also include the log-likelihood value and information criteria of the model fit.

Source

The code for the 3-component model has been adapted from Matlab code written by Paul Bays (https://bayslab.com) published under GNU General Public License.

Examples

```
# load the example data
data <- bays2009_full

# fit the 3-component mixture model ignoring condition

fit <- fit_mixtur(data = data,
                  model = "3_component",
                  unit = "radians",
                  id_var = "id",
                  response_var = "response",
                  target_var = "target",
                  non_target_var = "non_target",
                  set_size_var = "set_size",
                  condition_var = NULL)
```

---

get_summary_statistics

Obtain summary statistics of response error

Description

Returns participant-level summary statistic data of response error estimates ready for inferential analysis. Note that the function does not actually conduct the analysis.

Usage

```
get_summary_statistics(
  data,
  unit = "degrees",
  id_var = "id",
  response_var = "response",
  target_var = "target",
  set_size_var = NULL,
  condition_var = NULL
)
```

Arguments

data	A data frame with columns containing: participant identifier (declared via variable 'id_var'); the participants' response per trial ('response_var'); the target value ('target_var'); and, if applicable, the set size of each response ('set_size_var'), and the condition of each response ('condition_var').
unit	The unit of measurement in the data frame: "degrees" (measurement is in degrees, from 0 to 360); "degrees_180 (measurement is in degrees, but limited to 0 to 180); or "radians" (measurement is in radians, from pi to 2 * pi, but could also be already in -pi to pi).
id_var	The quoted column name coding for participant id. If the data is from a single participant (i.e., there is no id column) set to NULL.
response_var	The quoted column name coding for the participants' responses
target_var	The quoted column name coding for the target value.
set_size_var	The quoted column name (if applicable) coding for the set size of each response.
condition_var	The quoted column name (if applicable) coding for the condition of each response.

Value

Returns a data frame containing the summary statistics `mean_absolute_error`, `resultant_vector_length`, `precision`, and `bias` per participant (if applicable), set-size (if applicable), and condition (if applicable).

Examples

```
# load an example data frame
data(bays2009_full)

# calculate the summary statistics per condition and per set size
summary_data <- get_summary_statistics(data = bays2009_full,
                                       unit = "radians",
                                       condition_var = "duration",
                                       set_size_var = "set_size")
```

---

oberauer_2017 *Data set from Oberauer & Lin (2017)*

Description

A data set including data from 19 participants in a continuous report visual short-term memory experiment. The stimuli were coloured patches within the range 1-360 degrees. The experiment had a set sizes ranging from 1 to 8.

Usage

```
oberauer_2017
```

Format

A data frame with 15,200 rows and 11 variables:

id participant identification

set_size the set size of each trial

response the participant's recollection of the target colour in degrees (1-360)

target the orientation of the target colour in degrees (1-360)

non_target_1 the orientation of the first non-target in degrees (1-360)

non_target_2 the orientation of the first non-target in degrees (1-360)

non_target_3 the orientation of the second non-target in degrees (1-360)

non_target_4 the orientation of the third non-target in degrees (1-360)

non_target_5 the orientation of the fourth non-target in degrees (1-360)

non_target_6 the orientation of the fifth non-target in degrees (1-360)

non_target_7 the orientation of the sixth non-target in degrees (1-360)

Source

The data set is publicly available on the Open Science Framework: https://osf.io/j24wb/

References

Oberauer, K. & Lin, H-Y. (2017). An interference model of visual working memory. Psychological Review, 124, 21-59.

`plot_error` *Plot response error of behavioural data relative to target values.*

Description

Function to plot the response error in behavioural data relative to target values. Requires a data frame that (at least) has target value data and participant response data.

