Package 'RAR'

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Type Package

Title RAR: Parametric, Nonparametric, and Localized RAR Analysis

Version 2.0.0

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Depends R (>= 3.4.0)

Description This package offers three methods of analyzing rest-activity rhythms (RARs): sigmoidally transformed extended cosine models, spectrum analysis, and localized measure of RAR. Sigmoidally transformed extended cosine models are adapted from Marler et al. 2006 <doi: 10.1002/sim.2466>. Localized measures of RAR include the measures of, mean, standard devation, and relative activity and specified time bins (Graves, 2018).

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Encoding UTF-8

LazyData true

Imports magrittr,
tidyr,
ggplot2,
dplyr,
grDevices,
methods,
Rdpack,
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mgcv,
lubridate,
broom,
dotwhisker,
kableExtra,
knitr,
xtable

RoxygenNote 6.1.1

RdMacros Rdpack

R topics documented:

`age_wise` *Example dataset from AgeWise study*

Description

age_wise.rda is baseline data (n=57) from NIH-funded Aging Well, Sleeping Efficiently: Intervention Studies Program Project (P01 AG20677), also known as AgeWise. The primary goals of the study were intervention-based and emphasized caregiver stress management and sleep habits. Data for AgeWise was collected between November 2003 and June 2008.

Usage

```
data(age_wise)
```

Format

A dataframe with 1,333,524 rows and 3 variables. Activity measurements are acquired for every minute (60-second epochs).

Details

Variables include:

- date_time: date and time of observations, class: "POSIXct" "POSIXt"
- act: observed activity (raw counts).
- id: participant id

band_analysis *Frequency band analysis*

Description

Internal function used to estimate area under power spectrum at particular frequency bands

Usage

```
band_analysis(df, freq.bands, log_transform = c(TRUE, FALSE))
```

Arguments

df	dataframe of predicted smoothed power spectrum estimated from spectrum_est()
freq.bands	matrix specifying lower and upper bound of frequency band (e.g. (t(c(0, 2/24)), or rbind(c(0,2/24), c(2/24,25), c(25, 60))). Bounds must be between 0 and 60)
log_transform	specifies if log power spectrum should be calculated. TRUE is default

Author(s)

Jessica Graves

localized *Localized*

Description

Internal function used to analyze mean, standard deviation and relative activity within specified time-bins

Usage

```
localized(df, log_transform = c(TRUE, FALSE))
```

Arguments

df	dataframe containing actigraphy data and time.
log_transform	accepts logical specifying if log-transformation should be applied to activity data

Author(s)

Jessica Graves

person_time *Person Time*

Description

Internal function used to adjust for average waking hour before conducting localized RAR analysis

Usage

```
person_time(df, hour_bin, wake_hr)
```

Arguments

df	dataframe containing actigraphy data and time.
hour_bin	specifies length of time-bin.
wake_hr	specifies the average wake hour (can be number or column in dataset if multiple subjects).

Author(s)

Jessica Graves

processing *Data processing*

Description

Internal function used to process activity data files to work in RAR functions.

Usage

```
processing(df)
```

Arguments

df	dataframe containing actigraphy data and time.

Author(s)

Jessica Graves

RAR *RAR: Extended Cosine Model*

Description

This function fits sigmoidally transformed extended cosine model to activity data, as seen in Marler et al. (2006).

Usage

```
RAR(df, act_column, time_column, transform = c("antilogit", "arctan",
  "hill"), id_column = NULL)
```

Arguments

df	dataframe containing actigraphy data and time.
act_column	name of the column within df that contains the activity count data.
time_column	name of the column that contains date and time of observation. Time must be a POSIX object.
transform	specifies which transformation to apply. Options include Hill Function ("hill"), Anti-Logistic ("antilogit"), or Arctangent ("arctan")
id_column	name of column containing id if multiple subjects exist in dataframe.