Usage

```
plot_error(
  data,
  unit = "degrees",
  id_var = "id",
  response_var = "response",
  target_var = "target",
  set_size_var = NULL,
  condition_var = NULL,
  n_bins = 18,
  n_col = 2,
```

```
  return_data = FALSE,
  palette = "Dark2",
  scale_y_axis = NULL
)
```

Arguments

data	A data frame with columns containing: participant identifier ('id_var'); the participants' response per trial ('response_var'); the target value ('target_var'); and, if applicable, the set size of each response ('set_size_var'), and the condition of each response ('condition_var').
unit	The unit of measurement in the data frame: "degrees" (measurement is in degrees, from 0 to 360); "degrees_180 (measurement is in degrees, but limited to 0 to 180); or "radians" (measurement is in radians, from pi to 2 * pi, but could also be already in -pi to pi).
id_var	The column name coding for participant id. If the data is from a single participant (i.e., there is no id column) set to "NULL".
response_var	The column name coding for the participants' responses.
target_var	The column name coding for the target value.
set_size_var	The column name (if applicable) coding for the set size of each response.
condition_var	The column name (if applicable) coding for the condition of each response.
n_bins	An integer controlling the number of cells / bins used in the plot.
n_col	An integer controlling the number of columns in the resulting plot.
return_data	A boolean (TRUE or FALSE) indicating whether the data for the plot should be returned.
palette	A character stating the preferred colour palette to use. To see all available palettes, type ?scale_colour_brewer into the console.
scale_y_axis	A vector of 2 elements stating the minimum and maximum value to use for the y-axis in the plots.

Value

If return_data is set to FALSE (which it is by default), the function returns a ggplot2 object visualising the density distribution of response error averaged across participants (if applicable) per set-size (if applicable) and condition (if applicable).

If return_data is set to TRUE, the function returns a list with two components:

- plot: The ggplot2 object.
- data: A data frame with the data used to generate the plot.

Examples

```
plot_error(bays2009_full,
          unit = "radians",
          set_size_var = "set_size")
```

plot_error_non_target *Plot response error of behavioural data relative to non-target values.*

Description

Function to plot the response error in behavioural data relative to non-target values. Note that this function also applies a correction to account for the minimum angle distance on feature values. Requires a data frame that (at least) has target value data, non-target values, and participant response data.

Usage

```
plot_error_non_target(
  data,
  unit = "degrees",
  id_var = "id",
  response_var = "response",
  target_var = "target",
  non_target_var = "non_target",
  set_size_var = NULL,
  condition_var = NULL,
  n_bins = 18,
  n_col = 2,
  return_data = FALSE,
  palette = "Dark2",
  scale_y_axis = NULL
)
```

Arguments

data	A data frame with columns containing: participant identifier ('id_var'); the participants' response per trial ('response_var'); the target value ('target_var'); and, if applicable, the set size of each response ('set_size_var'), and the condition of each response ('condition_var').
unit	The unit of measurement in the data frame: "degrees" (measurement is in degrees, from 0 to 360); "degrees_180 (measurement is in degrees, but limited to 0 to 180); or "radians" (measurement is in radians, from pi to 2 * pi, but could also be already in -pi to pi).
id_var	The column name coding for participant id. If the data is from a single participant (i.e., there is no id column) set to "NULL".
response_var	The column name coding for the participants' responses.
target_var	The column name coding for the target value.
non_target_var	The column name coding for the non-target values.
set_size_var	The column name (if applicable) coding for the set size of each response.
condition_var	The column name (if applicable) coding for the condition of each response.

n_bins	An integer controlling the number of cells / bins used in the plot.
n_col	An integer controlling the number of columns in the resulting plot.
return_data	A boolean (TRUE or FALSE) indicating whether the data for the plot should be returned.
palette	A character stating the preferred colour palette to use. To see all available palettes, type display.brewer.all() into the console.
scale_y_axis	A vector of 2 elements stating the minimum and maximum value to use for the y-axis in the plots.

Value

If return_data is set to FALSE (which it is by default), the function returns a ggplot2 object visualising the density distribution of response error averaged across participants (if applicable) per set-size (if applicable) and condition (if applicable).