Details

Outputs from this function include: coefficient estimates for baseline cosine model and user-specificed extended cosine transformation, predicted values, and parameter estimates of interest.

Author(s)

Jessica Graves

References

1. Marler M.R., Gehrman P., Martin J.L., Ancoli-Israel S. (2006) The sigmoidally transformed cosine curve: a mathematical model for circadian rhythms with symmetric non-sinusoidal shapes. Stat Med. Nov 30;25(22):3893-904.

See Also

nls

Examples

```
data(age_wise)
d <- age_wise[age_wise$id==1,]
rar_ex <- RAR(d, act, date_time)
rar_ex$parameters # parameter estimates
rar_ex$messages # convergence message

# Multiple subjects
d4 <- age_wise[age_wise$id %in% c(1:4), ]
```

```
rar_ex4 <- RAR(d4, act, date_time, id_column=id)
rar_ex4$parameters # parameter estimates
rar_ex4$messages # convergence messages for each participant
rar_ex4$df_predicted # dataframe of obseved activity and predicted values
rar_ex4$df_interp # predictions based on interpolated data (i.e. missing data)
```

RAR_Bands_plot *RAR_Bands_plot*

Description

Estimates the effect of variability of residuals estimated from extended cosine model based on specific frequency bands.

Usage

```
RAR_Bands_plot(rar_object, freq.bands, sampling.rate = (1/60),
  id_vals = NULL)
```

Arguments

rar_object	default output from RAR().
freq.bands	a matrix of frequency bands, e.g. (t(c(0, 2/24))), ranging between 0 and 60.
sampling.rate	the number of observations per second. Default is 1/60 for 60-second activity epochs.
id_vals	character vector to print plots for each participant specified. Default is NULL.

Author(s)

Jessica Graves

Examples

```
data(age_wise)
d <- age_wise[age_wise$id==1,]
rar_ex <- RAR(d, act, date_time, "antilogit")
bands <- RAR_Bands_plot(rar_ex, t(c(0, 2/24)))
bands$plots # effect of filter

# Multiple bands
f1 <- c(0, 2/24); f2 <- c(2/24, 25); f3 <- c(25, 60)
fs = as.data.frame(rbind(f1, f2, f3))
bands_m <- RAR_Bands_plot(rar_ex, fs)
bands_m$plots[[1]] # effect of filter 1

# Multiple subjects, multiple bands
d4 <- age_wise[age_wise$id %in% c(1:4), ]
rar_ex4 <- RAR(d4, act, date_time, id_column=id)
bands_m.4 <- RAR_Bands_plot(rar_ex4, fs, id_vals=c("1", "2"))
bands_m.4$plots[[1]] # effect of filter from 0, 2/24 (filter [[1]])
bands_m.4$plots[[2]] # effect of filter 2
bands_m.4$plots[[3]] # effect of filter 3
```

RAR_CorrByTime *RAR Correlation by Localized Measures*

Description

This function correlates localized RAR measures for an entire sample (mean, standard deviation, and relative activity) at each time bin against an outcome of interest. This function will take a dataframe that contains RAR_Localized() measures with an outcome of interest already merged in. Or, it will take two separate dataframes, one with the RAR_Localized() measures and one with the outcome. If using two dataframes, you must specifiy the ID column, which will be used to merge the two together within the funciton.

Usage

```
RAR_CorrByTime(df_measures, df_outcome = NULL, id_column = NULL,
  second_var, corr_type = c("pearson", "kendall", "spearman"))
```

Arguments

df_measures	dataframe containing columns from RAR_Localized() for each subject. Mean, Standard Deviation, and Relative Activity columns must be named mean.act, sd.act, and rel.act, respectively. This dataframe must also have an id column. If dataframe is already merged with outcome of interest, leave df_outcome
df_outcome	dataframe containing outcome of interest. This dataframe must also have an id column, which is named the same as df_measures id column.
id_column	specifies the column name in df_measures and df_outcome that corresponds to the id
second_var	specifies the column name in the dataframe that contains the outcome of interest.
corr_type	specifies the type of correlation, e.g. ("pearson", "kendall", "spearman"). Remaining options are defaults of cor.test with exact p-value = FALSE

Author(s)

Jessica Graves

RAR_Local *RAR_Local*

Description

Calculates mean, standard deviation, and relative activity within user-specified time-bin widths (e.g. 4 hour time bins) across days. If user-specified, time will be adjusted for average rise-time.

Usage

```
RAR_Local(df, act_column, time_column, hour_bin, log_transform = c(TRUE,
  FALSE), wake_hr = NULL, id_column = NULL)
```

Arguments

df	dataframe containing actigraphy data and time.
act_column	name of the column within df that contains the activity count data.
time_column	name of the column that contains date and time of observation. Time must be a POSIX object.
hour_bin	user-specified numeric of hour length of bin (e.g. 4).
log_transform	specifies if log transformation of activity data should be performed.
wake_hr	average rise (i.e. wake) time for participant in hours. Must be numeric for single participant. For multiple participants, wake_hr must be merged in to activity dataset (df), wake_hr in this case represents the column name.
id_column	name of column containing id if multiple subjects exist in dataframe.

Author(s)

Jessica Graves

Examples

```
data(age_wise)
d <- age_wise[age_wise$id==1,]
rar_ex <- RAR(d, act, date_time)
# wake-hour adjusted, log scale
local <- RAR_Local(d, act, date_time, 4, TRUE, rar_ex$parameters$tLeft)
local$localized # mean, sd, and relative activity estiamtes across days within bins

# Multiple subjects
d4 <- age_wise[age_wise$id %in% c(1:4), ]
rar_ex4 <- RAR(d4, act, date_time, id_column=id)
d4.2 <- merge(d4, rar_ex4$parameters, by="id")
local4 <- RAR_Local(d4.2, act, date_time, 4, wake_hr=tLeft, id_column=id) # wake-hour adjusted
local4$localized

local4.clock <- RAR_Local(d4.2, act, date_time, 4, id_column=id) # clock time, log scale
local4.clock$localized
```

RAR_Local_plot *RAR_Local_plot*

Description

Visualizes observed and fitted activity data based on mean, standard deviation, and relative activity based on user-specified time bins

Usage

```
RAR_Local_plot(rar_local_object, id_vals = NULL)
```

Arguments

rar_local_object	default output from RAR_Local().
id_vals	character vector to print plots for each participant specified. Default is NULL. Use "ALL" to see activity measures for all participants simultaneously.

Author(s)

Jessica Graves

Examples

```
data(age_wise)
d <- age_wise[age_wise$id==1,]
local <- RAR_Local(d, act, date_time, 4, TRUE, 6.17) # get localized measures
RAR_Local_plot(local)

# Multiple subjects
d4 <- age_wise[age_wise$id %in% c(1:4), ]
rar_ex4 <- RAR(d4, act, date_time, id_column=id)
d4.2 <- merge(d4, rar_ex4$parameters, by="id")
local4 <- RAR_Local(d4.2, act, date_time, 4, wake_hr=tLeft, id_column=id) # wake-hour adjusted
RAR_Local_plot(local4, id_vals=c("1", "2"))

local4.clock <- RAR_Local(d4.2, act, date_time, 4, id_column=id) # clock time, log scale
RAR_Local_plot(local4.clock, id_vals=c("1", "2"))
```

RAR_plot *RAR_plot*

Description

Visualizes observed and fitted activity data based on the default output from extended cosine model (RAR()). Default plotting features interpolated data where missing occurs.

Usage

```
RAR_plot(rar_output, predicted = c(TRUE, FALSE), id_vals = NULL)
```

Arguments

rar_output	default output from RAR().
predicted	specifies to plot predicted values based only on observed data (i.e. does not interpolate if missing values present). Default is FALSE.
id_vals	character vector to print plots for each participant specified. Default is NULL.