If return_data is set to TRUE, the function returns a list with two components:

- plot: The ggplot2 object.
- data: A data frame with the data used to generate the plot.

Examples

```
plot_error_non_target(bays2009_full,
                      unit = "radians",
                      set_size_var = "set_size")
```

---

plot_model_fit *Plot model fit against human error data (target errors)*

Description

Plot model fit against human error data (target errors)

Usage

```
plot_model_fit(
  participant_data,
  model_fit,
  model,
  unit = "degrees",
  id_var = "id",
  response_var = "response",
  target_var = "target",
  set_size_var = NULL,
  condition_var = NULL,
  n_bins = 18,
```

```
  n_col = 2,
  palette = "Dark2"
)
```

Arguments

participant_data	A data frame of the participant data, with columns containing: participant identifier ('id_var'); the participants' response per trial ('response_var'); the target value ('target_var'); and, if applicable, the set size of each response ('set_size_var'), and the condition of each response ('condition_var').
model_fit	The model fit object to be plotted against participant data.
model	A string indicating the model that was fit to the data. Currently the options are "2_component", "3_component", "slots", and "slots_averaging".
unit	The unit of measurement in the data frame: "degrees" (measurement is in degrees, from 0 to 360); "degrees_180 (measurement is in degrees, but limited to 0 to 180); or "radians" (measurement is in radians, from pi to 2 * pi, but could also be already in -pi to pi).
id_var	The column name coding for participant id. If the data is from a single participant (i.e., there is no id column) set to "NULL".
response_var	The column name coding for the participants' responses
target_var	The column name coding for the target value
set_size_var	The column name (if applicable) coding for the set size of each response
condition_var	The column name (if applicable) coding for the condition of each response
n_bins	An integer controlling the number of cells / bins used in the plot of the behavioural data.
n_col	An integer controlling the number of columns in the resulting plot.
palette	A character stating the preferred colour palette to use. To see all available palettes, type ?scale_colour_brewer into the console.

Value

The function returns a ggplot2 object visualising the mean observed response error density distribution across participants (if applicable) per set-size (if applicable) and condition (if applicable) together with the model predictions superimposed.

---

plot_model_parameters *Plot best-fitting parameters of model fit*

Description

Function to plot the best-fitting parameters of either the 2-component or 3-component model. .

Usage

```
plot_model_parameters(
  model_fit,
  model,
  id_var = "id",
  set_size_var = NULL,
  condition_var = NULL,
  n_col = 2,
  return_data = FALSE,
  palette = "Dark2"
)
```

Arguments

model_fit	The model fit object containing the parameters to be plotted.
model	A string indicating the model that was fit to the data. Currently the options are "2_component", "3_component", "slots", and "slots_averaging".
id_var	The column name coding for participant id.
set_size_var	The column name (if applicable) coding for the set size of each response.
condition_var	The column name (if applicable) coding for the condition of each response.
n_col	An integer controlling the number of columns in the resulting plot.
return_data	A boolean (TRUE or FALSE) indicating whether the data for the plot should be returned.
palette	A character stating the preferred colour palette to use. To see all available palettes, type?scale_colour_brewer into the console.

Value

If return_data is set to FALSE (which it is by default),the function returns a ggplot2 object visualising the mean model parameters across participants (if applicable) per set-size (if applicable) and condition (if applicable).

If return_data is set to TRUE, the function returns a list with two components:

- plot: The ggplot2 object.
- data: A data frame with the data used to generate the plot.

---

plot_summary_statistic

Plot summary statistics of behavioural data

Description

Function to plot model-free summary statistics of behavioural data. Users can plot mean absolute error, resultant vector length, and precision of the behavioural data.