Author(s)

Jessica Graves

Examples

```
data(age_wise)
d <- age_wise[age_wise$id==29,]
rar_ex <- RAR(d, act, date_time)
RAR_plot(rar_ex)

# Multiple subjects
d4 <- age_wise[age_wise$id %in% c(1:4), ]
rar_ex4 <- RAR(d4, act, date_time, id_column=id)
p <- RAR_plot(rar_ex4, id_vals=c("1", "2")) # plot for participants 1 and 2 with interpolated data
p$plot_log.act # on log scale
p$plot_act # on natural scale

p2 <- RAR_plot(rar_ex4, TRUE, c("1", "2"))
```

RAR_RegByTime *RAR Regression by Localized Measures*

Description

This function performs linear regression on localized RAR measures for an entire sample (mean, standard deviation, and relative activity) at each time bin against an outcome of interest. This function will take a dataframe that contains RAR_Localized() measures with an outcome of interest already merged in. Or, it will take two separate dataframes, one with the RAR_Localized() measures and one with the outcome. If using two dataframes, you must specifiy the ID column, which will be used to merge the two together within the funciton.

Usage

```
RAR_RegByTime(df_measures, df_outcome = NULL, id_column = NULL,
  y_variable, formula, model_name = NULL, time_type = NULL,
  plots = c(TRUE, FALSE))
```

Arguments

df_measures	dataframe containing columns from RAR_Localized() for each subject. Mean, Standard Deviation, and Relative Activity columns must be named mean.act, sd.act, and rel.act, respectively. This dataframe must also have an id column. If dataframe is already merged with outcome of interest, leave df_outcome
df_outcome	dataframe containing outcome of interest. This dataframe must also have an id column, which is named the same as df_measures id column.
id_column	specifies the column name in df_measures and df_outcome that corresponds to the id
y_variable	a string describing outcome of interest (e.g, "Depression score")
formula	formula to run lm model, e.g. score ~ mean.act.
model_name	a string describing the model predictors, e.g. "Mean Activity". Optional.
time_type	a string describing the time type, e.g. "Person Time" or "Clock Time". Optional.
plots	a logical specifying if the user would like plot to be outputted. Default is FALSE

Author(s)

Jessica Graves

RAR_Spectrum *Spectral Analysis of Residuals of Extended Cosine Model*

Description

This function estimates and smooths the power spectrum of the residuals estimated from the extended cosine model (RAR()).

Usage

```
RAR_Spectrum(rar_object, method = c("pss", "whittle"),
  log_transform = c(TRUE, FALSE), id_column = NULL, ...)
```

Arguments

rar_object	default output from RAR().
method	specifies the method of smoothing, penalized smoothing spline ("pss") or Whittle-likelihood ("whittle"). Default is "pss".
log_transform	specifies if power spectrum should be estimated on log or natural scale. Default is TRUE (log scale).
id_column	name of column containing id if multiple subjects exist in dataframe. Default is NULL.
...	additional parameters

Details

Outputs from this function include: spectrum estimates as well as predicted smooth estimates.

Author(s)

Haoyi Fu, Jessica Graves

References

1. Krafty, RT, Fu, H, Graves, JL, Bruce, SA, Hall, MH, & Smagula, SF (2019). Measuring Variability in Rest-Activity Rhythms from Actigraphy with Application to Characterizing Symptoms of Depression. Statistics in Biosciences, 1-20.

2. Whittle, P (1953). Estimation and information in stationary time series. Arkiv för matematik, 2(5), 423–434.

See Also

nls dplyr

Examples

```
data(age_wise)
d <- age_wise[age_wise$id==1,]
rar_ex <- RAR(d, act, date_time)
spec <- RAR_Spectrum(rar_ex, "pss", TRUE)
spec$spectrum_value # the estimated power spectrum
spec$predict.ss # the predicted smoothed power spectrum

# Multiple subjects
d4 <- age_wise[age_wise$id %in% c(1:4), ]
rar_ex4 <- RAR(d4, act, date_time, id_column=id)
spec4 <- RAR_Spectrum(rar_ex4, "pss", TRUE, id)
spec4$spectrum_value
spec4$predict.ss
```

RAR_SpectrumBands *RAR_SpectrumBands*

Description

Calculates area under predicted smoothed power spectrum based on user-specified frequency bands.

Usage

```
RAR_SpectrumBands(rar_spectrum, freq.bands, log_transform = c(TRUE,
  FALSE), id_column = NULL)
```

Arguments

rar_spectrum	rar_spectrum default output from RAR_Spectrum().
freq.bands	a matrix of frequency bands, e.g. (t(c(0, 2/24))), ranging between 0 and 60.
log_transform	specifies if area should be measured on log or natural scale. If power spectrum was estimated on log scale, this should set to TRUE. Default is TRUE (log scale).
id_column	name of column containing id if multiple subjects exist in dataframe. Default is NULL.

Author(s)

Jessica Graves

Examples

```
data(age_wise)
d <- age_wise[age_wise$id==1,]
rar_ex <- RAR(d, act, date_time, "antilogit")
spec <- RAR_Spectrum(rar_ex, "pss", TRUE)
RAR_SpectrumBands(spec, t(c(0, 2/24)), TRUE)

# Multiple bands
f1 <- c(0, 2/24); f2 <- c(2/24, 25); f3 <- c(25, 60)
fs = as.data.frame(rbind(f1, f2, f3))
```

```
RAR_SpectrumBands(spec, fs, TRUE)

# Multiple subjects, multiple bands
d4 <- age_wise[age_wise$id %in% c(1:4), ]
rar_ex4 <- RAR(d4, act, date_time, id_column=id)
spec4 <- RAR_Spectrum(rar_ex4, "pss", TRUE, id)
RAR_SpectrumBands(spec4, fs, TRUE, id) # outputs bands for each participant
```

RAR_Spectrum_plot *Plotting Power Spectrum of Residuals*

Description

This function plots the estimated and smoothed power spectrum generated from RAR_Spectrum().

Usage

```
RAR_Spectrum_plot(rar_spectrum, id_vals = NULL)
```

Arguments

rar_spectrum	default output from RAR_Spectrum().
id_vals	character vector to print plots for each participant specified. Default is NULL.

Author(s)

Haoyi Fu, Jessica Graves

Examples

```
data(age_wise)
d <- age_wise[age_wise$id==1,]
rar_ex <- RAR(d, act, date_time)
spec <- RAR_Spectrum(rar_ex)
RAR_Spectrum_plot(spec)

# Multiple subjects
d4 <- age_wise[age_wise$id %in% c(1:4), ]
rar_ex4 <- RAR(d4, act, date_time, id_column=id)
spec4 <- RAR_Spectrum(rar_ex4, id_column=id)
RAR_Spectrum_plot(spec4, id_vals=c("1", "2")) # log scale, ids 1 and 2
```

spectrum_est *Spectrum estimation*

Description

Internal function used to estimate the power spectrum of residuals estimated from the RAR().

Usage

```
spectrum_est(df, method = c("pss", "whittle"), log_transform = c(TRUE,
  FALSE), ...)
```

Arguments

df	dataframe containing residuals from extended cosine model from RAR() and date and time.
method	specifies if smooth or penalized spline should be used. Default is smooth.
log_transform	specifies if log power spectrum should be calculated. TRUE is default
...	additional parameters from astsa::mvspec() or gss::gssanova()

Author(s)

Jessica Graves

transformations *Transformations*

Description

Internal function used to fit sigmoidally transformed extended cosine model. As

Usage

```
transformations(df, transform = c("antilogit", "arctan", "hill"))
```

Arguments

df	dataframe containing actigraphy data and time.
transform	specifies which transformation to use

Author(s)

Jessica Graves

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