Usage

```
plot_summary_statistic(
  data,
  statistic = "precision",
  unit = "degrees",
  id_var = "id",
  response_var = "response",
  target_var = "target",
  set_size_var = NULL,
  condition_var = NULL,
  return_data = FALSE,
  palette = "Dark2"
)
```

Arguments

data	A data frame with columns containing: participant identifier ('id_var'); the participants' response per trial ('response_var'); the target value ('target_var'); and, if applicable, the set size of each response ('set_size_var'), and the condition of each response ('condition_var').
statistic	The summary statistic to plot. This can be set to "mean_absolute_error", "resultant_vector_length", or "precision".
unit	The unit of measurement in the data frame: "degrees" (measurement is in degrees, from 0 to 360); "degrees_180 (measurement is in degrees, but limited to 0 to 180); or "radians" (measurement is in radians, from pi to 2 * pi, but could also be already in -pi to pi).
id_var	The column name coding for participant id. If the data is from a single participant (i.e., there is no id column) set to "NULL".
response_var	The column name coding for the participants' responses.
target_var	The column name coding for the target value.
set_size_var	The column name (if applicable) coding for the set size of each response.
condition_var	The column name (if applicable) coding for the condition of each response.
return_data	A boolean (TRUE or FALSE) indicating whether the data for the plot should be returned.
palette	A character stating the preferred colour palette to use. To see all available palettes, type ?scale_colour_brewer into the console.

Value

If `return_data` is set to `FALSE` (which it is by default), the function returns a ggplot2 object visualising the summary statistic averaged across participants (if applicable) per set-size (if applicable) and condition (if applicable).

If `return_data` is set to `TRUE`, the function returns a list with two components:

- `plot`: The ggplot2 object.
- `data`: A data frame with the data used to generate the plot.

Examples

```
plot_summary_statistic(bays2009_full,
                       unit = "radians",
                       statistic = "precision",
                       set_size_var = "set_size",
                       condition_var = "duration")
```

`simulate_mixtur` *Generate simulated data from mixture models*

Description

Generate simulated data from mixture models

Usage

```
simulate_mixtur(n_trials, model, kappa, p_u, p_n, K, set_size)
```

Arguments

`n_trials`	an integer indicating how many trials to simulate
`model`	a string indicating the model to be fit to the data. Currently the options are "2_component", "3_component", "slots", and "slots_averaging".
`kappa`	a numeric value indicating the concentration parameter of the von Mises distribution to use in the simulations. Note, when simulating from the 2_component or 3_component model, if multiple values are provided to the set_size argument, kappa must be a vector of parameter values to use for each set size).
`p_u`	a numeric value indicating the probability of uniform guessing to use when simulating from the 2_component and 3_component models. Note, when simulating from the 2_component or 3_component model, if multiple values are provided to the set_size argument, p_u must be a vector of parameter values to use for each set size).
`p_n`	a numeric value indicating the probability of a non-target response when simulating from the 3_component model. Note, when simulating from the 2_component or 3_component model, if multiple values are provided to the set_size argument, p_n must be a vector of parameter values to use for each set size).
`K`	a numeric value indicating the capacity value to use when simulating from the slots and slots_averaging models.
`set_size`	a numeric value (or vector) indicating the set size(s) to use in the simulations

Value

Returns a data frame containing simulated responses from the requested model per set-size (if applicable).

Examples

```
# simulate from the slots model

slots_data <- simulate_mixtur(n_trials = 1000,
                              model = "slots",
                              kappa = 8.2,
                              K = 2.5,
                              set_size = c(2, 4, 6, 8))


# simulate one set size from the 3_component model

component_data <- simulate_mixtur(n_trials = 1000,
                                  model = "3_component",
                                  kappa = 8.2,
                                  p_u = .1,
                                  p_n = .15,
                                  set_size = 4)


# simulate multiple set sizes from the 3_component model

component_data_multiple_sets <- simulate_mixtur(n_trials = 1000,
                                                model = "3_component",
                                                kappa = c(10, 8, 6),
                                                p_u = c(.1, .1, .1),
                                                p_n = c(.1, .15, .2),
                                                set_size = c(2, 4, 6))
```

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